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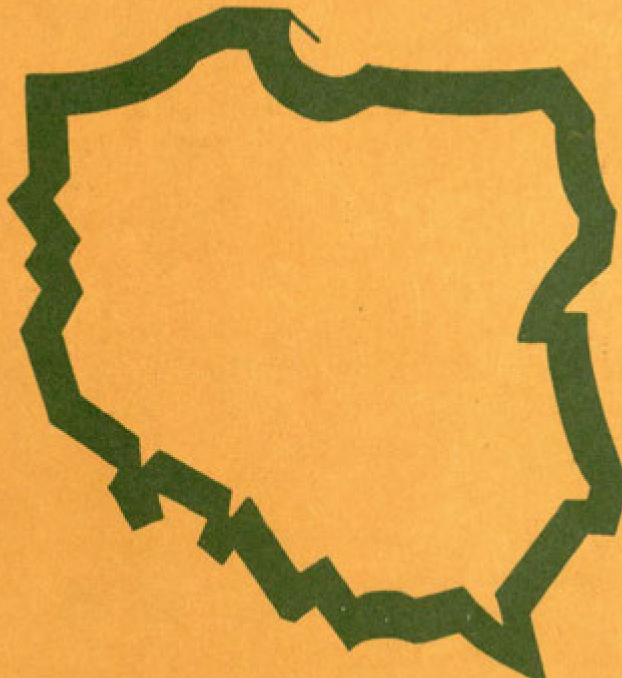

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PWN-POLISH SCIENTIFIC PUBLISHERS

Address of the Editorial Board

KRAKOWSKIE PRZEDMIEŚCIE 30
00-927 WARSZAWA
POLAND

Printed in Poland

POLISH ACADEMY OF SCIENCES
INSTITUTE OF GEOGRAPHY
AND SPATIAL ORGANIZATION

GEOGRAPHIA POLONICA

52

PWN — Polish Scientific Publishers • Warszawa 1986

ISBN 83-01-06753-5
ISSN 0016-7282

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ECONOMIC AND NON-ECONOMIC ESTIMATION OF LOSSES INCURRED DUE TO THE DEGRADATION OF NATURAL ENVIRONMENT

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The estimation of social and economic losses caused by the degradation and improper exploitation of natural environment is a particularly complicated task requiring the application of the 'cost-benefit' analysis of a given economic system approached both from the material as well as spatial aspects. Moreover, the knowledge of those losses is one of the basic factors influencing social consciousness regarding relationship with nature, its resources and values. However, if the consciousness is not raised to the level determined by the current state of knowledge, all activities aimed at protecting and rationally using the environment will not bear fruit and a social acceptance will not be gained.

The presentation of socio-economic problems in terms of global economics requires the introduction of far-going changes both in the theory of economics (regional economics in particular) as well as in the methodology and techniques of measurements. It also requires a new approach to the problem of losses incurred by society due to improper use of environmental resources.

The idea underlying global economics is to analyse phenomena occurring on the earth in the categories of a complex system 'nature–economy–space', the criterion of which is the quality of life of human societies in a given place and time. In this context the estimation of losses should naturally be much broader, since it concerns not only direct and indirect losses arising from the degradation of environment, but also losses due to its improper exploitation and refraining from any activities aimed at its rehabilitation. To obtain this aim the current methodological premises applied in economics should be developed and improved, and a gradual transition from the technico-economic to ecologico-economic approach obtained, from the criteria of subject rents to environmental rents, to a wider application of the concept of moving spatial calculus, etc. Economic sciences should first of all, though not solely, be concerned with the implementation of these tasks. The economist is unable to determine all variables of the system 'nature–economy–space' in terms of value, even if he is willing to do so. Other specialists must co-operate: naturalists, humanists, technologists, etc. However, they will have to change their views regarding investigated phenomena and adopt the socio-economic criterion as the superior goal in the investigation of individual components of the system 'man–environment'. This postulate does not imply that an end should be put to basic, narrowly specialized investigations, which should be continued and developed, since they are not only valuable but also informative and form a basis for applied research. The problem lies in a closer relationship between the two approaches: the ecologization of economics and other social sciences, or — to revert the term — the economization and humanization of natural sciences. If this postulate is not realized, the current situation will not be changed: economists will continue their divagations at a higher and higher level of generalization, or will — at least — approach the problem partially, while other specialists will continue to study problems lying within their own sphere of interest, possibly very interesting, but insignificant from the viewpoint of the world's future.

The identification of economic interdependences between economic man and nature is full of difficulties, the principal of which are:

a) highly complicated mutual links within the system 'nature–economy–space';

b) inadequate knowledge of consequences of human activities in their natural environment as well as the actual role of nature in stimulating social and economic development;

c) theoretical and methodological (as well as technical) deficiencies which make it difficult to carry out a global analysis of the system, which contains both quantitative as well qualitative variables, is characterized by a complicated network of matter, energy and information flows, and moreover is still developing.

Of course, these difficulties can be overcome, the majority of them have already been solved or are being solved. A rich literature on the subject, issued in both socialist as well as capitalist countries, is an evidence that the paradigm of environmental economy, if not already settled, is in the final stage of formulation. Moreover, the links within the discussed system are so well identified that adequate conclusions can be drawn. The methodological-technical problems, concerned with the measuring and interpretation, are the most difficult to solve but even in this field the progress is considerable. Interesting methodological attempts are presented by Cauter and Hill (1979), Tupytzya (1980), Gurman (1980), Mrktkhyan (1979), Szyrmer (1981) and others and by the Polish authors: Prandecka (1983), Ginsbert-Gebert (1976), Leszczyński (1978). A collected volume entitled *Ekonomiczne problemy ochrony środowiska* (Economic problems of the protection of environment), published in 1983, contains also some interesting propositions regarding methods of the evaluation of the losses.

The presentation of social and economic losses in the categories of global economics requires first of all a systematization of those losses, the determination of their duration, as well as the selection of measures appropriate for their introduction into the economic calculus.

In the current research practice the negative effects produced in an environment have mainly been analysed from the viewpoint of the factor at work. To express these effects an already standardized terminology is usually used, like 'losses incurred due to air pollution' or 'losses incurred due to water pollution'; it makes it possible to recognize immediately the source of a real danger and to liquidate it. However, it limits the problem to the relation: 'giver — taker', while both components of the equation are presented in such a way as if independent of any others. The whole sphere of synergic dependences among the forms of anthropopressure on the environment, between its spatial and functional structure and sensitivity to external influences, as well as the assessment of the consequences of improper exploitation of environmental resources, is here left out. Therefore, even if we do not negate the practical value of estimating losses from the viewpoint of a 'giver', we should also look for other solutions, which though they take into account overlooked phenomena, will to a certain degree be complementary to the 'classic' approach. An initial effort in this field — presented, of course, for discussion — is the system of socio-economic losses, constructed from the viewpoint of the 'taker' of negative effects.

A. Direct losses, measurable in economic terms, arisen as an effect of changed properties of the environment, air and water in particular, upon the production workshop, means of production and the final product.

A 1. Losses in the technical sphere (products made by man) due to chemical decomposition (corrosion):

– of the production workshop and means of production (raw materials, semi-products, etc.) in manufacturing industries;

– of the final product, including agricultural equipment, consumer goods and other machines and equipment;

– of fixed assets, including: houses and all-communal buildings; the communal, transport, industrial and other infrastructure; hydrotechnical and power equipment; service facilities, etc.;

– of cultural objects, including cultural relics and other monuments of the national and all-human culture, scientific apparatus, books, films, etc.

The estimation of losses in this group is relatively easy, though the gap between the minimal and maximal figures may be quite wide, which is connected with the selection of estimation methods and techniques. The spatial structure of this group of losses can be represented as points or networks, whereas their intensity in space depends on the three factors: the degree of aggressiveness of chemical pollution, the number and character of production establishments, and the number of population.

A 2. Losses in the bioproductive sphere (crop and animal production) due to:

– changes of soil parameters of agricultural land and woodland, manifested by lower yields of crops;

– changes in physiological-biochemical properties of crops and animals as an effect of toxic substances, manifested by lesser resilience, salubrity, increment of the mass, and therefore of the quantity and quality of the product;

– upset biocoenotic equilibrium and the transformation of the character of the habitat, especially in woodland, open waters and perennial grassland.

These losses affect both agricultural production as well as forestry or fisheries, though in agriculture they are less evident than in other branches, since agriculture is incomparably more flexible and thus easily adapts itself to changed environmental conditions.

The estimation of economic losses in this group is more difficult than in the former group, due to a number of objective causes: inadequate knowledge of the production potential of the habitat (natural potential), which – especially in agriculture – is as if concealed by agrotechnical practices (fertilization, rational rotation, technical soil cultivation, etc.); overlapping of anthropogenetic factors and natural transformations due, for instance, to climatic fluctuations and a tremendous dynamism characterizing particularly agriculture. These factors cause that in spite of an evident deterioration of soils agricltural production may increase, which is however impossible in forestry or fisheries. Therefore, it is easier to estimate losses in the latter branches than in agriculture.

The spatial structure of this group of losses is of a surface character and their intensity is a resultant of the degree of aggressiveness, i.e. the degree to which chemical substances damage the environment (and the living organisms) and the degree of resilience (ecological valence) of ecosystems, as well as their possibilities for the detoxication of noxious substances.

B. Direct losses, measurable in economic terms, arisen as an effect of changes in the sphere of the utilization of environmental resources.

B 1. Losses due to changes in the character of the utilization of space like:

– the deterioration of the spatial structure of the utilization of environmental resources (a limit put to the external economies of the neighbourhood, the development of the spatial patterns of the system of the function collision, etc.);

– the limitation of usable space to the benefit of non-productive aims;

– putting out of use (a full or partial degeneration of land formerly economically exploited, due, for instance, to a direct emission of toxic substances by industrial establishments, storage of solid and fluid wastes, etc.;

– putting out of use of land formerly economically exploited due to mechanical influences (excavations, embankments, dumps, etc.);

– necessary translocation of industrial establishments and services, requiring a particularly pure environmental elements.

The estimation of losses in this group is not too difficult, with the exception of the first sub-group, since the estimations of losses due to the loss of the neighbourhood economies as well as consequences of the collision of functions require some more exhaustive investigation.

The character of the spatial structure can be represented as points or surfaces and their intensity depends on the number of errors committed in space economy (incorrect location decisions, underestimation of the role of certain elements in the landscape, or simple errors in the assessment of the significance of the separate forms of land use).

B 2. Losses in the utilization of environmental resources due to:

– techniques of the acquisition of mineral raw materials, degrading or putting out of use the deposits;

– techniques of the transformation of mineral raw materials which cause that a large part of raw materials is not used;

– faulty techniques applied in the bio-productive system (i.e. in agriculture, forestry, fisheries), degrading environmental resources, and production potential as well as the quantity and quality of the product;

– faulty techniques in construction, causing an excessive devastation of raw materials and lowering the quality, durability and reliability of buildings and equipment.

In this group losses due to faulty techniques devastating natural resources are also not difficult to estimate.

The character of the spatial structure can be represented as points, seldom as points and surfaces; their intensification is a simple function of techniques applied.

C. Direct and indirect losses, measurable in economic terms, due to a necessary substitution of economies lost due to not entirely rational utilization of environmental resources, like outlays on:

– the import of raw materials which, though sufficiently rich in the country, are only partially exploited;

– the import of foodstuffs and other products of vegetable and animal origin to make up for losses incurred due to insufficient use of own resources.

This section includes in principle this part of costs which are born by the national economy to make up for lost economies due to improper use of environmental resources (sections A and B). Thus, it corresponds with the environmental rent. The estimation of those losses, though seemingly easy, is actually a difficult task since it requires that the substitution and supplementary imports should be differentiated.

The character of those losses is, of course, not spatial, and their intensification is a resultant of social needs and the state of economy.

D. Direct and indirect social losses, hardly measurable or entirely immeasurable, due to negative transformations of the environment (losses in the quality of life):

– permanently or partially impaired professional and intellectual efficiency of the population and therefore impaired labour efficiency;

– increased absenteeism, due to sick leave, premature retirement, etc.;

– hereditary diseases, deteriorated psycho-physical condition, especially among children and young people;

– shrinkage of spaces free from pollution, including spaces for recreation, as well as degraded conditions in health resorts, and therefore less efficient processes of the restitution of strength and post-disease rehabilitation;

– limited possibilities for temporal translocation of population due to increased cost of adaptation to other conditions of the natural environment than those in the place of permanent residence;

– intoxication and a lower nutritive value of foodstuffs, a lower quality of drinking-water;

– a gradually impoverished natural conditions, especially of natural ecosystems and the degradation of the landscape, i.e. those elements of natural environment which are a source of not only aesthetic experiences but also an area which means a social identification with the homeland.

This group contains in principle expenses associated with restitution of social heath deteriorated due to environmental dangers. The estimation of such expenses is very difficult, mainly because it is impossible to separate indirect or direct envronmental effects from other factors determining conditions of life (demographic, political, sociological, etc.).

The spatial structure of social losses can be represented both as points or surfaces, since it affects both individuals as well as human populations and the area (occupied by individuals, populations, societies), whereas the intensification is a complex function of the state of the environment and a social possibility for selection.

E. Indirect (and direct) losses, measurable in economic terms, due to the discontinuation of measures optimizing and rationalizing the management of the environment (costs incurred due to conservative thinking and acting, particularism, lack of imagination, and also – though to a lesser degree – caused by objective reasons, i.e. the country's socio-economic situation). The examples of the discontinuation causing high, measurable social and economic losses are many, for instance:

– discontinuation of search and application of alternative technical-productive solutions, minimizing threat to the environment in industry, agriculture, forestry, fisheries, etc.;

– discontinuation of activities enabling a full utilization of industrial, communal and other wastes, which are a rich source of scrap materials;

– discontinuation of steps aimed at the optimation of the spatial structure of the environment, especially the utilization of 'economies of the environment' as a stimulus to increase the efficiency of bioproductive economic activities;

– discontinuation of activities aimed at a full utilization of various raw materials;

– insufficient appreciation of the necessity to introduce a system of general envronmental education, which is a condition *sine qua non* of all activities leading to an improved quality of the environment and a proper exploitation of its resources.

The consequences of those 'discontinuations' expressed in economic terms are a relation between economies which could be gained and those which are gained at the current level of knowledge and all-economic possibilities. Therefore, they correspond, in large measure, to the notion of 'lost economies'. Losses which are incurred by the economy and the whole society as an effect of the discontinuation of optimizing activities are tremendous, whereas financial and material outlays are not very high since the majority of activities do not require any investment. When we approach the problem from the economic point of view, all investment in that direction would be highly profitable. Actually, however, it is not economy but socially conditioned determinants, which are a decisive factor contributing to the existence of those 'discontinuations'.

The presented attempt to systematize economic and social losses may facilitate assessment both in the regional as well as the national approach. Taking into consideration 'costs and benefits', both direct and indirect, and the effects of synergic influences we may determine in economic terms the significance of natural environment in regional economy with a much greater precision than this is possible when traditional methods are applied. To fill the proposed system with concrete matter requires, possibly not so much the construction of an adequate methodological apparatus, but the application of an efficient information system, of the monitoring type, in such a way that the bank could be permanently supplemented with new data. Contrariwise the character of all global assessments will be historical.

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GEOGRAPHIA POLONICA 52, 1986

ENERGY EXCHANGE BETWEEN THE ATMOSPHERE AND THE UNDERLYING GROUND AS A BASIS FOR AN ANALYSIS OF THE FUNCTIONING OF THE ENVIRONMENT

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1. INTRODUCTION

Energy exchange between the atmosphere and the underlying ground is an object of interest in many branches of physical geography. So far this exchange has been studied in the most detailed way as a basic climatogenic process, but, on the other hand, it is one of the most significant physicogeographical processes. The significance of that broader aspect of energy exchange was stressed by Armand (1980), Budyko (1974), Chorley and Kennedy (1971), Miller (1981) and others. This article treats the process of energy exchange between the atmosphere and the underlying ground as one of the most important processes which shape the temporal and spatial structure of the environment and determine the functioning of the environment. The notion of the functioning of the environment should be understood as the stability of a definite sequence of changes of different states of the environment under the influence of differentiated solar energy influx. This definition is close to the definition of the functioning of the environment proposed by many authors. For example, Blazhko et al. (1979) emphasize that the functioning is a process which transforms the environment, i.e. changes the number and degree of heterogeneity of components and relations occurring in that environment. Thus, functioning is a developmental process of the geosystem and determines its dynamics. The representation of energy exchange in the form of a map is a significant issue from the geographical point of view because it makes it possible to carry out a temporal and spatial analysis of this process.

2. THE AIM OF THE WORK

Earlier work on the construction of energy exchange maps had led to the working out of general theoretical assumptions of such maps and the construction of a number of topoclimatic maps. The construction of these maps was based on the assumption that a homogeneous physicogeographical spatial unit may be described by means of the heat balance characteristics (Paszyński 1963, 1964, 1968, 1973, 1983; Paszyński and Kluge 1973). The further research resulted in the working out of methods for direct delimitation of homogeneous spatial energy exchange units and suggestions on their terminology (Grzybowski 1981, 1983); it also produced characteristics of relations between different energy fluxes (Grzybowski 1984; Grzybowski and Itier 1984). The aim of this study is an attempt to apply these relations to estimating approximate quantities of different heat fluxes under the conditions of changing characteristics of the active layer (its moisture and the height and density of plant cover in the first place) at different types of weather in the course of the year. Field research cannot be the only basis for constructing maps of energy exchange since, in general, it represents quite an accidental period of research. It is difficult to measure the heat balance in a dozen or so or several dozen points with a stationary system. Hence, it is necessary to apply indirect methods which will make it possible to analyse variations of the spatial structure of the heat balance in diurnal and annual cycles and also those due to acyclic changes of solar energy influx.

The spatial differentiation of energy exchange between the atmosphere and the underlying ground is sharpest at clear wheather when wind velocity is low and soil moisture moderate. Such conditions, however, constitute only a small portion of all possible weather situations and do not take into account extreme situations such as long-lasting droughts and rains. An interpretation of the map of energy exchange with the help of relations between heat fluxes should make it easier to analyse the functioning of the environment under conditions different than those mentioned.

3. RELATIONS BETWEEN DIFFERENT COMPONENTS OF THE HEAT BALANCE OF ACTIVE SURFACE

The suggested method of estimating approximate quantities of different heat fluxes is the result of the assumption that the type of empirically stated relations between different heat fluxes does not change during the year. In other words, these relations can be represented in the form of a function for any twenty-four hours during the growing season. Research on relations between the turbulent flux of sensible heat and the net radiation and between the soil heat flux and the net radiation was carried out on the basis of the results of heat balance measurements made in different types of the geographical environment. A diagram of relations between different fluxes shown in Figs 1, 2 and 3 is a generalization of this research.

a. RELATIONS BETWEEN THE TURBULENT FLUX OF SENSIBLE HEAT AND THE NET RADIATION

The turbulent flux of sensible heat. i.e. the heat flux which exerts the strongest influence on the heating of surface boundary layers can be presented in the form of the formula

$$H = \varrho C_p K \frac{\delta T}{\delta z}$$

where ϱ is air density, C_p – specific heat, K – turbulent exchange coefficient, T – air temperature, and z – height of measurement.

The temperature gradient depends, on the one hand, on the quantity of the differential radiant flux and, on the other, on the properties of active surface itself, and in the first place, on its thermal and moisture characteristics and plant cover characteristics. A parameter which well characterizes those properties of plant cover which influence the quantity of the turbulent flux of sensible heat is roughness coefficient z_0. Its size depends on the height and density of plant cover and on wind velocity. An approximate length of roughness parameter may be derived from a formula which takes these elements into account or from a simple dependence $z_0 = 0.1h$ (where h is plant height), which is an oversimplification, however.

A soil property which causes changes in the intensity of turbulent flux H is sol porosity and, as a result of it, its moisture. Higher humidity on the ground suface results in heat losses for evaporation, which indirectly decreases the quantity of flux H. Rainfall also most frequently results in additional cooling down of suface bounary layers.

In this connection it is assumed that the quantity of flux H depends on the net raliation to the greatest extent, and, next, on roughness parameter, soil moisture, wnd velocity and sum of precipitation. (These values influence the temperature gradient taken into account in the formula.)

The first figure (Fig. 1a) refers to a theoretical situation when wind velocity V, roıghness parameter z_0 and diurnal sum of precipitation p do not change, while

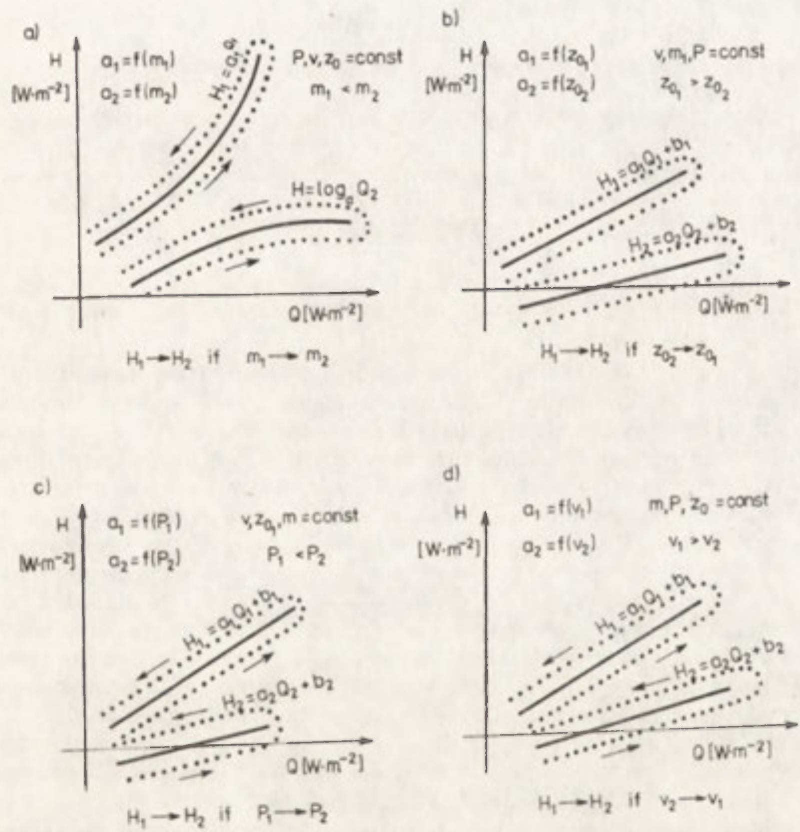

Fig 1. Relations between the turbulent flux of sensible heat H and the net radiation Q: v – wind velocity ($cm \cdot s^{-1}$), m – soil moisture (per cent of weight), P – diurnal sum of precipitation (mm), z_0 – roughness parameter (cm). Arrows show the direction of daily course of relations $H = f(Q)$

soil moisture m does change. When soil moisture is low, the diurnal variation of cornections $H = f(Q)$ approximates the power function. Steady increases of the net radiation Q are accompanied by growing increases of the turbulent flux of sensible heat H, which is connected with a loss of moisture in the ground and decreasing heat consumption for evaporation. An increase in soil moisture results in higher heat consumption for evaporation, and, therefore, increases in flux H are slight. The diurnal course of relations $H = f(Q)$ approximates the logarithmic function.

In Fig. 1b wind velocity, soil moisture and sum of precipitation are assumed to be constant. An increase in the roughness parameter results in an increase of flux H (this dependence was earlier described by K. Miara, 1975). The third diagram (Fig. 1c) is based on the assumption that the diurnal sum of precipitation is a variable, while the remaining agents are constant. An increase in the diurnal sum of precipitation causes a decrease in flux H, flux Q being usually little. The last figure (Fig. 1d) shows a situation when an increase in the quantity of flux H is related to an increase in wind velocity.

The diagram of $H = f(Q)$ relations refers to day-time. For night-time correlation coefficients are low and statistically insignificant. Correlation coefficients at day-time are highest under the conditions of unstable equilibrium.

b. DIAGRAM OF RELATIONS BETWEEN THE SOIL HEAT FLUX AND THE NET RADIATION

Heat exchange between the active surface and the ground primarily depends on thermal and moisture characteristics of the ground and the height and density of plant cover. The vertical soil heat flux can be described with the following equation

$$S = \varrho C_p \frac{\delta T}{\delta t} = \frac{\delta}{\delta z}\left(\lambda \frac{\delta T}{\delta z}\right)$$

where ϱ is soil density, C_p – its specific heat, T – temperature, t – time, z – depth, and λ – heat conduction.

The equation indicates that the basic factors influencing the quantity of soil heat flux and soil temperature and its heat conduction or heat capacity. The greatest influence on variation of these components is exerted by soil moisture. The quantity of soil heat exchange is also influenced by rainfalls. Cool rain water falling on the relatively warm underlying ground may lower its temperature, while its fast evaporation results in additional losses of energy from active surface. The plant cover decreases the influx of solar radiation, which makes the ground surface be less heated. In this connection the following factors are considered to have the greatest influence on the quantity of heat exchange with the ground, next to the net radiation: soil moisture, diurnal sum of precipitation and height and density of plant cover. These factors are taken into account in the diagram of relations $S = f(Q)$ shown in Figs 2 and 3. We assumed, however, the constant density of plant cover – maximum for each class of plant in the growing season.

The first figure (Fig. 2a) shows a decrease in soil heat flux when the diurnal sum of precipitation increases, while the second one (Fig. 2b) shows a decrease in this flux connected with an increase in the height of plant cover. Figure 3 presents the diurnal variation of relations $S = f(Q)$ under the conditions of changing soil moisture. The first figure (Fig. 3a) refers to dry ground which gets warm quickly and quickly loses heat (compare directions of arrows representing the diurnal course of flux S). The second figure (Fig. 3b) presents a situation when moist soil gets warm slowly in morning hours but owing to increased heat capacity, loses heat slowly. The function $S = f(Q)$ is presented by the elliptic equation. The diagram in its general form applies to both day- and night-time.

These diagrams are very simplified and can be applied only to flat areas. Appropriate corrections should be introduced with regard to sloping areas. Functions $H = f(Q)$ and $S = f(Q)$ have been based on results of research carried out between 40°N and 55°N with the diurnal sum of precipitation $P < 2$ mm and wind velocity $v < 5\,\mathrm{m \cdot s^{-1}}$. Therefore, the diagram is true only under such conditions. It is based on measurements of heat fluxes made every hour or even more frequently, and, thus, it may be applied only with regard to temporal values of components of the heat balance.

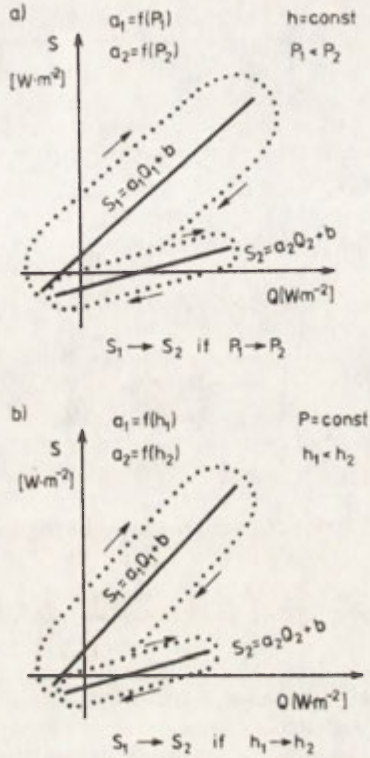

Fig. 2. Relations between the soil heat flux S and the net radiation Q when the assumed soil moisture is constant: h – height of plant cover (cm), P – diurnal sum of precipitation (mm)

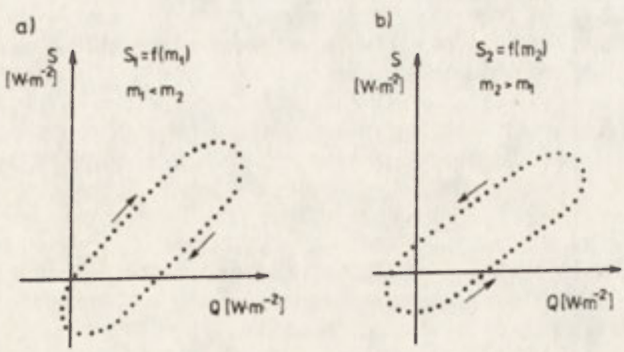

Fig. 3. Variation of the diurnal course of function $S = f(Q)$ under the conditions of changing soil moisture m when the assumed height of plant cover is constant

4. INTERPRETATION OF MAPS OF ENERGY EXCHANGE ON THE BASIS OF THE DIAGRAM OF RELATIONS BETWEEN HEAT FLUXES

The method of constructing maps of spatial units of energy exchange, i.e. energotopes and complexes of energotopes, is presented on the example of the Biebrza Basin (Grzybowski 1980, 1983, 1984). The author defines the complex of energotopes as an area of a relatively homogeneous structure of the active layer where differences in the structure of the heat balance are due exclusively to diurnal and annual variations of solar energy influx. The scale from 1 : 25 000 to 1 : 100 000 – and maps of energy exchange were most frequently made by the author for such scales – is proper for delimiting complexes of energotopes. It is admissible that in the complex of energotopes slight differences occur in the spatial structure of the heat balance, stemming from the local variation of some properties of the active layer. Complexes of energotopes are delimited by means of an analysis of mostly inclination and exposure of slopes, soil porosity, humus content, type of water circulation and the height and density of plant cover. Differences in mineralogical composition of soil do not play any major role under the conditions of the Polish Lowland. Therefore, the analysis takes into account those components of boundary layer which influence relations $H = f(Q)$ and $S = f(Q)$ to the greatest extent.

On the basis of such a map of complexes of energotopes it is possible to describe physical properties of the active surface. We may optionally assume the quantity of the net radiation, wind velocity and diurnal sum of precipitation, thus determining the type of weather at which the diurnal structure of the heat balance is of interest to us. Starting from the assumption that a definite angle of inclination of functions $H = f(Q)$ and $S = f(Q)$ corresponds to the quantity of different characteristics of the active layer (soil moisture, plant height, etc.), we may estimate the approximate quantity of S and H fluxes.

At the present stage the model is of a general character. It is still necessary to apply relative definitions of quantities of different heat fluxes. Bigger or slighter deviations from average conditions will indicate oscillations of different fluxes in different types of the active layer and under meteorological conditions different from the so-called 'radiational' ones. The reference surface for these oscillations is still the standard surface. Further research is aimed to express these dependences in the form of empirical formulae.

5. CONCLUSIONS

These considerations show that the proposed method of analysis of the structure of the heat balance in different types of the geographical environment and under different meteorological conditions consists in modelling this structure. The legend to the map includes the characteristics of physical properties of the active surface and model of relations between heat fluxes which is the key to reading the approximate structure of the heat balance under optionally assumed meteorological conditions.

Field measurements of the structure of the heat balance may be the basis for preparing a general diagram of occurrence of different types of structures of the heat balance at different types of weather and under different natural conditions. The results of field measurements may also provide an illustration to the map based on the field mapping of the active surface.

These considerations are of a methodical character. They may provide the basis for analyses of the diurnal course of heat exchange at different stages of the growing season and analyses of relations between the energy balance and matter shifts.

Thus, the map of spatial units of energy exchange and the topoclimatic map are not identical. but the former may provide a basis for analyses of relations in the geosystem and their cyclic variations. Homogeneous spatial units of heat exchange are practically geocomplexes delimited from the point of view of the process which connects all the components of landscape.

The analysis of physicogeographical processes from the point of view of energy exchange between the atmosphere and the underlying ground is a peculiar 'selective photograph' of the mechanism of landscape formation. The duration and intensity of all physicogeographical processes depend on the intensity of this exchange in diurnal and annual cycles and on acyclic changes of radiation energy influx. Therefore, it seems justified to analyse the process of energy convertion from radiation energy into heat energy as a fundamental process which determines landscape functioning.

The map of energy exchange as the basic climatogenic factor has been applied in practice in spatial planning (Paszyński 1983). The version of the map of energy exchange suggested in this article may be also used for making maps of estimated natural conditions for the needs of planning. The method of the map's construction makes it possible to avoid mistakes committed when overlaying maps of different components of the environment on one another, which is generally done in practice. An analysis of the map of energy exchange makes it possible not to lose sight of relations and dependences in the geosystem which are frequently missed at the 'overlaying' method.

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GEOGRAPHIA POLONICA 52, 1986

GEOMORPHOLOGICAL EVOLUTION OF SELECTED MOUTH SECTIONS OF THE LOWER VISTULA RIVER TRIBUTARIES IN THE LATE GLACIAL AND HOLOCENE

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INTRODUCTION

Valleys of the rivers of the Polish Lowland have already been dealt with in numerous geomorphological studies (Lencewicz 1927; Galon 1934, 1953, 1961, 1968; Kozarski 1962; Kozarski and Szupryczyński 1958: Niewiarowski 1968; Wiśniewski 1976 and others). However, the above compilations discuss chiefly single valley forms and are mostly intended to describe their Pleistocene history against the progressing recession of an ice sheet. A lot of valuable results are available in this respect. On the other hand, there are no detailed studies concerning the problem of the Late Glacial and Holocene evolution of valleys understood as river systems comprising tributaries and their parent river. The present paper is intended to fill in the gap. Its objective is to present interrelationships in the development of three mediumsized tributaries of the Vistula river, i.e. the rivers Zgłowiączka, Mień and Tążyna, against the common local baselevel, i.e. the Vistula. that remained changeable, especially in the Late Glacial (Fig. 1). Several-year geomorphological studies carried out within the above valleys were concerned with the identification of factors contributing to similarities and differences in the mode of development of those valleys, and with the tentative reconstruction of the operation and general nature of fluvial processes on the Vistula.

The above problem presented in outline is undoubtedly a complex one since as yet no complete information has been provided concerning the response of a tributary to a variety of alterations in the valley of the trunk river. Much controversy is also caused by general trends in the operation of fluvial processes at the time interval between the glacial and interglacial. especially by a question of the beginning of phases of fluvial erosion and deposition (Soergel 1921; Penck 1938; Jahn 1956; Schumm 1965; Galon 1968). The above problem has been tackled in more detail by Kozarski and Rotnicki (1978).

The present author carried out studies of the lower parts of the valleys, i.e. their portions developed within terraces along the Vistula valley as far as the plateau. The compilation of a detailed geomorphological map at a scale of 1 : 10,000 was based on air photos. Structural-textural analysis was made of genetically varying valley fills.

This study deals largely with the Zgłowiączka valley where a wider range of investigations were carried out. Besides a detailed geomorphological-sedimentological study, they included the dating of organic sediments by means of the palynological analysis and radiocarbon method.

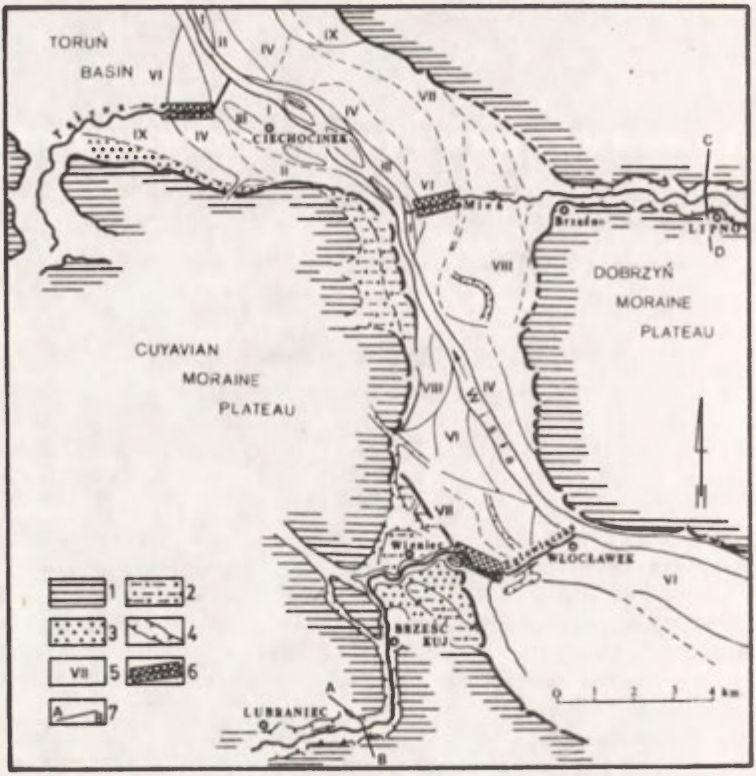

Fig.' 1. Schematic sketch-map showing the studied valley mouth sections against general morphology of the Vistula valley (after Wiśniewski): 1 — morainic plateau, 2 — erosional levels of meltwater, 3 — meltwater levels with glaciofluvial sedimentary cover, 4 — subglacial channels modified by meltwater and river water, 5 — terrace numbers in the Vistula valley, 6 — valley fragments presented in the paper, 7 — location of geologic sections

MORPHOGENETIC CHARACTERISTICS OF THE STUDIED VALLEY REACHES EXTENDING THROUGH MORAINIC PLATEAUX

The Zgłowiączka river is the greatest left-bank tributary joining the Vistula between the Warsaw Basin and the Toruń Basin. Its valley remains a prominent relief detail in southern Kujawy. It extends from Głuszyńskie Lake to Włocławek where it enters the Vistula. The Zgłowiączka valley that is about 55 km long consists of three morphogenetically different sections (Andrzejewski 1984). The upper reach, that is the longest one and represents over 50 per cent of the whole valley length, is a subglacial channel. The middle reach extending across the depressed portion of the Kujawy Plateau to the north of Brześć Kujawski is most likely to locate along the axis of small-sized troughs which were liable to major changes in response to meltwater and river flow. It is just the 10 km long mouth section of the valley, running in the Vistula valley, that is the valley proper formed completely by the Zgłowiączka river.

Valley levels and isolated hills composed largely of silts and fine sands can be identified within the trough. They have been classified as kame terraces and hills (Fig. 2). The basis for this classification is provided by the reconstruction of the

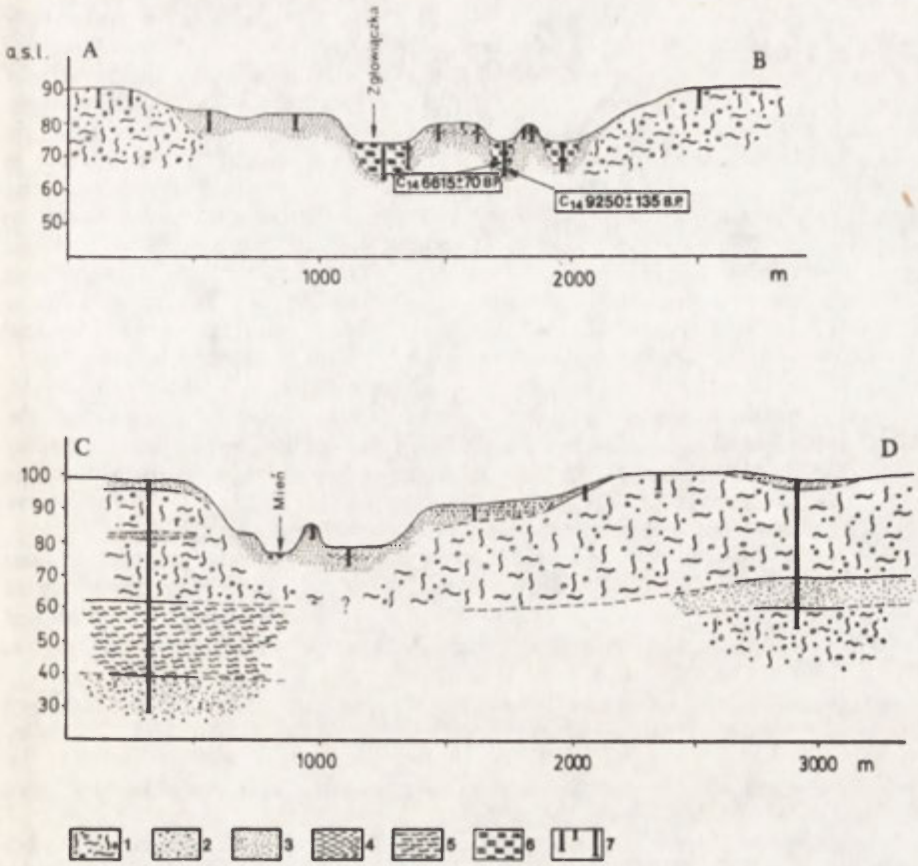

Fig. 2. Geologic sections through the subglacial channel portions of the valleys Zgłowiączka and Mień: 1 – till, 2 – vari-grained sands, 3 – fine sands, 4 – silts, 5 – clays, 6 – peats, 7 – boreholes

environment of sedimentation of the above deposits by means of detailed structural-textural analysis (Andrzejewski 1984). The above forms developed simultaneously in hollows and crevasses in the trough ice-fillings. Ice degradation ceased to operate at the close of the Late Glacial, as can be inferred from the date of 9250 ± 135 BP (Gd-1155) available for the base of the organic sedimentary fill of the trough. The above fact is of principal significance for paleohydrological reconstructions in the mouth section of the valley since ice masses filling in the trough probably served for a long time as a source of extra quantities of water affecting the floor morphology below the trough.

The Mień river valley, the length of which is 50 km, also cuts through forms foreign to subareal erosion on the Dobrzyń Plateau. It joins the Vistula at a distance of 30 km to the north of the Zgłowiączka mouth (Fig. 1). A detailed geomorphological study was made of its western part from the Mień mouth to Lipno. This part comprises a 15 km long valley reach cut in the Vistula terraces and a 10 km long reach situated within the escarpment of the Dobrzyń Plateau.

The Mień valley cuts as deep as 20–25 m into the plateau. Its maximum width approaches 2 km. Numerous levels consisting of sand-gravel material can be identified along this valley reach. The uppermost level that is 92.5 m a.s.l. high is particularly prominent in vicinity to Lipno. At the contact with the Vistula valley near Brzeżno, it becomes lowered to an altitude of 80 m a.s.l. Two lower levels, the heights of which are 87 and 81 m a.s.l., are minor and extend locally. Besides the above levels, numerous convex forms with varying heights that become lowered westward are present in the floor of the plateau valley reach. The uppermost level that is cut in upper till (Fig. 2) varies in geologic structure. Sand-gravel deposits remain dominant there but there are very fine sandy-silty sediments and thin clay intercalations in many localities. Their structural-textural properties indicate that periods of sand and gravel deposition were interrupted by water stagnation of short duration. During the deposition of glaciofluvial sediments such a situation as that described above might have occurred in a developing meltwater valley extending along the subglacial channel that represented the best location for meltwater streams.

The geologic structure of lower levels which extend locally and vary in height, as already mentioned, resembles that of convex forms found in the floor of the studied valley reach. The sediments among which fine sands and silts prevail display a high degree of homogeneity. In the present author's opinion, their deposition can be linked to sedimentation in hollows in the trough ice-fillings. At the subsequent stage of development of the trough, the Mień river flowed through it.

The morphology of the Mień and Zgłowiączka valleys on the plateaux remains thus unrelated to the action of these rivers. As already established, they ran in genetically different forms such as the above subglacial channels. The above established relationship also receives confirmation from the third of the analysed valleys, i.e. the Tążyna river valley.

As opposed to the Zgłowiączka river, the Tążyna river drains the north-eastern part of the Kujawy Plateau and enters the Vistula below Ciechocinek. Its valley has already absorbed the attention of geomorphologists who are chiefly attracted to the study of its role in carrying down meltwater during deglaciation of that area (Niewiarowski 1968, 1983; Wiśniewski 1976).

Within the escarpment of the Kujawy Plateau, the Tążyna crosses a 3–4 km wide extensive depression where four streamflow levels can be identified. From the geomorphologic setting and the relationship between the levels and the mouth section of the Tążyna valley cut in the Toruń Basin terraces, it can be inferred that merely the origin of the lowest level out of the above mentioned ones can be linked to the development of the mouth section of the Tążyna valley. That level which is 70–72 m a.s.l. high represents the floor of the above depression. The formation of upper terraces and thus, that of the extensive depression occupied by the Tążyna is the result of meltwater and streamwater release due to deglaciation within the plateau and due to first contributions of runoff from the Toruń Basin.

THE OPERATION OF FLUVIAL PROCESSES IN THE MOUTH SECTIONS OF THE STUDIED VALLEYS LOCATED IN THE VISTULA VALLEY

Somewhere to the east of Wieniec, the Zgłowiączka river leaves the depressed area of the Kujawy Plateau and cuts into terraces along the Vistula valley, first into terrace VII and finally, into terrace VI (Wiśniewski 1976). The terrace correlates with the level of the floodplain in the Płock Basin. According to Skompski (1969), the floodplain dates as far back as to the Oldest Dryas. Thus, it may be assumed that at the beginning of the Late Glacial the Zgłowiączka valley reach began to develop. The valley slopes that are 5–6 m in height are steep there. The variable valley width approaches 900 m. Such a great width of the valley, the slopes of which are meander-shaped in plan geometry, is indicative of a prolonged cycle of uninhibited action of the Zgłowiączka. This process is still taking place, as can be inferred from intense and free development of the present-day meandering river (Fig. 3).

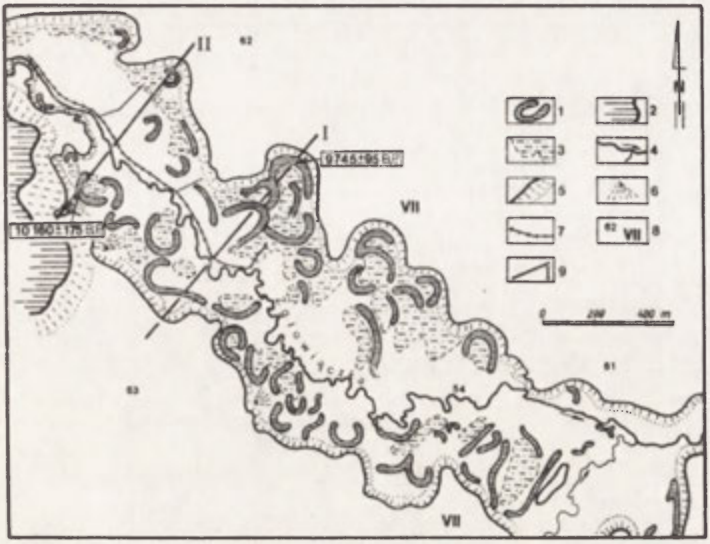

Fig. 3. Fragment of the valley floor at the mouth of the Zgłowiączka: 1 – paleomeanders, 2 – morainic plateau, 3 – upper floodplain, 4 – present-day Zgłowiączka channel, 5 – valley slopes, 6 – alluvial fans, 7 – protection dikes, 8 – Vistula terrace numbers, heights in m a.s.l., 9 – location of geologic sections

The morphologic characteristics of the valley floor along that reach are two levels, i.e. the floodplain and the upper floodplain, differing in height by up to 2 m. Well-formed paleomeanders with varying geometric parameters add to a variety of relief details at those levels. The paleomeanders are largely filled with 2–3.5 m thick peat that is frequently underlain by a thin layer of gyttja.

Dates are available for organic sediments at one of the bends undercutting directly the valley slope. The underlying gyttja at a depth of 2.30–2.35 m yields the age of 10160 ± 175 BP (Gd-1156) that points to the Younger Dryas as the onset of organic sedimentation (Fig. 4). Thus, it can be roughly stated that the bend was developed during the Alleröd at the latest although it cannot be excluded that it might have formed earlier. The age of organic sediments at the other bend on the floodplain on the opposite side of the river is 9745 ± 95 BP (Gd-1153). This implies that the above meander became filled with sediments at the beginning of the Pre-Boreal and hence, it might have developed at the close of the Late Glacial, i.e. during the Younger Dryas. The analysis of elevations of filled paleomeander bottom positions has also provided interesting data (Fig. 4). Their gradual lowering towards the central portions of the valley floor is indicative of erosive action of the meandering river. Note should be made that no traces of the action of a braided river have been detected along the studied section of the Zgłowiączka valley floor.

The analysis of geologic structure of the valley floor shows its vertical stability of the latest part of the Holocene and probably, the effects of intensified aggradation processes within it. The presence of increasingly thicker silty-clayey alluvium in the lowest floor portions can be linked to that (Fig. 4).

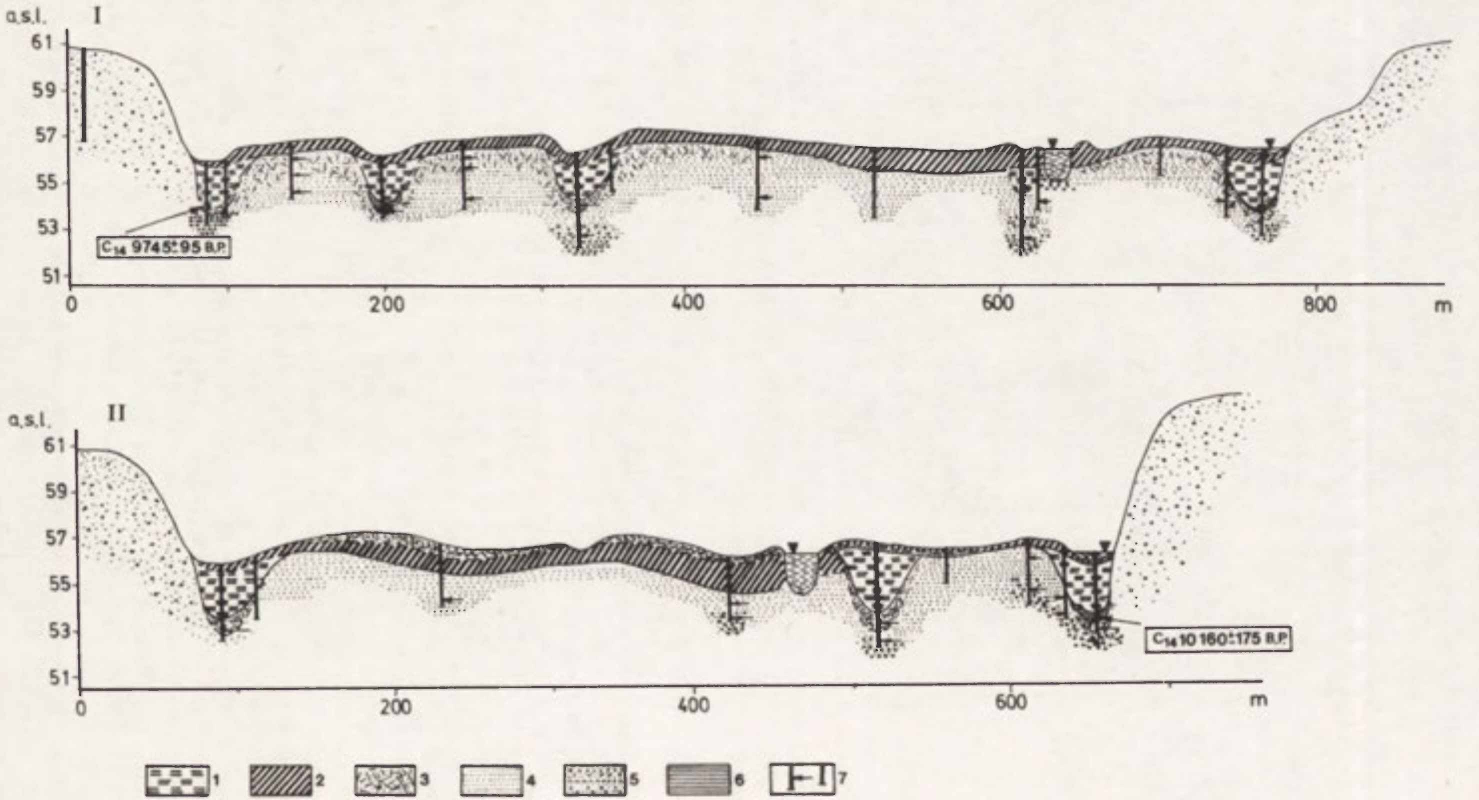

Fig. 4. Geologic sections in the floor of the Zgłowiączka valley mouth section: 1 – peats, 2 – sediments of flood facies, alluvial clays, 3 – fine sands of flood facies containing organic particles, 4 – fine sands, 5 – vari-grained sands, 6 – gyttja, 7 – boreholes and sampling sites

The analysis of geometric parameters of the paleomeanders and their comparison with the shape of the present-day Zgłowiączka meanders (Table 1) indicates a marked reduction in their values throughout the period between the close of the Late Glacial and the present time. This inference receives confirmation from the studies of Kozarski and Rotnicki (1978), Szumański (1972, 1981), Mycielska-Dowgiallo (1972) and Falkowski (1975).

TABLE 1. Mean and extreme values *m* of selected geometric parameters for 25 paleomeanders and present-day meanders alongside the mouth section of the Zgłowiączka valley

	W		*R*		*L*/2		*A*/2	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*
Paleomeanders	24.8	32–18	60.3	115–30	99.2	185–49	79.6	120–42
Present-day meanders	8.8	12–7	17.0	22–10	33	50–16	24.5	36–12

W – mean channel width, *R* – mean radius of curvature of meander, *L*/2 – half the wavelength of meander, *A*/2 – half the amplitude of meander, *a* mean values, *b* extreme values

An explanation for the causes of variations in the size of meanders should not only be provided by paleoclimatic reconstructions and those of the hydrological regime, but also by a better understanding of relationships between geometric parameters of bends and hydrodynamic conditions of the channel. Many authors, including Leopold, Wolman and Miller (1964), expect a close correlation to exist between the cross-sectional form of the channel, i.e. its width and depth, together with radii of curvature, and mean annual discharge. Additional factors such as the kind of debris and the mode of its transport, or the geologic structure of channel banks complicate the above relationship (Schumm 1968). However, it can be widely recognized that the greater the meander bends, the higher the discharges are. The analysis of some relations between geometric parameters of the greatest meanders shows that the former discharge was about 10 times greater than the present discharge that is about 2.55 m^3/s. The greater discharge of the close of the Late Glacial may have not only been the effect of climatic conditions, i.e. the amount of precipitation and its contribution to runoff, but also, it may have been linked to water contributions due to the melting out of the remainder of the trough ice-fillings. At that time the trough already contributed to the uniform runoff to the Zgłowiączka valley.

The Mień and Tążyna valleys cut into a series of the Vistula terraces at their mouths over a distance of about 15 km (Fig. 1).

The Mień cuts its course 8 to 10 m into bedrock, forming a wide valley with meander-shaped slopes in plan geometry, as is the case with the Zgłowiączka (Fig. 5). Two major terraces can be identified within the valley, i.e. the present-day floor with fragments of the upper floodplain and a terrace lying 3–4 m over the floor. The latter remains dominant in the valley morphology. The relief features of that terrace comprise paleochannels of a meandering river with geometric parameters approaching those specified above for the Zgłowiączka valley. Paleochannels of a meandering river though considerably smaller in size, can also be traced in the lowest floor of the Mień valley. Thus, there are two age generations of meanders. It can also be inferred that discharge of the studied river was decreasing gradually at the time interval between the close of the Late Glacial and Holocene.

The Tążyna, the third of the studied rivers, formed at its mouth a valley with geomorphological characteristics similar to those of the Zgłowiączka and Mień valleys. Its reach located at terrace IV of the Vistula (Fig. 5) and numerous traces of an intensely meandering river through it are particularly indicative of nearly the identical operation of fluvial processes within the studied valley mouths. It also appears that the above parts of the valley mouths (Figs 3 and 5) may have formed synchronously.

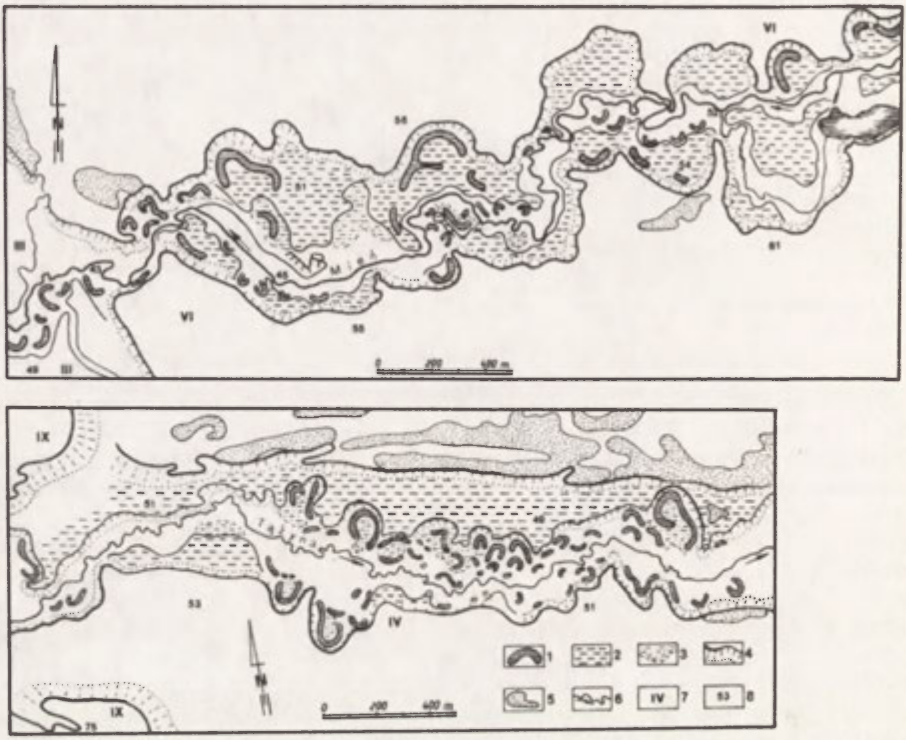

Fig. 5. Fragments of valley floors at the mouths of the valleys Mien and Tązyna: 1 — paleomeanders, 2 — upper terraces, 3 — upper floodplain, 4 — valley slopes, 5 — dunes, 6 — present-day channels, 7 — Vistula terrace numbers, 8 — heights in m a.s.l.

SOME RELATIONSHIPS BETWEEN THE EVOLUTION OF FLUVIAL PROCESSES AT EACH OF THE STUDIED VALLEY MOUTHS AGAINST CHANGES IN THEIR COMMON LOCAL BASELEVEL

The common feature of the studied valleys is that two reaches of basically varying origin can be identified on their course. The rivers flow through forms of glacial origin within the plateaux, resulting in their modification to a lesser or greater degree. The river valleys proper function merely within the Vistula valley terraces. Their development began as late as at the beginning of the Late Glacial and the basic developmental stage ended as early as at its close. This can be inferred from the dates available for the Vistula terraces (Skompski 1969; Drozdowski 1974; Drozdowski and Berglund 1976; Wiśniewski 1982; Tomczak 1982). Intense erosion and the Late Glacial lowering of the Vistula level can be linked to its course of gap sections, first from the Plock Basin to the Toruń Basin (Wiśniewski

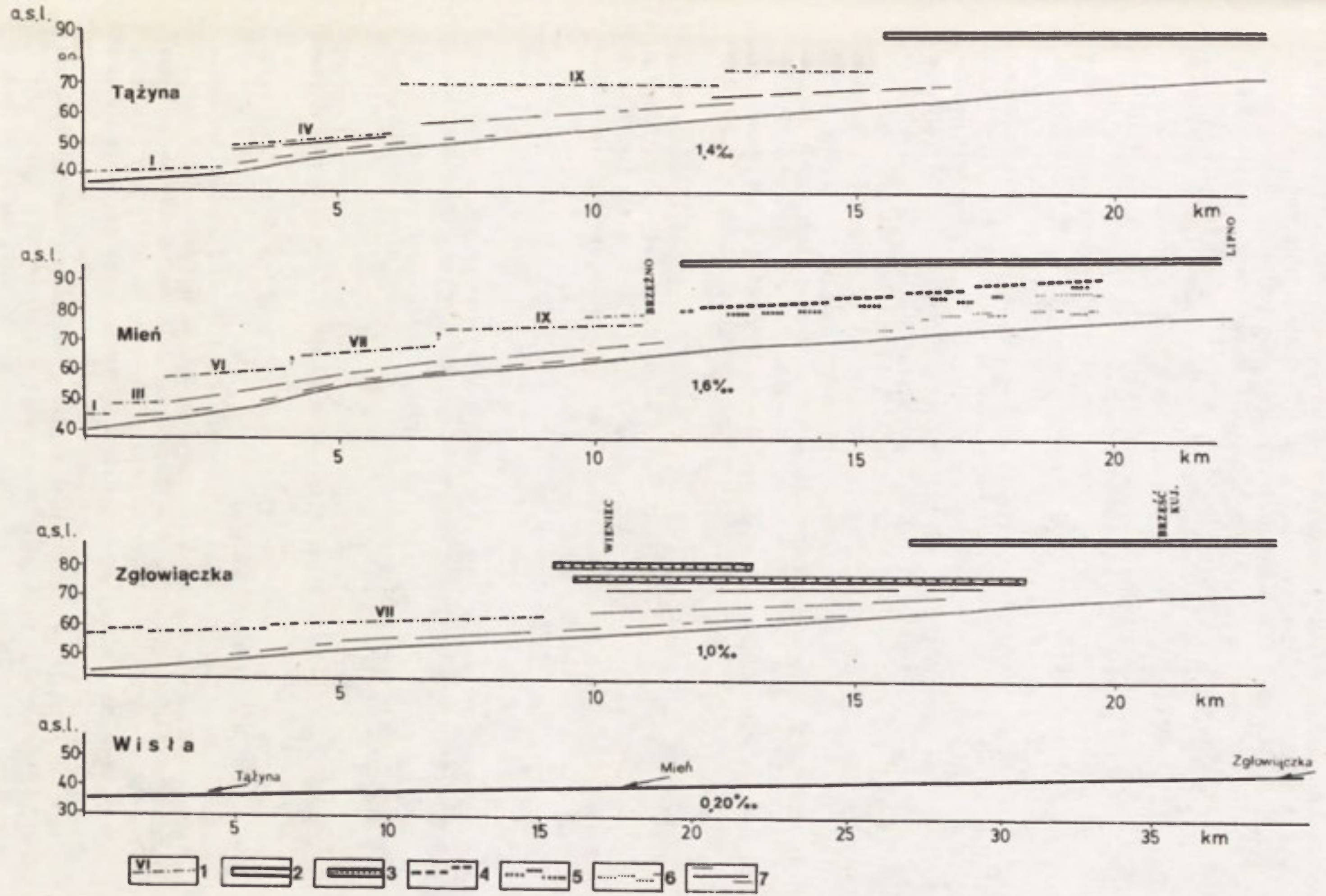

Fig. 6. Longitudinal profiles of the studied valleys against the Vistula valley: 1 – Vistula terraces, 2 – plateau level, 3 – depressed plateau levels near Wieniec, 4 – erosional levels of meltwater, 5 – kames, 6 – kame terraces, 7 – erosional-depositional terraces

1976) and next, northward to Baltic Ice-Lake. Those factors produced equally intense backward erosion at the mouths of the rivers Zgłowiączka, Mień and Tążyna.

From the analysis of longitudinal profiles of the studied rivers (Fig. 6), it can be inferred that a number of terraces does not increase towards their mouths, as in case of many other valleys of the Polish plains. This is due to the fact that the valleys of the above rivers developed gradually towards the mouths and became longer as the Vistula level was increasingly lower. Thus, erosional tendency in upstream reaches of the tributaries was partly eliminated by a reverse process associated with the elongation of valleys towards their mouths.

The rivers assumed a meandering course along the valley mouth sections from at least the Allerod. This can be inferred from the dates available for organic sediments in the Zgłowiączka valley and from similar morphologic-lithological characteristics of the valley floors, especially in the case of the Zgłowiączka and Tążyna valleys. The situation is somewhat different in the case of a right-bank tributary of the Vistula, i.e. the Mień, where paleomeanders with geometric parameters similar to those of the greatest paleomeanders of the Zgłowiączka and Tążyna lie above the upper floodplain level that is 50–69 m a.s.l. high (Fig. 5). It thus appears that at the same time the erosional tendency of the Mień was greater than that of the Zgłowiączka and Tążyna. At the present time the process is reflected in steeper slope of the Mień valley floor, $1.6^{0}/_{00}$, as opposed to the Zgłowiączka and Tążyna slopes (Fig. 6). These differences result from a considerably higher elevation of the Dobrzyń Plateau surface, i.e. by 10–15 m, compared with the Kujawy Plateau. Thus, the same erosional tendency associated with the lowering of the Vistula level produced more intense erosion in the right-bank tributary (Mień), as opposed to the left-bank tributaries (Zgłowiączka and Tążyna).

No traces of frequent vertical changes in the river level and associated cycles of erosion and deposition have been detected within the studied valleys. Erosional tendency of the studied rivers, which was particularly intense in the Late Glacial, diminished during the Holocene. At the close of the Holocene the valley floors became gradually stabilized vertically.

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DRAINAGE DENSITY AS AN INDEX OF THE RATIO OF BASE FLOW TO TOTAL RUNOFF

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INTRODUCTION

Hydrological models can be applied to predict phenomena occurring within investigated basins or they can be used for evaluation of various hydrological characteristics within ungauged basins. Many works treated drainage density as an index for runoff modelling. This index has been viewed as useful because it is an integrative index reflecting physiographic characteristics of a basin (lithology, relief, soil, plant cover).

The studies to date show that there exist many, sometimes even contradictory approaches to the relationship between runoff characteristics and drainage density. These approaches can be summed up in a following way: Some authors *make correlations* between drainage density and:

– mean annual flood or flood peak (Hadley and Schumm 1961; Gregory and Walling 1968),

– mean annual runoff (Hadley and Schumm 1961; Gregory and Walling 1968),

– base flow (Carlston 1963; Trainer 1969; Gregory and Walling 1968; Orsborn 1970).

Other authors state that there is *no correlation* between drainage density and:

– mean annual flood or flood peak (Bigwood and Thomas 1955; Dingman 1978),

– mean annual runoff (Hidore 1965; Dingman 1978),

– base flow (Dynowska 1976; Dingman 1978).

Drainage density reflects the integrated action of *factors determining base flow*. These factors are:

– permeability and water capacity of the soil and rock type i.e. the less permeable the soil and rock type, the lower the water capacity and less water infiltrates, therefore the drainage density is higher;

– relief differentiation i.e. the more differentiated the relief, the steeper the slopes, the higher the overland flow velocity and the resulting drainage density;

– amount of rainfall i.e. the more water comes from rain the better developed river network;

– land use.

Therefore drainage density can be treated as an index of infiltration capacity.

The following *theoretical assumptions* are made relating base flow to drainage density. The higher drainage density:

– the higher is the surface runoff,

– the higher is the velocity of surface runoff,

– the more rapid is the occurrence of floods,
– the flood peak is higher,
– the less water infiltrates,
– the lower is the base flow.

The *aim* of this paper is to present the application of drainage density exclusively for *evaluation of the mean ratio* of base flow to total runoff, or in other words, the share of base flow in total runoff, *within ungauged basins*. Only a few basins, especially those of small areas have been observed long enough to evaluate the mean outflow, including base flow. In majority of small drainage basins the outflow has not been measured. For this reason it would be useful to find a relationship between base flow and a parameter, by origin bound to base flow. Drainage density can be considered such parameter. In this paper drainage density has not been used as an input for rainfall-runoff modelling, so it can be treated as a static parameter.

Knowledge of the ratio of base flow to total runoff may have practical applications. On the basis of this ratio it is possible to, indirectly, estimate water resources. The higher the ratio, the less variable the discharges and the lesser the droughts.

METHODOLOGICAL DIFFICULTIES

Methodological difficulties may arise concerning:
– methods of base flow estimation,
– methods of drainage density estimation.

Base flow can be evaluated by many methods, none of which is satisfying. The most frequently applied method is the graphic separation of the hydrograph of daily discharges into surface runoff and base flow. In this method there are various ways of marking the dividing line between surface and base flow. Results obtained for moderate climates are probably too high since after this method, water from subsurface flow is taken into account. In this paper Kille's method (1970) was applied. In this method data of lowest monthly discharges were arranged in the order of magnitude and on this basis base flow was estimated.[1]

The values of base flow calculated by this method are lower than the values obtained by graphic separation of the hydrograph of daily discharges. It can be assumed that only water from the saturation zone is taken into account.

Methodological difficulties arising during *drainage density* (D_d) *estimation* are discussed below. This difficulties are pointed out by many authors. Drainage density is most frequently expressed by division of the length of all watercourses (L, km) by area of the drainage basin (A, km^2); $D_d = L/A$. Difficulties arising during estimation of length of watercourses can be summed up in a following way:

– The estimated total length of the watercourses depends upon degree of generalization of a map, which is usually related to the scale. The estimated length is shorter than the existing one. More precise length of watercourses can be estimated from field measurements and/or from air photographs which are sometimes difficult to obtain.

– There is a question of length estimation for cremulating rivers and for rivers anastomosis. It is not decided if drainage ditches should be taken into account.

– There is a question of the range of the watercourses, the small watercourses are equally ranged with the large ones.

– The total length of the watercourses within the drainage basin may vary over time. During times of drought watercourses may be less numerous and shorter than during times of rain.

[1] I do not discuss the method in detail as it is irrelevant for further consideration.

In spite of these objections the drainage density is a frequently applied parameter in hydrological studies. It is especially convenient for the evaluation of base flow. The application of drainage density as an index parameter has one more advantage, it can be easily obtained from topographic maps.

Drainage density as an index of the ratio of base flow to total runoff was examined on the example of the upper Vistula basin.

Drainage density within the upper Vistula basin was estimated from measurements of the blue streamlines on topographic maps having a scale of 1 : 25000 and the measurements were made using the same methodological assumptions. Uniform method of watercourses estimation and uniform level of generalization of topographic maps make the results comparable.

DISCUSSION

I have found that there is no correlation between drainage density and base flow expressed in absolute units as was stated by C. W. Carlston (1963), K. J. Gregory and D. E. Walling (1968) and F. W. Trainer (1969). The correlation between drainage density and base flow observed by these authors resulted from low differentiation of rainfall within investigated basins. Lithology and land use were the main differentiating factors. In my opinion the correlation between base flow and drainage density is satisfactory only within such areas where the water supply from rainfall is not spatially differentiated. It limits the practical application of drainage density for evaluation of base flow.

The same opinion is expressed by S. L. Dingman (1978). He questions not only the application of drainage density as a parameter for hydrological models in general, but also the application of drainage density for the evaluation of base flow.

I have observed a satisfactory correlation between drainage density and the share of base flow in total runoff. The same conclusion was drawn by J. L. Paszczyk (1975). This opinion is contrary to the one expressed by S. L. Dingman (1978), who questioned such dependence.

V. Gardiner and K. J. Gregory (1982) believe that besides drainage density such factors as channel size, channel relief and channel roughness should be taken into consideration. Unfortunately these data are difficult to obtain since they require separate survey. For this reason they cannot be used as parameters for most rivers.

Recent literature suggests the use of drainage density as a parameter varying over time. The aim of this paper is not, however, the estimation of applicability of drainage density for prediction of base flow volume, but only the estimation of the *mean* ratio of base flow to total runoff in its *spatial* differentiation.

RESULTS

The correlation between base flow and drainage density was calculated considering 17 basins in the upper Vistula drainage basin. The area of each basin does not exceed 1000 km². The runoff within these basins was not influenced by man's activity; the runoff data were obtainable for the period 1951–1970.

The best correlation between the share of base flow in total runoff is represented by the regression curve in logarythmic function. The regression equation is as follows

$$y = 38.64 - 18.65 \ln x$$

where y – ratio of base flow to total runoff in per cent,
x – drainage density, km/km².

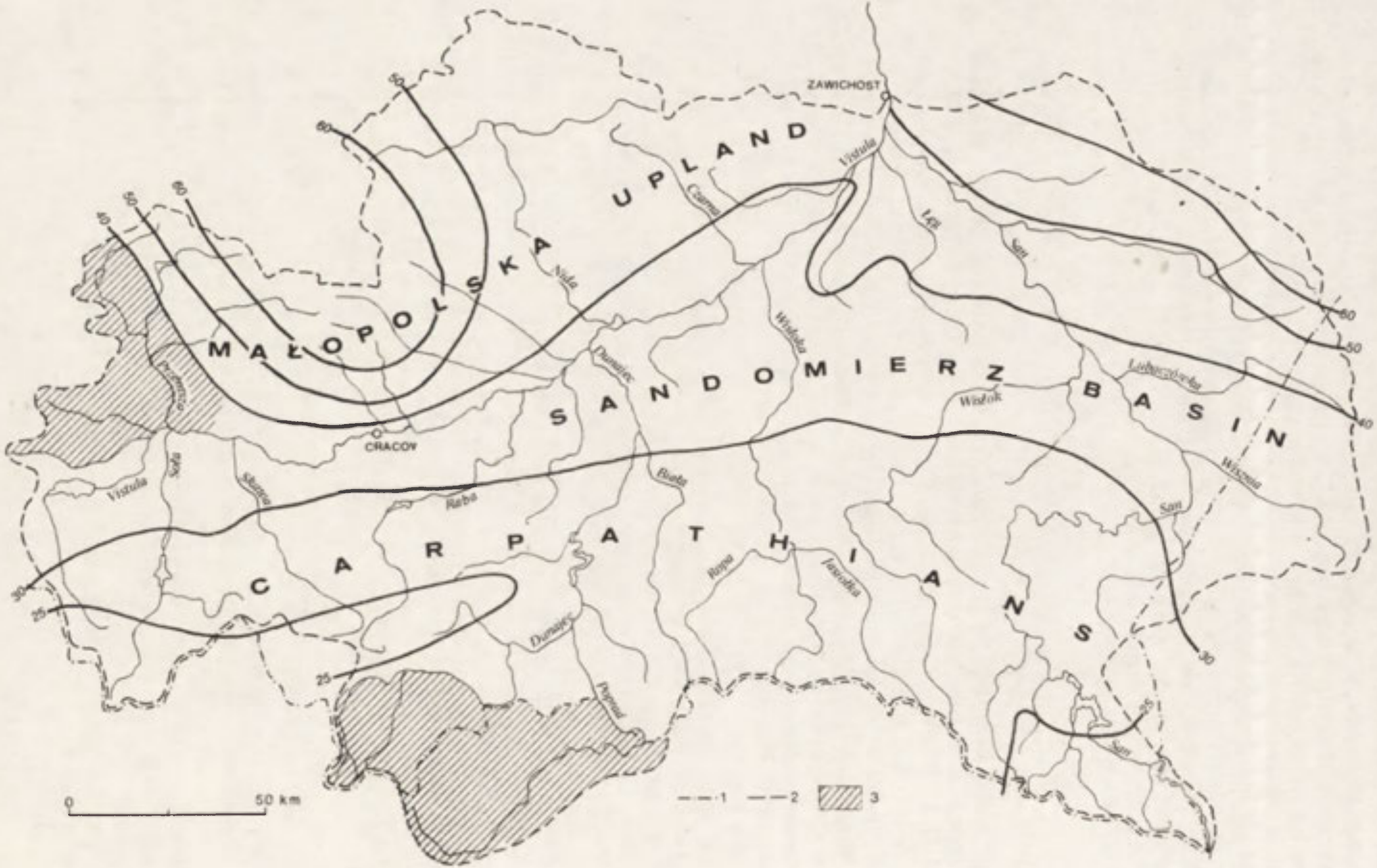

Fig. 1. Upper Vistula drainage basin. Ratio of base flow to total runoff (in per cent): 1 – state boundary, 2 – divide of the Upper Vistula drainage basin, 3 – areas not investigated

The correlation is rather a precise one because the coefficient of correlation is $r = 0.89$ and is significant at a 0.1% level. The standard error in estimation of the ratio, expressed by per cent, equals 4.63.

On the basis of the established regression equation and calculated drainage density it is possible to estimate the share of base flow in total runoff for ungauged basins. This equation, of course, has only regional application.

This equation was used to establish the ratio of base llow to total runoff in 132 basins within the upper Vistula drainage basin. The obtained values were further utilized for making a map (Fig. 1). Isarithms were interpolated in relation to geometric centers of basins and to the geographical environment.

The map has a limited application because it does not inform about the water resources. However, knowing the ratio of base flow to total runoff in spatial distribution one can tell where the runoff is more stable or where it is more variable. The higher the share of base flow in total runoff the more stable the runoff and better chances for economic utilization of these rivers.

CONCLUSIONS

1. Drainage density cannot be used for evaluation of base flow in absolute units (l/s or l/s km^2) because the volume of base flow depends upon water supply from precipitation.

2. There is a satisfactory correlation between drainage density and the ratio of base flow to total runoff in relative units (i.e. in per cent). This is so since drainage density is a result of the integrated action of those factors of the geographical environment which determine the river supply by groundwater.

3. Estimation of the ratio of base flow to total runoff based upon drainage density alone, excluding any hydrometeorological data, is very convinient, since there is lack of hydrometeorological data for small ungauged basins.

4. In a regression model additional environmental factors (multiple regression equation) should not be taken into account, as drainage density is correlated to each element of the geographical environment.

5. The established regression equation enables the calculation of the share of base flow in total runoff in ungauged basins, on the basis of drainage density only.

6. The regression equation can be used for ungauged basins using maps that are of the same scale as those used for calculation of the drainage density in the regression equation.

7. Calculation of the share of base flow in total runoff is justifiable only for basins with natural network. That applies mostly to uplands and mountains.

8. However, for engineering purposes it is more useful to know the absolute amount of base flow. Nevertheless even the relative quota is a valuable information which indirectly indicates the water resources and the retention capacity of a basin.

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GEOGRAPHIA POLONICA 52, 1986

TRANSFORMATION OF THE WŁOCŁAWEK RESERVOIR BANKS

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I. THE INFLUENCE OF SPILLWAY STEPS ON CHANGES IN SHORE PROCESSES

Rivers of the Polish plains either cut into bedrock or deposited transported load, depending on climatic conditions. Throughout thousands of years their valleys and channels developed. A hydrodynamic equilibrium has already been achieved in the longitudinal profile of the rivers that carry a variety of materials delivered from the entire drainage basin, depending on the energy that they possess. Their transporting capacity depends on values of discharge and the flow velocity. The greater the discharges, the higher the erosive activity and transport capacity of rivers. If a river flows through the channel of low and average water, deep and lateral erosion is negligible. On the other hand, at high stages when the river occupies the channel of the so called high water, its erosive power increases a large number of times. It was just under such hydrodynamic conditions that the Vistula river destroyed its banks, especially the steep ones. Fluctuations in its stages in the profiles of Płock and Włocławek reached 6 m prior to the damming (1959–1968). The mean annual discharges fluctuated between 677 and 1191 m^3/s (Glazik 1978). There were large variations in its erosive activity and transport capacity because of varying stages, discharges and velocities.

The construction of a spillway step on the river alters its hydrological regime above the dam and below it. The creation of cascades on the river in the form of a stairway permits regulation of the outflow of water from the catchment throughout the year.

After the construction of the dam across the river and the start of damming in the spring of 1969, the flow velocity decreased gradually. In the mid-summer of 1970 the damming up of the Vistula became accomplished. The backwater section reaches over 58 km in length upstream and extends as far as above Płock. Oscillations in the water level do not exceed 1.5 m. Thus, the extent of fluctuations in the base of the Vistula along the Płock-Włocławek reach has undergone a fourfold reduction and is now controlled by the needs and safety requirements of the step. A fall in the water table level has decreased from 21 to 0.5 cm/km downstream. There has thus been a marked decrease in the erosive power. However, a new factor contributing to bank destruction has appeared, namely abrasion by wind-generated waves. Lateral erosion has been replaced by wave abrasion. Each time a dam is constructed across the river, the flow velocity decreases, whereas the width and depth increase markedly. This contributes to alterations in hydrodynamics of the river within the backwater section and facilitates wind action on the surface of the open basin (Photo 1).

Photo 1. Dobiegniewo. Low bank destruction by waves at high water stage in the reservoir. Wave height up to 50 cm, 21st August 1980

The shore zone remains one of the most variable environments. The shore configuration alters under the influence of physical, chemical and biological processes. The present paper deals merely with physical processes, especially the effects of their operation.

II. STUDY OF TRANSFORMATION OF RESERVOIR BANKS IN POLAND

There are no specialized institutions and clearly specified methods in the history of studies on artificial water basins. This is largely due to the fact that this problem has not been of importance in economy from the viewpoint of hydrology, as well as that of engineering. Hence, no long-term and regular measurement and observation results are available. There is a complete gap in information of bank transformation in terms of quality and quantity before the start of damming, during filling-up and in the first two or three years of exploitation when the processes become most intense. The most reliable data are merely concerned with siltation, i.e. a degree of sedimentation in reservoirs, since it is of major importance in exploiting them. The available data permit more accurate prediction of the life expectancy of artificial basins. The above data are provided by Cyberski (1970), Onoszko (1962), Wiśniewski (1969) and Śliwiński (1979) in their papers.

The study of bank abrasion was begun chiefly in mountain and foot-hill regions in the sixties. An attempt was made to determine a contribution of bank destruction products to the siltation of reservoirs. The longest cycle of observation and measurement was carried out in the Rożnów reservoir. After 20 years following its creation, banks undergoing destruction made up 11 per cent of the total length of the shoreline. The recession rate of cliffed banks approached 3 m every year, while 1.4 m^3 of material was removed from a metre of the bank length per year. This represented about 1 per cent of the mean annual siltation rate in the reservoir (Cyberski 1965).

The study of abrasion in the Zegrze reservoir was begun in 1964. Only a few per cent of the shoreline undergo transformation. There is a small amount of material eroded there (Wiśniewski 1966). The above author draws similar conclusions as to the situation in other Polish reservoirs of lake type such as Otmuchów, Goczałkowice and Turawa. A contribution of bank destruction products to the siltation of reservoirs is estimated as relatively low (p. 491).

Quite different inferences can be made from the quantitative assessment of the seventies in reservoirs at Solina, Tresna and Nysa after their several-year life. Special emphasis is put on a major role of bank destruction in sedimentation in storage reservoirs (Kieraś et al. 1973, Kostecki 1975, Dąbkowski 1978).

After the three-year exploitation of the Solina reservoir, banks undergoing destruction represented 91.5 per cent. The total volume of material removed from the banks during three years was estimated as 600,000 m^3, i.e. 200,000 m^3 a year. The mean annual siltation rate in the Myczkowce reservoir was 150,000 m^3 prior to the creation of the Solina reservoir (Kieraś et al. 1973).

After the reservoir at Tresna existed for seven years, the banks liable to destruction represented 67.7 per cent. The mean annual material loss was 60,000 m^3 (Kostecki 1975).

Dąbkowski (1978) studied the transformation of reservoir banks at Nysa. According to him, the ground losses ranged from 5 to 49 m^3 per 1 metre of the bank along a reach 4.8 km long over a period between November 1975 and May 1977. Large variations in the amount of losses are related to the slope and geologic structure of banks. Those composed of sands, silts and clay-sized particles are liable to greatest destruction. The transformation of sand-gravel banks is less by about 50 per cent.

Up till now the reservoir on the Vistula at Włocławek has been the only step in the planned creation of cascades on the lower Vistula. Immediately after the damming in 1970, the research into the effect of the reservoir on the surrounding area was begun at the Department of Lowland Geomorphology and Hydrology at the Institute of Geography and Spatial Organization of the Polish Academy of Sciences in Toruń.

III. STUDY OF THE RESERVOIR BANKS ON THE VISTULA AT WŁOCŁAWEK

In 1976, i.e. after the six-year life of the reservoir, investigations were undertaken to acquire information of changes in the shore zone along its entire length. They were accomplished in 1980.

1. MORPHOMETRY AND HYDROLOGY OF THE RESERVOIR

The dam closes part of the Vistula basin which is 171,250 thousand km^2 in surface area. The backwater section reaches 58 km in length. At the ordinary level of damming the reservoir occupies the area of 70.4 km^2 (Fig. 1). The effective layer included within the zone of fluctuations of the order of 0.8 m represents 13.6 per cent, i.e. 52.7 million m^3, of the total storage capacity, i.e. 387.2 million m^3. The mean width of the reservoir is 1.2 km, while the maximum width reaches 2.4 km. The water level has risen by 10.7 m near the dam, by 8.1 m at Dobrzyń and by 2.5 m at Płock, when compared to the average water stage of the years 1959–1968

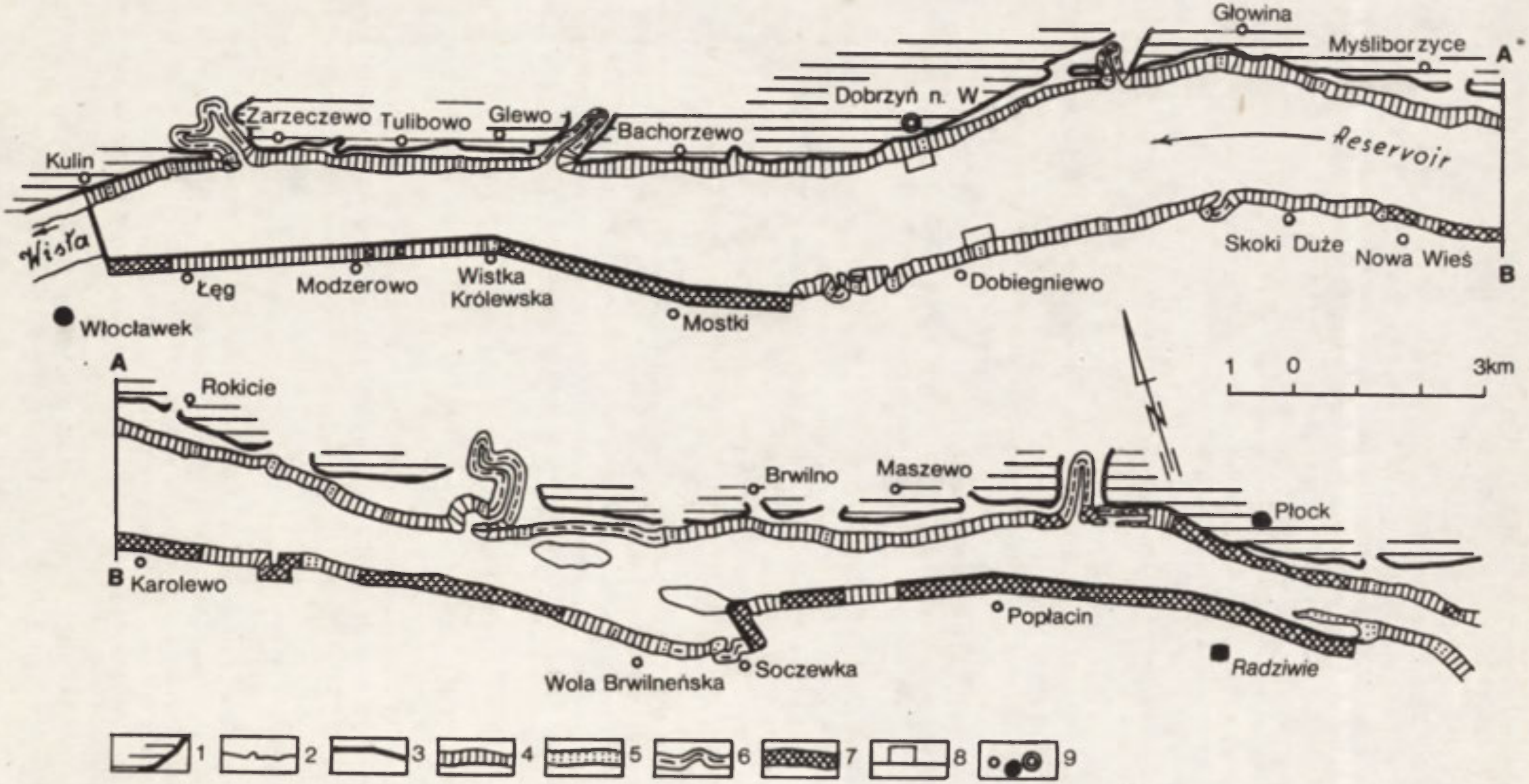

Fig. 1. Types of the Włocławek reservoir banks, August 1980 1 – plateau scarp (terrace), 2 – natural bank, 3 – artificial bank (earth walls), 4 – abrasional bank, 5 – depositional bank, 6 – inactive bank, 7 – protected bank, 8 – sites of stationary investigations, 9 – localities

(Glazik 1978). The mean depth of the reservoir is 5.5 m, while the maximum depth approaches 15 m. The surface area of 22 km^2 has become inundated.

Maximum fluctuations in water stages in the middle portion of the reservoir (Dobiegniewo) were 140 cm between October 1977 and November 1980. Monthly amplitudes range from 44 to 102 cm. Both the highest and lowest stages are recorded in winter and summer; in winter they produce mechanical destruction of banks due to the formation of shore ice pile-up, whereas in summer bank destruction is promoted due to wave action at high stages and the depositional portion of a platform is washed away at low stages.

Maximum wave heights that are 50–60 cm at the boundary of the shore platform (20–30 m from the bank) are sporadically recorded. Wave heights approach 1.1 m in the open basin over 5 m deep. Waves with heights of 10 cm and more represent 18 to 60 per cent of records during particular ice-free months, whereas waves 20 cm and more in height make up merely 1 to 29 per cent. The year 1980 was most windy in the years 1977–1980. In August and November of that year the highest of waves during the entire cycle were observed. The highest waves are generated by winds blowing along the reservoir axis, most frequently from the western sector. The wave height was measured by the use of wavemeter rods, anchored wavemeters or those driven into the bottom.

2. PRESENT STAGE OF RESERVOIR BANK TRANSFORMATION

Information is provided concerning characteristics of both banks along a reach about 50 km long over a distance from the spillway step at Włocławek upstream.

(a) geology and morphology of banks

The reservoir banks vary considerably in geology and morphology. They are composed of Neogene and Quaternary sediments (Photo 2). Neogene deposits occur as sands, silts interlayered with Miocene brown coal and Pliocene clays and silts, and remain strongly disturbed. Their top lies up to 20 m over the reservoir water table. The Neogene sediments are overlain by a continuous coating of Quaternary deposits occurring as till, gravel, sand, silt, clay and residual mass of debris. There are no terraces along nearly the entire length of the right bank. The water table adjoins the morainic plateau slope. The angle of slope is conditioned by a degree of development of sediments that it consists of. Bank parts composed largely of Miocene and Quaternary sediments are high, steep and form spits or shore convexities. The heights reach 20 to 45 m and the slope of angle is 20–50°. The bank parts, the profiles of which display a high contribution from disturbed clay sediments, are lower and slope down to a higher degree. They are the sites of landslides. The amount of colluvial material represents 43.6 per cent (28.2 km) of the total length of that bank. Colluvium from present-day active slides makes up 22.4 per cent (14.5 km). These bank parts are lower as they are up to a few metres in height but they deliver largely material susceptible to the washing away by waves. Over a distance of almost 1 km active cliffs undercut the plateau scarp. The right bank serves as the main source of material deposited in the reservoir. The average height of the bank being destroyed is 8.4 m. Both geology and morphology of that bank have already been discussed in more detail earlier (Banach 1973, 1977).

The left bank is low, sloping and nearly homogeneous in lithology. It consists of Quaternary and Pliocene deposits. The Pliocene sediments that occur as clays project over the water table along few reaches (Nowa Wieś, Karolewo, Duninów). Quaternary sediments include chiefly sands and terrace gravels. There are no larger landslide zones there. The average height of the bank liable to destruction is 1.3 m. The highest active cliffs do not exceed 6 m. The bank is protected over a long

Photo 2. Dobrzyń-Rumunki. Outcropped Neogene sediments in the cliff-face along the abrasional bank. Average water stage, 14th August 1980

distance. There is a larger variety of details along the shoreline of unprotected parts, as opposed to the right bank. More data on geology and morphology of that bank are provided by Glazik (1978).

(b) typology of banks

Every typology based on many factors affecting the course of bank transformation is not clear enough. For the purpose of a better understanding, only one factor has been selected, i.e. a morphodynamic process now prevailing along a given part of the bank. This factor provides the basis for distinguishing between abrasional, depositional, inactive and protected banks.

The bank part from which sediments are removed throughout a longer period of time, e.g. a year, is recognized as an abrasional one. A portion of the bank above the water level recedes and the upper portion of the platform subsides. Every bank is grouped into this category, irrespective of height, slope angle and lithology of its portion above the water level (Photo 3).

Depositional banks comprise bank parts on which the sediment load is deposited throughout a longer period of time. The bank portion above the water level moves forward (towards the reservoir) and the upper portion of the platform is liable to uplift (Photo 4). This category also includes any banks, regardless of height, slope angle and lithology of their portions above the water level. In many cases a depositional bank of the first years after damming bacomes the abrasional one with time, because of continuous recession of the nearby abrasional parts. This can be linked to the straightening of the shoreline. Depositional parts rarely exceed 100 m in length.

Photo 3. Dobrzyń. Abrasional part of shore platform along high bank. Low water stage, 11th June 1980

Banks which remain unaffected by wave-generated morphodynamic processes operating along them are classified as inactive. They are mostly found in the backwater sections of the Vistula tributaries and in other large bays.

Protected banks are recognized as a separate category, though one similar to the previous group. Physical processes operating along them do not produce any apparent changes since their portions above the water level are not susceptible to washing away. Some banks were protected prior to the damming (lateral embankments) and others were strengthened during the useful life of the reservoir (natural-abrasional banks). Auxiliary structures being employed include concrete and fascine-stone jackets and a sand-silted-up shore zone. Rarely are protected banks liable to destruction.

The above categories are shown in Figure 1 and Table 1. The listing of banks does not include the spillway step, basins of the Plock Docks and islands. Most depositional parts are enlarged on the map because of technical requirements. An explanation should also be provided for a somewhat different classification of banks presented in the Table, as opposed to that mentioned above. Each wall of earth heaped up prior to the damming up of a river in order to separate the reservoir from the surrounding low-lying regions is an artificial bank. It may either be protected or unprotected. A more general classification into natural and artificial banks has been applied so that artificial, unprotected banks liable to abrasion or sedimentation are not left out of account.

The total length of the shoreline is 126.2 km through a 49.5 km stretch on the Vistula. The extent of the left and right banks is nearly identical. Unstable banks

Photo 4. Dobiegniewo. Exposed depositional-abrasional bank of the reservoir at average water stage, 10th October 1980

liable to transformation make up half their total length, with abrasional and depositional banks representing 45.3 per cent (57.2 km) and 4.6 per cent (5.8 km), respectively. Abrasional parts make up 67.8 per cent (37.6 km) of the entire length of the right bank. Merely a 4.7 km stretch (Plock) remains protected. It is a highly destroyed natural bank. On the other hand, 33.8 per cent (20.8 km) of the left bank has become protected. Abrasion affects 31.9 per cent (19.6 km) of the bank, i.e. twice

TABLE 1. The Włocławek reservoir banks, August 1980

Bank type	Total		Right bank		Left bank	
	km	%	km	%	km	%
I. Natural	96.0	76.0	55.5	100.0	40.5	100.0
1. Abrasional	52.6	·	37.6	67.8	15.0	37.2
2. Depositional	5.6	·	2.6	4.7	3.0	7.3
3. Inactive	29.9	·	13.8	24.8	16.1	39.7
4. Protected	7.9	·	1.5	2.7	6.4	15.8
II. Artificial	30.2	24.0	9.2	100.0	21.0	100.0
1. Abrasional	4.6	·	—	—	4.6	21.9
2. Depositional	0.2	·	—	—	0.2	1.0
3. Inactive	7.9	·	6.0	65.2	1.9	9.0
4. Protected	17.5	·	3.2	34.8	14.3	68.1
Total	126.2	100.0	64.7	51.3	61.5	48.7

less than in the case of the right bank. Depositional banks represent only 5.2 per cent (3.2 km) but this figure is higher than that available for the right bank (2.6 km). Unprotected banks not liable to transformation make up 30 per cent of their total length.

(c) quantitative changes in bank transformation

The mean annual material losses from the right and left banks amount to 245.9 thousand m^3 and 31.4 thousand m^3, respectively (Table 2). Part of the material from abraded banks is deposited elsewhere in the shore zone at over the average

TABLE 2. Quantitative changes in the Włocławek reservoir banks

No	Parameter	Unit	Right bank 1977–1980	Left bank 1976–1980
1	Abrasional bank length	km	37.6	19.6
2	Depositional bank length	km	2.6	3.2
3	Average height of abrasional bank	m	8.4	1.3
4	Average height of depositional bank	m	0.4	0.4
5	Bank recession rate	m/y	0.8	1.2
6	Bank accretion rate	m/y -	1.4	1.6
7	Material loss per 1 m	m^3/y	6.7	1.6
8	Material deposition per 1 m	m^3/y	0.5	0.6
9	Volume of washed material	thousand m^3/y	245.9	31.4
10	Volume of deposited material	thousand m^3/y	1.3	1.9
11	Difference between volume of washed material and that of deposited material	thousand m^3/y	244.6	29.5
12	Volume of material delivered to reservoir	thousand m^3/y	274.1	

stage in the reservoir. The annual amount left on the right and left banks is 1.3 thousand m^3 and 1.9 thousand m^3, respectively. Thus, 274.1 thousand m^3 of material, including 244.6 thousand m^3 from the right bank and 29.5 thousand m^3 from the left one, become deposited in the reservoir. The amount delivered from the low left bank makes up only 12 per cent of the total amount. From data provided by the literature (Cyberski 1965; Ikonnikov 1972; Kachugin 1975; Kornilov et al. 1979) and from the present author's own measurements, it can be inferred that most material from the destroyed banks is used to develop wider shore platforms, while the remainder is deposited at the bottom or carried as suspension load below the step.

The practical value of the above calculations involves determining the contribution of sediments derived from abraded banks to the reservoir fill. In 1971 and 1978 soundings were carried out in over 80 cross sections of the reservoir by 'Hydroprojekt', the Central Office of Studies and Designs of Water Engineering at Włocławek. The mean annual sediment delivery throughout a 7-year period was estimated as 1.4 million m^3 (Śliwiński 1979). It was the total volume comprising material delivered from the catchment closed with the spillway step and from destroyed banks. From a comparison between sounding data and those presented in Table 2, it follows that sediments derived from the banks contribute 19.6 per cent of material to the reservoir fill. This figure is extraordinarily high. when compared with the data reported from Poland so far (see p. 38–39). The above figures are regarded as rough estimates because of short duration of measurements.

Bank destruction or recession rates vary considerably. They range from 0.2 to 6 m throughout the period of observations, i.e. 3–4 years. Fragmentary data of ten years, available for the lower and middle portions of the reservoir (the right bank), are included within the range of 4–46 m, the highest values being recorded along low, slip and convex banks. Throughout the ten-year period the volume of rock waste ranges between 3.5 and 196 m^3 per 1 m of the bank. The largest amounts of material are lost from convex parts of the bank.

(d) characteristics of shore platforms

A shore platform forms due to the shore recession, i.e. abrasion, and deposition of sediments moving over the slope. Along many reaches it consists only of load moved by nearshore currents conditioned by wave regime. In many cases the development of foreshore shoals due to the movement of sediment alongshore tends to follow an abrasional or depositional pattern but most frequently, it follows a mixed pattern, i.e. the abrasional-depositional one.

The widening of the platform is directly proportional to time (Ikonnikov 1972). As years pass, the platform becomes wider. Narrow shoals expand more rapidly in the first years following the creation of the reservoir but then the rate of expansion decreases gradually with time. The schematic section of the abrasional bank with a well-developed platform is shown in Figure 2.

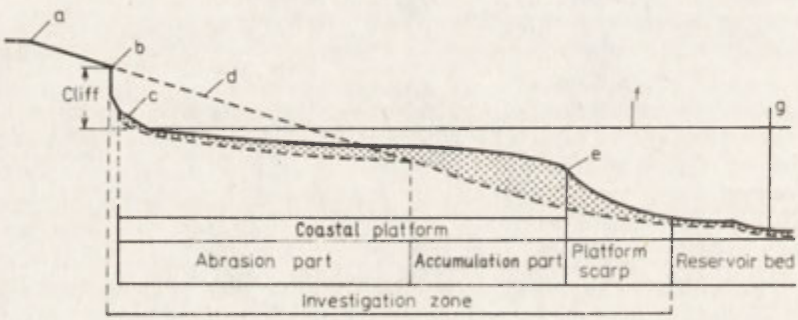

Fig. 2. Schematic section of abrasional bank
a — plateau scarp, b — cliff edge, c — beach, d — original slope profile, e — shore platform edge, f — average reservoir water level, g — original Vistula channel

Rock abrasion by breakers and transport of rock waste towards the reservoir by return bottom current take place on the beach at the base of the cliff. Sediments move across the abrasional part and are deposited on the depositional part and on the scarp, i.e. on the platform slope. The finest ground particles are transported as suspension load into the open basin. The effects of wave action on the bank become reduced as the shoals expand (Akimov et al. 1975; Kornilov et al. 1979).

Parameters of the shore platform for selected bank parts are listed in Table 3. The platform width ranges between 7 and 55 m and is largely dependent on the original slope profile and on hydrodynamic conditions in the entire shore zone. If the above two factors are similar, the effect of characteristics of sediments making up the cliff and the influence of the shoreline contours become apparent. The platforms are narrower and more inclined along banks with originally steep inundated slope, whereas they are wider and gently sloping along banks with gentler original slope angle. Shoals are already well developed in the middle portion of the reservoir,

TABLE 3. Parameters of shore platforms in the Włocławek reservoir, 1978

Profile name	a (m)	l (m)	b	c	bank type
Kulin	27.0	14.0	6°00′	31°00′	abrasional
Tulibowo	3.0	12.0	6°00′	11°00′	„
Rumunki I	21.0	32.6	2°30′	27°00′	„
Rumunki II	0.8	23.0	2°00′	25°00′	depositional
Dobrzyń – Rybaki Street	4.6	16.0	4°00′	29°00′	abrasional
Dobrzyń – Góra Zamkowa	46.0	20.5	3°00′	30°00′	„
Dobrzyń – Podzamcze Street	2.0	23.0	2°30′	18°00′	depositional
Dobrzyń – landslide site	1.5	23.5	4°00′	19°00′	abrasional
Dobrzyń – Zjazd Street	43.0	29.0	3°00′	27°30′	„
Kamienica	8.0	25.0	3°30′	25°00′	„
Rokicie	1.8	30.5	3°00′	8°30′	„
Płock – Podolszyce	3.1	7.0	7°00′	52°30′	„
Łęg	0.5	17.0	3°30′	14°00′	„
Dobiegniewo I	0.5	8.0	4°30′	25°00′	„
Dobiegniewo II	0.4	55.0	1°30′	3°30′	depositional
Karolewo	3.6	10.0	5°30′	43°00′	abrasional
Wola Brwileńska	0.6	9.5	4°30′	19°00′	„

a – bank height, b – shore platform slope angle, c – shore platform scarp slope angle, l – shore platform width

whereas they remain narrow and steep in the upper portion. The platform slope angle is higher in close vicinity to the clay bank than near the sand-gravel bank. The reverse holds for the inclination of the platform scarp (compare Dobrzyń – Góra Zamkowa with the landslide site). The platform widening rate is more rapid in bays than near spits (shore convexities). This can be linked to the distribution of wave energy and the movement of the sediment alongshore. As the energy of waves is gradually lost on the leeward side of spits, the deposition of sediments is more intense there. This leads to the straightening of the shoreline. The largest amounts of sediments are deposited on the east side of spits in the Włocławek reservoir since the prevailing winds blow from the western sector.

IV. RECAPITULATION AND CONCLUSIONS

(1) In consequence of the construction of a dam across the river, shore erosion becomes replaced with abrasion due to wind-generated waves over an enlarged stretch of water.

(2) Up till now the study of shore zones as most variable environments in artificial water basins in Poland has not been systematic but fragmentary. The available results cannot provide the reliable basis for practical activities because of insufficient knowledge of the very process of bank transformation in terms of quality and quantity.

(3) There should be long-term and systematic research into the entire cycle of shore development between the initial stage prior to damming and the final achievement of a new hydrodynamic equilibrium. The study should not only deal with the very effect of bank changes but also, with factors producing them.

(4) Factors affecting bank transformation in the geologic setting of the Polish plains include wave action, fluctuations of water stages, currents and ice movement. During an ice-free period wind-generated waves and water table fluctuations are

the leading factors. The highest waves are generated by winds blowing along the reservoir axis. They approach 1.1 m in height in the Włocławek reservoir. As water stage fluctuations in the reservoir at Włocławek do not exceed 150 cm and are a few times less there than in mountain and foot-hill regions, they do not produce major changes in hydrodynamics on slopes but merely affect the development of shore platforms.

(5) The research that was begun six years after the damming up of the Vistula water at Włocławek is still being carried out. The available results do not provide a full picture of changes. After the 10-year life of the reservoir, banks liable to changes represent 50 per cent of the total shoreline length; abrasion affects 45.3 per cent of banks. The contribution of sediments derived from banks to siltation in the reservoir amounts to 19.6 per cent, i.e. 274.1 thousand m^3 per year. This figure is extremely high. Most material derived from abraded banks contributes to the widening of shore platforms; the remainder is deposited at the bottom of the open basin or is carried as suspension load below the step.

(6) The right bank of the Włocławek reservoir is characterized by extremely unfavourably developed stability conditions. It is high and steep, and varies in hydrogeology and geodynamics. This is promoted by particularly disturbed Neogene sediments projecting over the reservoir water level and by a high percentage of colluvium; active landslides sites make up over 22 per cent of banks. It is expected that there will not exist such unfavourable geological conditions on banks in other reservoirs of the planned cascades.

(7) As technical specifications suggest (Biegała 1980), most reservoir banks below Ciechocinek will overlap the existing embankments alongside the river. The embankments will be raised higher and strengthened by means of concrete slabs. The percentage of natural banks will be negligible. The degree of damming will not exceed that at Włocławek. It will reach 10.4 m merely in the case of the Opalenie step. The equilibrium is likely to be disturbed there on natural banks. The highest percentage of natural banks will be observed in the Ciechocinek reservoir.

(8) The most important hydrotechnical problem involves protecting banks in historical towns Nieszawa, Toruń, Chełmno, Grudziądz and Gniew. Wysokiński's conception (1980) of research work and scarp protection in the vicinity of historical towns is justifiable.

(9) Increased bank destruction should be taken into consideration, regardless of a rise in the river water table on designed spillway steps on the lower Vistula. The intensity of destruction will largely depend on the bottom profile at the contact between water and land and on wave length. Geologic structure and morphology of the bank will be of minor significance. The bottom along unprotected lateral embankments should be carved to parallel the minimum slope angle of shore platforms, i.e. that of not more than 2°. This will restrict considerably the destroying action of waves.

(10) In historic times man appeared as a new factor affecting the intensity and nature of geological processes in the Vistula valley. Its importance increases in more than in geometrical progression (Mojski 1980). Human activity now plays a greater part in the development of the Vistula valley than the action of all natural factors does. There has never been such a powerful factor in the geological time scale.

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ICE JAMS AND FLOODS ON THE LOWER VISTULA RIVER

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INTRODUCTION

Ice jamming phenomena on rivers in temperate and high geographical latitudes are often the cause of severe floods. Water level rises caused by ice jams are violent and difficult to forecasting. Information on this subject is still very scanty (Bolsenga 1968; E. R. Ficke and J. F. Ficke 1977; Michel 1971). In a great majority of cases accurate pinpointing of the site and height of the jam water level rise is very difficult. This kind of research should therefore be proceeded by listing the ice jamming phenomena on a given river as the basic starting material for fixing the jamming river reaches and for planning hydro-power stations (Williams and MacKay 1973). An engineer is now always faced with the difficult job of estimating *a priori* the rise in water level as a result of ice formation.

The necessity of conducting investigations on jam floods has been often pointed out in Polish literature (Kolberg 1861; Słowikowski 1881, 1892; Puciata 1894; Walewander 1932; Kobendzina 1954; Mikulski 1955, 1957, 1962; Wokroj 1954; Tyszka 1954; Pasławski 1970), as well as in papers concerning ice phenomena (Gołek 1957; Zubrzycki 1927). Only disastrous jam floods have been adopted as the scale of the jam. The floods caused by ice jam overflow the populated areas in the river valley and bring forth much damage. The main aim of the present paper was to present a historical record of the greatest water level rises due to ice jams on the Lower Vistula, the regions in which they formed and their main causes.

THE GREATEST ICE JAM FLOODS ON THE LOWER VISTULA UNTIL THE END OF THE 19TH CENTURY

The earliest information on the subject can be found in old chronicles of Długosz, Bielski, Kromer, Wapowski (Mamak and Tyszka 1954). It usually refers to towns and villages. It follows from an analysis of the height and time of occurrence of great water level rises marked on the town walls that many of them were due to ice jams. Thus for instance, the maximum water levels marked on the town walls of old Toruń (in February and March) were ice jams rises (Photo 1). The earliest mark is from the year 1570. Information of comparable value go back to the 18th c. W. Kolberg (1861) quotes data on the freezing of Vistula dating to 1724. That autor is the first in Polish literature to analyse the causes of ice jam formation. He tells about disastrous ice jam floods in the years 1828/29, 1839/40,

Photo 1. The markes of flood water levels during breakup period on the old town wall in Toruń

1844/45, 1854/55. They were ice jam water level rises during the period of ice cover formation. In the Warsaw region, 14 great floods took place between 1817 and 1864, half of which were ice jam floods (Kobendzina 1954). One of the most severe was the winter of 1854/55. From Warsaw downstream to the river mouth, dikes were broken-up in 66 places, many villages were completely destroyed, 162 persons died (Tyszka 1954). Vast areas were flooded in the Vistula delta. That area was very often affected by floods caused by ice jams (spring ice jams). According to W. Danielewicz (1983), in the years 1328–1896 there are reports of 174 cases of breaking-up of dikes as a result of jam-caused water level rises.

The jam-caused water level rise in the region of the Vistula outflow into the Gdańsk Bay (near Pleniewo) in January 1840 resulted in the formation of a new river mouth. During one night a 1.5 km wide bar was broken-up and a 750 m wide channel was formed.

It must be pointed out that already in the 19th c. a number of regularities in the formation of ice jams were observed. J. Słowikowski (1881, 1892) was one of the first in the world to attempt an explanation of the formation of frazil and anchor ice. He also pointed at the relationship between river regulation and winter ice jam formation. In the middle of the 19th c. a special warning system of observation stations and wire telegraph were organized and groups of miners were trained (Puciata 1894). Tests were carried out to assess the effectiveness of using gun-powder charges for destroying ice jams (Kolberg 1861).

In the 1870s, in the region of the Vistula mouth, special sledges ballasted with stones were used for breaking the ice (Wiśniewski 1975). 1881 marks the launching of the first steam icebreaker, 120 hp, 'Weichsel', which worked in the Vistula mouth. By 1895 there were already 12 such vessels working on the Lower Vistula.

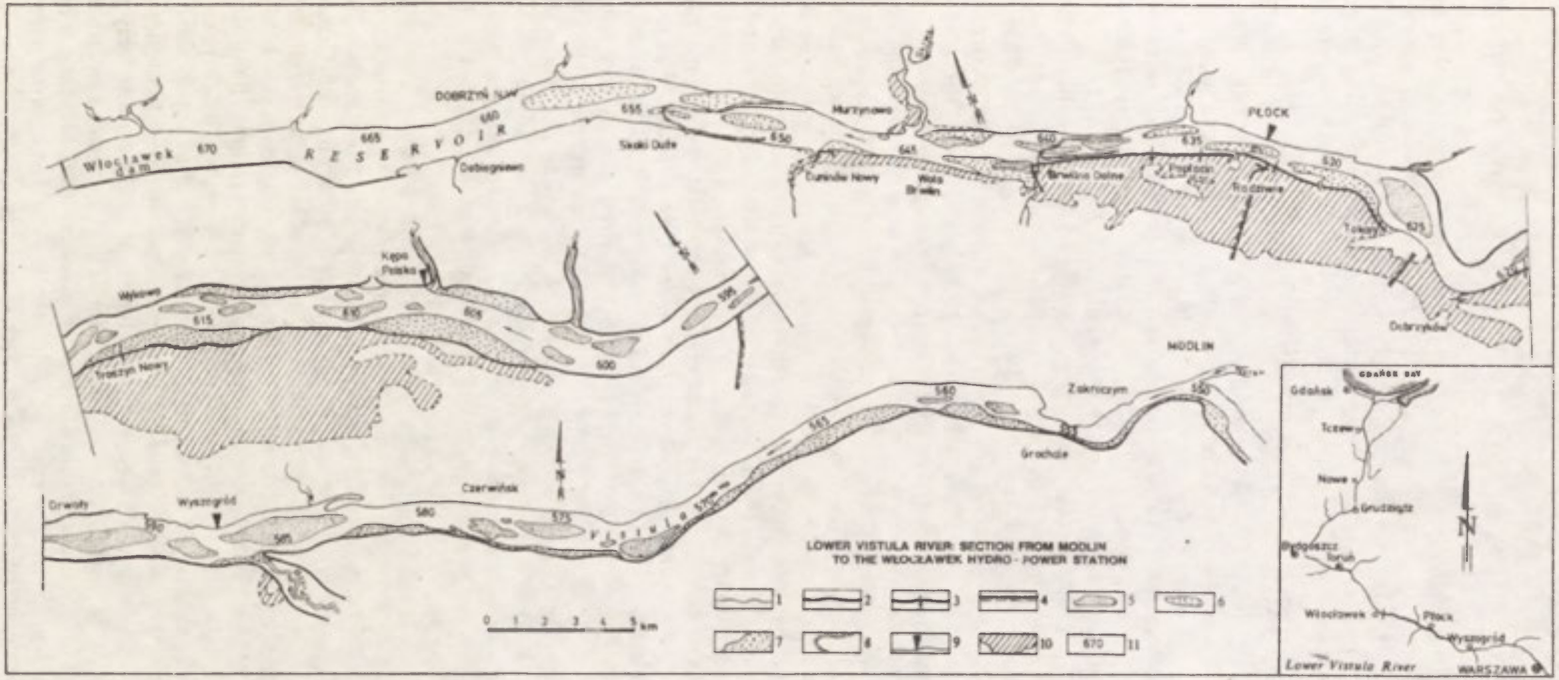


Fig. 1. 1 – shore line, 2 – longitudinal dikes, 3 – places of dikes disruption and flow over dikes, 4 – cross dikes in post glacial valley, 5 – islands, 6 – islands with near surface ridges, 7 – flood plain, 8 – heads of ice jams, Jan. 1982, 9 – water gauges, 10 – flooded land, Jan. 1982, 11 – kilometres of river course

THE GREATEST ICE JAM FLOODS ON THE LOWER VISTULA IN THE 20TH C.

The work on the regulation of the Lower Vistula, which was started towards the end of the 19th c., was accompanied by regular hydrological observations. The amount of information on ice jamming phenomena has increased. Areas where regulation works were fairly advanced were much less prone to flooding. Regulation works were conducted over the section from the river mouth up to the locality Silno (km 718).

One of the greatest jam-caused water level rises of the beginning of the 20th c. was in the region Czerwińsk – Wyszogród (km 578–km 587) in 1909. Vast areas of the Kampinos Forests were then flooded. An extremely dangerous jamming situation occurred on the Lower Vistula in March 1924. In the region of the locality Jabłonna, downstream from Warsaw, formed an ice jam piling the water over the dikes. The jam moved downstream below the junction with the river Bzura. An area of more than 100 km^2 was flooded (Kobendzina 1954).

Very frequent on the Lower Vistula are winter floods occurring during the freeze-up period. This happened in November 1927 when a number of frazil jams were then observed between Warsaw and Plock (Szachtmajer 1928). That section of the river is known to be prone to ice jamming. This has been illustrated with several examples without going into the causes of the phenomena. The relationship between river regulation and ice jam formation has been pointed out.

One of the causes (generally mentioned) of ice jamming is considered the S–N direction of the river flow, linked with an earlier break up of ice cover in the upper course of the river. Such was probably the origin of the ice jam formed upstream from Chełmno at the end of March 1937. The water level rose by 4 m. It was broken up by icebreakers and the lower-lying portion of Bydgoszcz was saved from flooding (Wokroj 1937). It has been found that after long and snowy winters there always occur ice jams on the Lower Vistula. This was also the case in March 1947. Longitudinal dikes in the region of Czerwińsk, Świecie and Chełmno were broken-up. Considerable changes occurred in the river channel (Wokroj 1954). On the Upper Vistula ice broke up one month earlier than at the river mouth. Bridges, provisionally rebuilt after World War II, were destroyed. A very dangerous ice jam formed near the locality Czerwińsk (km 570), causing the water level to rise by about 3.5 m. This case has been illustrated by a longitudinal profile (Fig. 2). The ice-jam-caused flood in February 1966 proceeded in a similar way (Kostrzewa 1966). In the region of Wyszogród an ice jam was formed (Fig. 3) threatening with flooding 100 km^2 of valuable farmland in the valley (it was flooded in January 1982).

It follows from an analysis of historical records that the Lower Vistula can be divided into three characteristic sections with regard to its proneness to ice jam formation. The first one covers the region of the river's mouth – here ice jamming depends on the possibility of the ice being carried into the Bay of Gdańsk. At reduced flow of velocity during ice movement, the shallow delta mouth becomes blocked. It is necessary to use icebreakers to keep it clear (Slomianko 1956).

The section of the Vistula from its mouth up to the locality Silno (km 718) after regulation has shown a much lower frequency of jamming. If ice jams occur, they are effectively cleared by icebreakers. The section of the Vistula from Silno up to the junction with Narew (km 550) is characterized by high frequency of ice jamming. Until the dam in Włocławek was built in 1969, it was very poorly regulated and could be termed a braided river. Jamming phenomena occurred there every winter, and major ones resulted in flood disasters. Ice breaking (Photo 2) was impeded by small depths. The effect of the reservoir Włocławek on ice phenomena on the Vistula is discussed in following chapter.

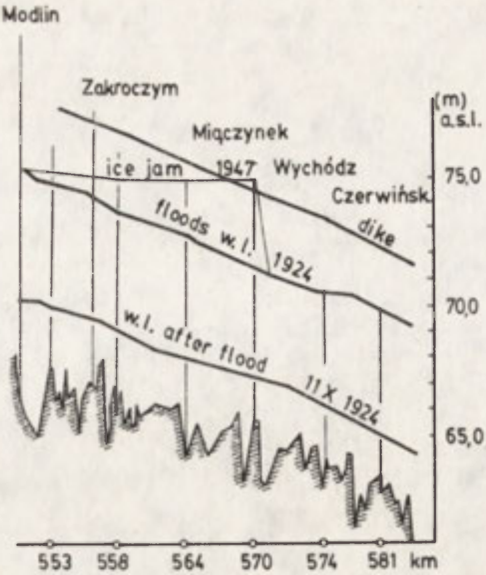


Fig. 2. Longitudinal profile of water level during spring ice jam, March 1947. After K. Dębski in: M. Parde (1957)

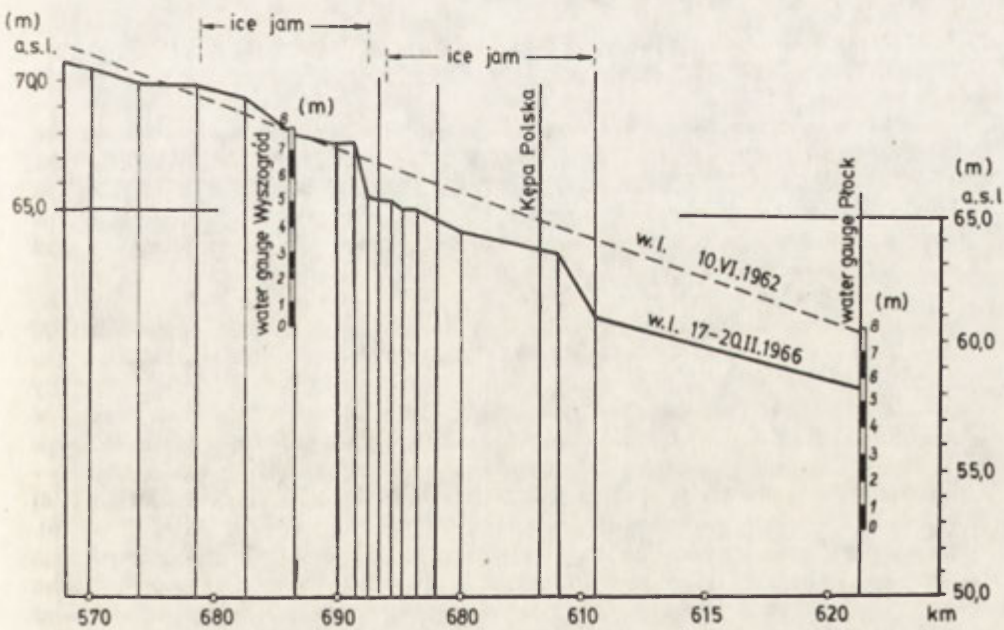


Fig. 3. Longitudinal profile of water level during spring ice jam, March 1966. After K. Dębski (1970)

Photo 2. The typical icebreaker (770 hp) operating in the Lower Vistula River

THE EFFECT OF THE RESERVOIR WŁOCŁAWEK ON THE PROCEEDING AND INTENSITY OF ICE PHENOMENA

In 1969 the dam of Włocławek (km 675) was completed. It constitutes one element of the project of the Lower Vistula Cascade. The damming of the river by about 11 m resulted in the formation of reservoir 75 km^2 in area, 408 million m^3 in volume and 55 km in length. During the 14 years it has been in use, observations have been carried on ice phenomena. The conditions of ice cover formation and decay have changed significantly. There has been an increase in jamming frequency. In comparing observation records before(1960–1969) and after damming (1970–1979) it has been found that ice cover formation in the latter period comes about 20 days earlier than in the former one. The earlier formation of the ice cover on the reservoir is due to a reduction in stream-flow velocity. The ice cover generally develops from the dam upstream and comparatively quickly reaches the region of km 650–655 (Fig. 4). The frazil running downstream (Photo 3) is stopped at the edge of the earlier formed ice cover. This phenomenon is accompanied by frazil deposit – accumulation in the reservoir (Photo 4). The contact zone of immobile ice (Fig. 4) with mobile ice is always subject to jamming hazard (Fig. 4, A/B, Photo 5 and 6). Its location zone depends on the volume of discharge and hydrometeorological conditions. The sites of greatest risk are centrally situated scarcely submerged sand banks and a rapid change in the water elevation. About 2.2 million m^3 of sand is deposited in the area every year, which considerably deteriorates the conditions of ice flow (Fig. 4, Grześ 1983). It is worth mentioning that about 50–60% of the ice phenomena on the Vistula upstream from the Włocławek Reservoir is taken by

Płoto 3. Frazil slush in the high part of the Włocławek Reservoir during winter season 1983/84

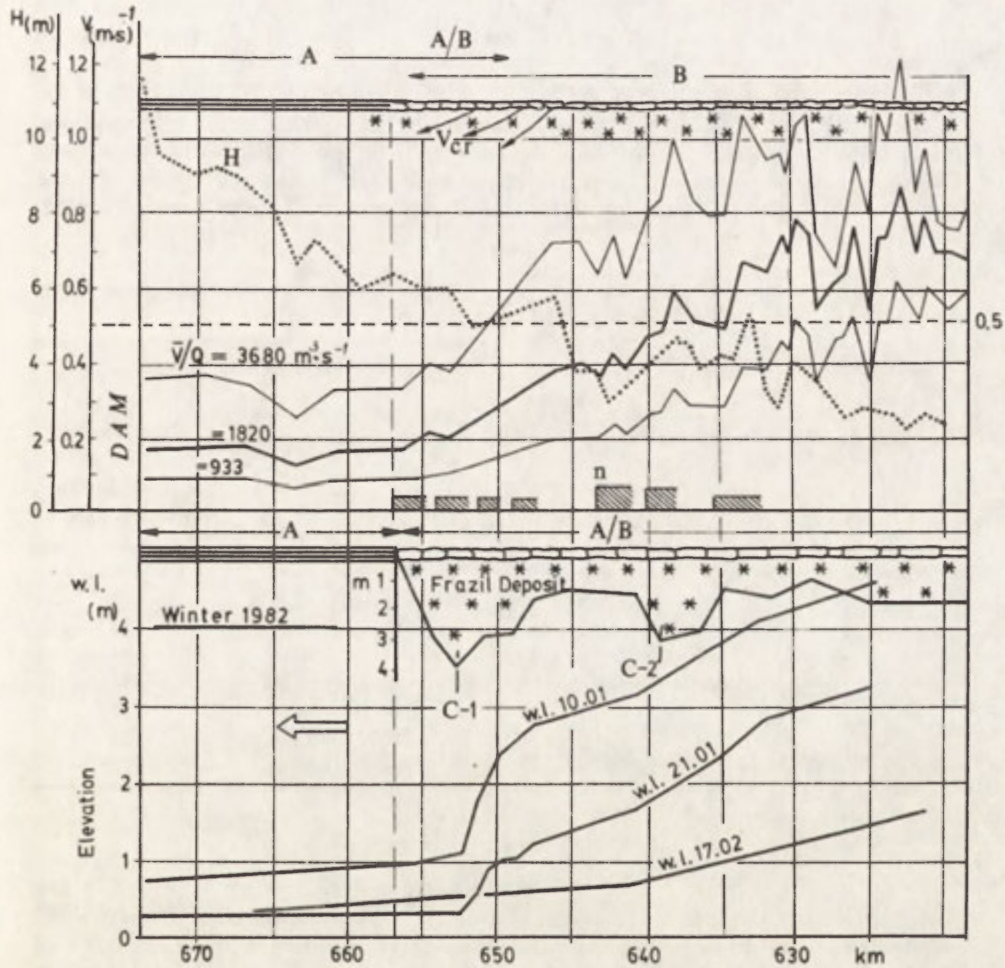
Photo 4. Slush ice jam observed during Dec. 5, 1983

Photo 5. Main ice jam at Skoki Duże during the catastrophic flood in Jan. 1982

Photo 6. Slush ice jam at Brwilno during the catastrophic flood in Jan. 1982

the running of frazil slush, which has been already pointed out by J. Lambor (1948) and J. Gołek (1964). The critical flow velocity (Michel 1971) has been fixed at about $0.5\ \mathrm{m \cdot s^{-1}}$ (Pasławski 1970). This marks the zone of ice jamming occurrence (Fig. 4).

The duration of ice phenomena on the reservoir in regulation to the time before damming has undergone any significant change and amounts to 80 days. However, the ice cover tends to keep longer within its boundaries. This constitutes a significant element of jamming risk during the spring (spring ice jam). For that



RESERVOIR

Fig. 4. Sequence of events during ice formation on the Wloclawek Reservoir in winter: a scheme of the freeze-up process and an example

H – mean depth of cross-sections, V – mean flow velocity of cross-sections, w.l. – water level, n – frequency of winter and spring ice jams (1970–1982), A – ice sheet-zone of low velocity flow, B – conglomerate ice cover, hummocked ice with underhanging dam. A/B – contact zone, V_{cr} – critical velocity, C-1 and C-2 – location of cross-sections (see Fig. 5) reason every year before the ice break-up, a 300–400 m wide channel along the reservoir is made in the ice cover by icebreakers. The breaking of ice cover must be associated with the flowing of ice through the dam. This is routine operation each winter.

Yet before the construction of the Włocławek Reservoir, ice jamming, typical of braided rivers, was observed within its present boundaries. Within the reach Płock – Włocławek alone, seven ice jams were found to occur from 1961 to 1968. After the construction of the dam and the reservoir, ice jams have formed with greater frequency (Fig. 6). Over 14 years of use of the reservoir, 17 ice jams have formed in it, all of them above km 655 (cf. Fig. 1 and Fig. 6). As follows from the foregoing data, ice jamming phenomena on Włocławek Reservoir are connected with its earlier freezing-up and breaking-up. An important factor is the morphology of the reservoir bottom.

Since 1980 dredging works have been done in the reservoir. About 2 million m^3 of sandy material is dredged up every year from the former sand banks and the presently forming delta. As the flow has decreased in speed, the above mentioned factors causing ice jamming lead to severe risks and disastrous events. In the Table 1, only selected instances of ice-jam-caused flow rises have been presented.

TABLE 1. The characteristics of maximum ice jam heights recorded on the water gauge Płock, Vistula River – Włocławek Reservoir, km 632.4

Winter	Maximum ice jam heights (cm)	Alarm water stages (cm)	Number of days with alarm water stages	Water discharge (m's)	Date	Difference between max. water stage and top of longitudial dike in Płock (cm)
1970	700	650	4	–	28.03	–126
1971	750	650	13	3181	3.02	–76
1974	680	650	2	1481	29.01	–146
1976	732	650	33	1234	30.01	–94
1977	675	650	3	2126	5.03	–151
1979	814	650	56	3047	14.03	–12
1981	800	650	55	1300	15.01	–26
1982	918	650	67	1600	10.01	+122[a]

[a] Flooded area 100.5 km^2

Twice in the 14 years of use of the reservoir, the water came up to within a few centimetres from the top of the dikes. During the disastrous flood of January 1982 water poured the dikes with a one-metre-thick layer, flooding a 100.5 km^2 area of the valley (Banach and Grześ 1983). A sharp rise in river water level occurs as a result of an ice jam or the formation of an ice stopper of frazil (Fig. 4 and 5). It was caused by an influx into the reservoir of enormous quantities of frazil (144 million m^3) and the formation of three ice jams (Photo 5 and 6). Within the main section of the jam slush and ice occupied to a maximum 82% of the reservoir cross-section and their thickness reached to 8.4 m (Fig. 5). The reservoir was filled with ice in about 37%. The water level rose by about 3 m. The ice reduction coefficients reached the value 0.158 (water gauge – Płock), which is unprecedented under conditions prevailing in Poland (Żelaziński 1983).

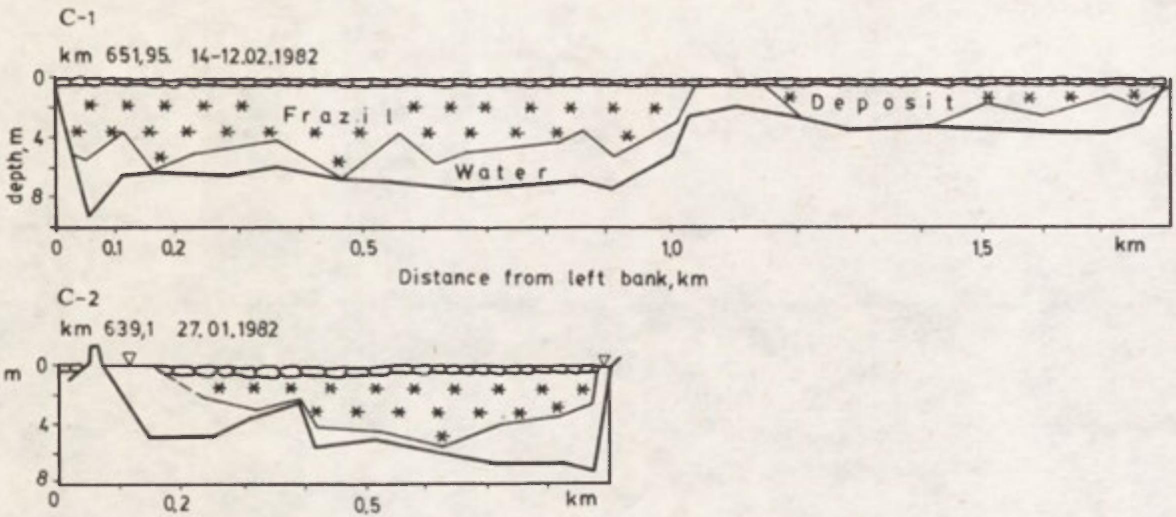


Fig. 5. Typical cross-sections of a frazil-ice deposit in the Włocławek Reservoir, winter 1982

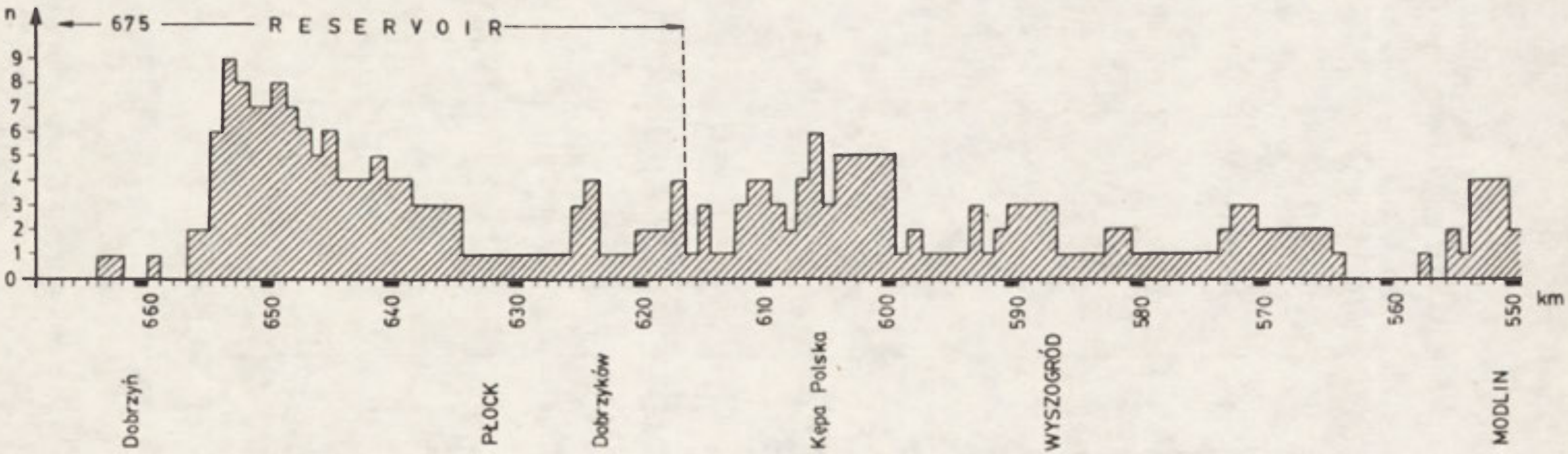


Fig. 6. Frequency of the ice jamming (winter and spring ice jams together) on the Lower Vistula River, between Modlin (km 550) and the Włocławek hydro-power-station (km 675), 1961-1982

CONCLUSIONS

Ice jams are observed only on individual sections and not every year. Floods caused by ice jams occur on the Lower Vistula at an average rate of once in every two or three years. The maximum water level rise caused by ice jamming was 6 m and occurred near the town of Nieszawa, km 700 (Słomczyński 1964). The most frequent jam-caused water level rises reached 2–3 m (Table 2). On most

TABLE 2. The characteristics of typical ice jams on the stretch between Modlin (km 550) and Płock (km 632.4). After: Institute of Meteorology and Water Management

Gauging stations	kms of the river course	Date	Alarm water stages (cm)	Water stages: before ice jamming	Water stages: after ice jamming	Water stages: difference (in cm)
Modlin	551.5	8–9.03.1954	700	437	782	345
Modlin		4–13.03.1976	700	604	820	216
Wyszogród	586.9	18–24.03.1963	550	386	719	333
Wyszogród		12–19.02.1966	550	486	791	323
Wyszogród		26.03.1970	550	538	682	144
Wyszogród		8–15.03.1979	550	500	777	277
Wyszogród		9–11.01.1982	550	567	765	198
Kępa Polska	606.5	10–23.03.1979	400	480	670	190
Kępa Polska		9–11.01.1982	400	550	682	132
Płock	632.4	11–23.03.1979	650	651	822	171
Płock		1–10.01.1982	650	720	948	228

water gauges on the Lower Vistula the maximum water stages are the result of ice jamming and are higher than the dikes. The flooded areas often extended over more than 100 km^2. On regulated river reaches the frequency of ice jamming has greatly decreased, while on the braided reaches jamming recurs regularly every winter. The construction of dikes should therefore go along with river regulation, and the height of the dikes should be suited to that of the water level rises. At the moment of the breaking-up of ice jams the velocity of water flow locally reaches $3\ m \cdot s^{-1}$. This results in considerable changes in the morphology of the channel bottom. In places the bottom sinks by as much as 5 m.

The location of ice jams depends chiefly on the morphology of the channel and on the character of the valley between the dikes. The inner structure of the ice jam depends on hydrometeorological conditions (Photo 8 and 9). Each ice jam is the result of the characteristics of a given river reach under given hydrometeorological conditions.

Particularly adverse conditions of ice run arose as a result of the construction of the dam at Włocławek. Large amounts of frazil accumulate in the reservoir forming ice jams (winter ice jams) and causing floods. At present the shallow places in the reservoir are being deepened and the dikes are being raised by 2–3 m. The question remains, whether the solid ice sheet (immobile ice) in the reservoir form sooner than the free-flowing river containing frazil ice, and if yes, where in the reservoir the frazil slush meets the ice sheet (V_{cr}, winter ice jams).

The breaking-up of the Vistula-river is followed by ice jams formation (spring ice jams) on the stretch between Modlin (km 550) and Gdańsk Bay. The Vistula

Photo 7. Ice floe on the embankment, three weeks after the maximum water level during the catastrophic flood in Jan. 1982

Photo 8. The inner structure of the frazil deposits in the Włocławek Reservoir during Febr. 1982

Photo 9. Masses of frazil grounded on shallows at Duninów Nowy, Febr. 23, 1982

breaking-up starts at the river head and goes on downstream which makes possible spring ice jam formation (with floes mainly). Ice jams are determined by morphology of river channel and flood plain. The jam formation is a very complex process, depending on many factors, during the freezing-up and breaking-up period. The Vistula is also characterized by winter ice jam events formed as a result of the river breaking-up in winter.

The risk of jamming was reduced by the elimination of sand banks, islands and obstacles along the banks (regulation). The situation is expected to improve radically after the construction of the following dams together with the planned nuclear power stations.

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GEOGRAPHIA POLONICA 52, 1986

LES INONDATIONS DE LA MOYENNE VALLEE DE LA VISTULE

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Après les inondations de la moyenne vallée de la Vistule entre les villes de Włocławek et Zakroczym, il s'est avéré indispensable de rechercher les causes de ces inondations et les moyens de les prévenir. A cette fin, la section "Aménagement du territoire" de l'Institut de Géographie et d'Aménagement du Territoire de l'Académie Polonaise des Sciences a entrepris l'étude de cette valleé.

Les informations recueillies sont soit descriptives, soit quantitatives. Elles concernent surtout le niveau des crues dans les localites étudiées et l'ampleur des dégats provoqués. Des enquêtes ont été menées auprès des bureaux de paroisse situés sur les territoires touchés par les inondations.

1. LES INONDATIONS HISTORIQUES DE LA VISTULE, EN PARTICULIER DANS LA RÉGION DE VARSOVIE

1.1 LES GRANDES CATASTROPHES

Les renseignements obtenus proviennent de sources diverses: tout d'abord de chroniques anciennes; celles de Dlugosz, de Kromer, de Bielski et Wapowski. Les chroniqueurs mentionnent les inondations en se fondant surtout sur les informations communiquées par les paroisses submergées périodiquement. Les renseignements les plus anciens remontent au XIème siècle. Cependant toutes ces données sont fragmentaires et se contentent d'illustrer les phénomènes naturels et leur impact sur la vie des habitants, sans chercher à estimer l'ampleur des catastrophes. Tuszko (Tuszko 1977) cite par exemple le cas de l'inondation de 1270 qui causa des pertes et des dégâts considérables. En 1404 les eaux de la Vistule sont arrivées jusqu'à l'église St. Bernardin à Cracovie. En 1553, le fleuve a inondé presque tout le quartier Praga à Varsovie et rompu des ponts à Cracovie. En 1635, le quartier de Praga fut à nouveau touché: les eaux atteignirent aussi la ville de Radzymin, submergeant les champs et les villages sur une largeur de 30 km. Les crues au XVIIIème siècle eurent la même ampleur. Celle de 1813 par exemple, provoquée par les affluents issus des Carpates et en particulier par le Dunajec, entraîna des destructions énormes dans la vallée. Mais la plus forte crue, jamais enregistrée, sur la Vistule moyenne s'est produite le 27 juillet 1844; ce jour là le flot atteignit un débit de 8 000 mètres cubes par seconde et le fleuve monta jusqu'au niveau 8,55 m à l'échelle de Varsovie. En amont de Cracovie, la crue la plus importante date de 1813 avec un débit de 2 000 m^3/s.

Ce n'est qu'à partir de 1844 (Mamak, Tyszka 1947), que l'on commença à collecter des statistiques relatives aux dégâts provoqués par les inondations dans la partie méridionale de la Pologne. Les données recueillies devaient servir de base au calcul du montant des indemnités à verser aux habitants des régions sinistrées, ainsi que de justification au coût des travaux à entreprendre pour la régularisation

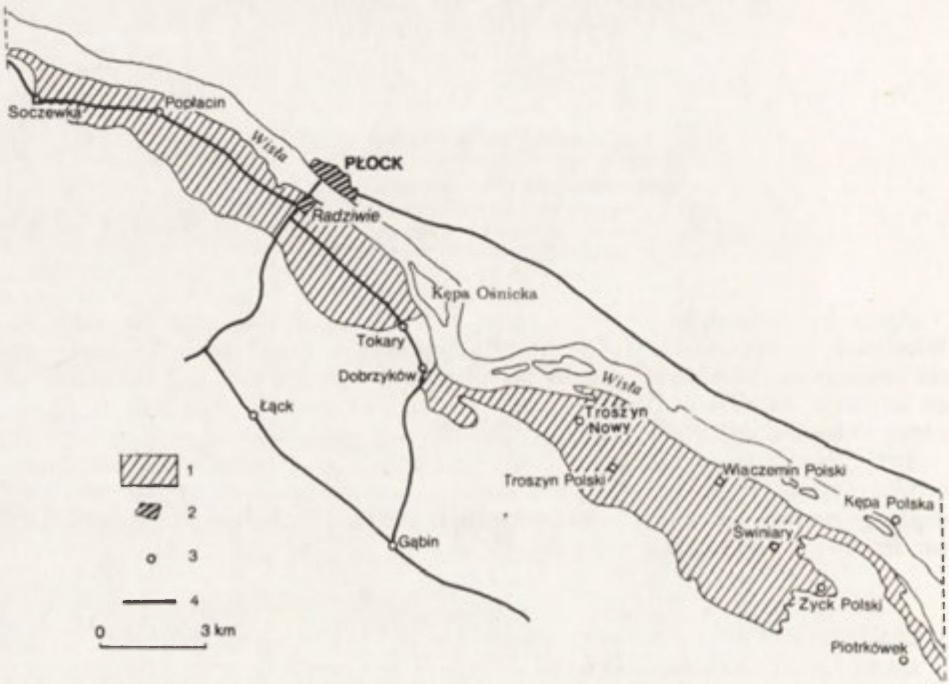

Fig. 1. Inondation dans la region de Płock en 1982: 1 — territoire inondé, 2 — ville, 3 — villages, 4 — routes principales

des cours d'eau. Mais ces données statistiques englobent aussi les sinistres provoqués par les averses violentes de pluie ou de grêle. En outre, il convient de signaler que ces chiffres ne sont ni systématiques ni homogènes, tout comme les informations rassemblées postérieurement. Il est par conséquent difficile d'apprendre l'ampleur des catastrophes, néanmoins l'étude de Mme Jadwiga Kobendzina nous fournit une analyse detaillée des inondations qui ravagèrent les environs de Varsovie ainsi que leur distribution saisonnière.

1.2 LA RÉPARTITION SAISONNIÈRE DES CRUES

Sur les vingt deux cas de crues catastrophiques enregistrées au cours des deux derniers siècles (1729–1947) quatorze se produisirent au printemps, six en été, une seule en hiver (1839) et aucune en automne. Les inondations de printemps, les plus fréquentes ont pour origine d'une part une accumulation exceptionnelle d'eaux de fonte bloquées à l'aval par des amoncellements de glace et d'autre part de fortes précipitations de fin de printemps.

Le relief et la configuration de la vallée de la Vistule permettent dans certaines parties du fleuve, la formation d'embacles en hiver ou au début du printemps. Tel est le cas par exemple en aval de Varsovie, entre Jablonna, Zakroczym, Secymin, Wyszogród et en amont de la capitale, entre Magnuszewo et Mniszewo. La partie du fleuve située en aval du confluent du Bug est plus particulièrement exposée aux inondations. Ainsi en 1845, la pluie est tombée en abondance le 24 mars après un hiver rude et long, une débâcle brutale a suivi s'accompagnant de la formation d'un bouchon de glace en amont de Glusko. Les champs aux alentours ont été submergés et la glace y est restée presque jusqu'au 12 avril. Les crues de mars, provoquant de gros dégâts ont détruit des ponts, des bâtiments et inondé les terres agricoles. Elles ont été fréquentes: 1846, 1860, 1870, 1880, 1909, 1922, 1924, 1929, 1934 et 1947.

Les inondations d'été sont consecutives à la crue des cours d'eau dans le sud du pays. Celle du 29 août 1813 dans les environs de Varsovie inonda les récoltes pendant huit jours et les détruisit. Les dégâts furent aussi importants les 28 et 29 août 1839, en août 1840, en juillet 1844 et 1845 et même en 1925 malgré la construction de nouvelles digues. Ces débordements d'été ont anéanti les récoltes de fruits et légumes dans les vergers, ont empêché la fenaison, noyé le cheptel et endommagé les bâtiments agricoles. En 1844 la crue a eu pour origine des précipitations violentes survenues dans les environs de Varsovie, les 20 et 21 juillet. Il a fallu huit jours pour que les eaux du fleuve regagnent leur lit.

Les inondations d'hiver: le cas unique jusqu'en 1929 est celui du 29 decembre 1839. Jadwiga Kobendzina cite à ce propos les chroniques de l'époque: "... les glaces ont soudain rompu le pont de Varsovie entravant trois piles en bois jusqu'au village de Wilkowo Niemieckie à 5 km en aval, elles sont restées jusqu'au 22 janvier 1840". Un embâcle s'était formé entre Wilkowo Niemieckie et Grochale, si bien que les eaux de la Vistule avaient submergé les champs et villages voisins provoquant de gros dégâts.

2. LES DIFFÉRENTS TYPES DE CRUES

Afin de pouvoir prévenir les inondations, il faudrait arriver à classer les différents types de crues à partir des phénomènes qui les déclenchent, telles les conditions hydro-météorologiques qui les précèdent en accompagnant le débordement, la saison de l'année où celui-ci se produit et sa portée territoriale. Ces critères d'analyse concernant la nature, la période et la localisation des inondations répondent aux trois questions fondamentales qu'il faut résoudre: comment (ou de quelle manière?), où et quand se produisent les crues. La classification du professeur Lambor (Lambor 1954) tient compte de ces 3 interrogations. L'auteur distingue quatres types de crues:

1. Les crues d'origine pluviale (O),
2. Les crues d'origine nivale (R),
3. Les crues dues aux tempêtes (Sz),
4. Les crues dues à la glace.

Chaque type est specifique par ses origines, ses caractères et son envergure (tabl. 1). La première catégorie peut se subdiviser en deux selon le mécanisme des précipitations: crues de pluie convectives (On) et de pluies frontales (Of et Or).

TABLEAU 1. Types d'inondations – leurs causes, caractère et extension (d'après J. Lambor, 1954)

Causes			Caractère	Extension
PRÉCIPITATION	Pluie de convection	On	Pluies convectives locales Orages thermiques	Fortes inondations locales sur les torrents de montagnes ou petits cours d'eau
	Pluie frontale	Of	Pluies frontales	Inondations normales à grande portée
		Or	Pluies frontales renforcées par les phénomènes orographiques	Graves inondations de longue durée dans des régions montagnardes
DÉGEL		R	Fonte brusque des neiges, accompagnée de vents violents et avec une surface du sol gelée	Vaste portée territoriale dans des conditions favorables (plaines et montagnes)
TEMPÊTE		Sz	Situation barométrique favorisant les inondations	Le littoral, la Baie de la Vistule (Żuławy), la Baie de Szczecin
CRUES DUES À LA GLACE		Zś	Glace concassée: baisse brusque de la température allant jusqu'à moins 10°C	Inondations locales dans des régions particulièrement disposées (la partie centrale de Noteć, Brda)
		Zz	Montée des eaux durant la débâcle en particulier sous les ponts	Inondations locales dangereuses sur les rivières et les torrents dans les endroits où l'écoulement des glaces est freiné

3. LA CRUE DE JANVIER 1982

L'inondation qui touche la région de Płock en janvier 1982 résulte d'une inondation d'embâcle charriant des débris de glace concassée. Mais elle n'a pas été typique, ni par son caractère, ni par son déroulement, en raison de la saison et de ses origines. Les causes de cette crue apparue en une saison inhabituelle pour ce genre de phénomène sont multiples. On peut citer, entre autres, les conditions météorologiques et hydrologiques très particulières dans les jours qui ont précedé: une baisse brutale de la température de 19 degrés en 15 heures dans la nuit du 6 au 7 janvier, des vents forts soufflant à la vitesse de 27 m/s, des bourrasques, un écoulement rapide de l'eau charriant des glaçons. La carte ci-jointe localise les territoires inondés en 1982 et définit les zones à protéger et à aménager lors de la construction du future barrage sur la Vistule.

L'inondation de la vallée à été provoquée par un gonflement inhabituel des eaux accompagné d'un débit relativement modéré. On estime que le débit maximal produit pour cette crue a atteint 2300 m^3/s. à Płock, soit moins que pendant les hautes eaux qui se produisent tous les deux ans (3800 m^3/s.) d'après les estimations de l'Institut de Météorologie et d'Hydrologie, le débit centenaire est de 8970 m^3/s. et le débit millénaire de 11 490 m^3/s. Le débit annuel record enregistré à Płock fut celui de 29 mars 1924: il s'élevait à 8620 m^3/s. et avait été provoqué par la fonte des neiges c'est à dire par un phénomène tout à fait différent. La crue observée à Płock a dépasse le niveau maximal noté depuis plusieurs siècles, elle est due à l'embâcle situé à l'aval de Skoki. Le 6 janvier la température a brusquement baissé, si bien que les glaçons se sont changés en une couverture de glace. Ce bouchon à l'amont du barrage de Włocławek sur une longueur de 100 km a fait obstacle à l'écoulement des eaux et a provoqué l'inondation.

Le 8 janvier, les eaux ont franchi une digue laterale du reservoir de Duninów et submergé la route entre Duninów et Soczewka. L'eau s'est déversée par la crète de la digue et l'a rompu à Brwilno. Ainsi la région de Popłacin et une partie de Płock, le quartier de Radziwie, se sont trouvées partiellement sous les eaux. Une quatrième brèche s'est ouverte près du pont routier et ferroviaire de Płock, inondant les jardins ouvriers de Radziwie et les villages de Tokary et Budy Dolne plus en aval. Le 10 janvier les digues de Dobrzyków et de Troszyn ont cédé à leur tour et l'eau a envahi quelques hameaux de la vallée (Dobrzyków – Iłów sur le territoire des communes de Gąbin et Słubice). Etant donné ses caractères morphologiques, la partie de la vallée de la Vistule située entre Modlin et Plock est prédisposée à la formation d'embâcles et de glaçons. Le barrage de Włocławek, en abaissant le niveau des eaux à l'aval et en favorisant le dépôt des alluvions entrave la libre circulatiom des glaçons. L'accroissement annuel de la sédimentation dans le réservoir est de 1.4 millions de mètres cubes. Le projet de réalisation d'un autre barrage à 10 km en amont de Płock ne ferait qu'accroître les risques d'inondation et plus particulièrement les inondations provoquées par des embâcles.

Ce risque augmente déjà, d'année en année avec le barrage existant. Ainsi, la retenue d'eau de Włocławek a favorisé la crue de 1982 pour les raisons suivantes: le bassin du réservoir n'était pas convenablement nettoyé, l'existence d'îlots, de troncs d'arbres flottants et de roseaux en témoignaient, la sédimentation faisant suite à la baisse du débit des eaux, continuait de s'accroître, les hauts fonds, qui sont l'une des embâcles se développaient, les îlots qui persistaient dans le lit de la Vistule entre Płock et Włocławek ont aussi favorisé la formation des embâcles dans cette partie du fleuve, l'accumulation des alluvions a entraîné le relèvement du fond du réservoir et par la le niveau du plan d'eau rendant insuffisante la hauteur des barrages latéraux et des digues. Ce contexte hydrologique local fut de plus (comme nous l'avons deja mentionné) accompagné de très mauvaises conditions atmosphériques. Il faut aussi signaler le manque d'efficacité des moyens techniques mis en oeuvre pour prévenir l'inondation: petit nombre des brises-glaces et insuffisance de leur puissance, coupure des liaisons téléphoniques. De ce fait, la glace n'a pas été brisée qu'avec retard, les embâcles n'ont pu sauter à temps et l'écoulement des glaces a été entravé. En même temps une digue du port de Płock se rompait, entravant l'inondation de la partie restante de Radziwie.

Actuellement la retenue de Włocławek augmente sa sédimentation d'année en année pour les raisons suivantes:

– le bassin du réservoir n'était pas convenablement entretenu ou moment de la crue puisqu'on y apercevait des îlots, des roseaux et des troncs d'arbres,

– la sédimentation due à la dimunition de la vitesse du courrant demeurait forte.

– les hauts fonds sont l'une des causes de l'embâcle et de l'arrêt des glaces,

– l'accumulation des alluvions provoque un exhaussement du fond du réservoir et du niveau du plan d'eau, ce qui rend insuffisant les barrages latéraux.

Selon les estimations des services du voïévodie de Płock le bilan matériel de l'inondation a été le suivant:

– 10 346 hectares inondés (soit 2% de la surface de la voïévodie) dont 9 178 hectares de terres arables,

– 5 250 bâtiments inondés totalement ou en partie,

– 14 376 personnes rescapées, 12 379 animaux sauvés et 2 239 fermes évacuées,

– environ 1000 animaux noyés.

La carte ci-jointe montre les détails géographiques concernant le territoire inondé.

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GEOGRAPHIA POLONICA 52, 1986

MORPHOGENETIC WIND ACTION IN THE HIGH-MOUNTAIN AREA OF THE TATRA MTS

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The highest parts of the mountains are the area, where strong winds often appear and attack a rocky substratum with poor vegetation. But the morphological effects of this activity are hardly known. Difficulties in a quantitative estimation of wind action results in the mountains, connected with changeable wind directions and speeds, in space and in time as well, led often the authors to formulate extremal opinions, i.e. to overrate or underrate a role of the wind as a morphological factor. In Tricart's (1970) opinion, a snow cover and ground moisture limit considerably a deflation process. A lack of eolian accumulation forms and weak rounding of eolian material in the Cordilleras is treated by Cailleux (1973) as a prove of the weak wind action. On the other hand, Paschinger (1928) interpreted a range rows genesis as the deflation one and Thompson (1962) considered the debris covers on the Cascades Range as a deflation pavement.

Klimaszewski (1971) enumerates the deflation as one of the most important morphogenetic processes of the Holocene period in the cliff and alpine belts. In the areas situated above the upper timber line, the wind is treated mostly as the factor of the mountain soils degradation, participating with the needle-ice in solifluction terraces remodelling (Plesnik 1956) and in gelideflaction terraces forming. In the development of the latter forms, the deflation is considered as a process of an equal rank (Troll 1973) or even the dominating one (Soutadė 1980) over the phenomena resulting from frost action.

The measurements leading to quantitative valuation of the wind action effects were carried out only sporadically. In the Tien-Shan Mts eolian deposition gives an annual increase of the deposits thickness at some 1–2 mm (Wojtanowicz 1972). In the High Tatra Mts. during the winter 1960/61, Klapa (1963) collected from the surfaces of 1 m^2 from 26 to 218 g of mineral material brought by wind. The rate of a retreat of the gelideflational terraces walls in the Pyrenees amounts to 0.8–3.5 cm/yr (Soutade 1980). In the Western Tatra Mts the rate of the similar forms retreat amounts to 2.28 cm/yr (Kotarba 1976), but eolian degradation leading to the surface lowering was estimated at 0.05 mm/yr. The latter value is referred to by the author to the mountain ridges and to upper section of windward slopes of the alpine belt, covered by thick, fine-grained periglacial covers, exposed in the places where vegetation has been destroyed. In analogical conditions of the Bielskie Tatra Mts the surface is lowered by deflation at 11–12 mm/yr (Midriak 1972).

The author's own systematic 4-years field work was a continuation, widening and deepening of the investigations presented above. Her aim was to determine a dynamic of eolian processes observed above the upper timber line in the Tatra Mts. The area of a research work was the upper section of the Sucha Woda Valley (2300–1505 m a.s.l.), especially favourable for the morphogenetic wind action. The course of deflation, transport and eolian deposition amount were precisely characterized in separate papers (Izmailow 1984, in print). The theme of the presented paper is the valuation of the morphogenetic wind action in the high-mountain area.

CONDITIONS OF EOLIAN PROCESSES

The Sucha Woda Valley, with a glacial relief, was eroded in the northern slope of the Tatra Mts, at the border of the High Tatra Mts cristalline massif and the sedimentary series of the Western Tatra Mts. It extends from south-west to north-east, perpendicular to a transversal depression of the main ridge crest. A facilitation of the local air masses exchange across the main ridge crest causes the often and long term winds. The active winds, with velocity more than 5 m/s are observed in 212 days per year. The course of the main orographic lines determines the locally dominant wind directions: south and north on the ridge and south-west, north-east and south in the valley bottom (Fig. 1). Among the strong winds, over 10 m/s and the very strong, over 15 m/s, the south and south-west directions are the most important. Of the latter ones, 2/3 are the foehn winds, which velocity is the greatest at 80 m/s maximally and the variations in speed are considerable, at some tens m during several seconds (Otruba and Wiszniewski 1974). Because of their character and their velocity, the foehn winds are of the greatest role in the eolian processes.

From the morphological wind action point of view, the lithological features of the substratum and vegetation mantle are less favourable. The investigated area of 4.5 km^2, contains all the elevational zones of the vegetation above the upper forest belt (Fig. 1). Among these zones only the cliff belt in the cristalline area of the High Tatra Mts, the south-eastern uppermost fragment of the discussed valley, with the area of 1 km^2, can be treated in the whole as the deflation area. The process of blowing off the material from the rocky ridges, rockwalls and sheet talus and moraine covers has a superficial character. The main ridge area lies in the zone highly influenced by foehn winds. Especially in the depression of the passes, because of an air streams confluence, the air movement is accelerated. But the maximal speeds, connected with the effect of descent, increased by the uneven longitudinal profile of the valley, are reached by the foehn winds some 100 m below the main ridge, in the upper sections of the rockwalls facing north-east (Sokolowski 1934). The rockwalls facing west-south-west are equally strongly attacked by wind, exposed on the wind strucks (Plesnik 1956). The course of deflation on the rockwalls depends on the rate of weathering.

The loose material lies at the foot of the rockwalls as moraine-scree covers, which accumulate in deep and shaded glacial cirques. The mechanical composition of that material, in which the fraction of boulders and rock debris prevails (Kostrzewski 1975) makes that it is hardly possible to blow it away. On the sheet talus, besides the deflation, the deposition of the eolian material from the rockwalls is observed, too.

More fine-grained are the loamy solifluction covers in the alpine belt, developed on the substratum of the Western Tatra Mts sedimentary rocks. They become exposed only locally, where the compact turf cover has been destroyed. These expositions, situated especially on the passes and on slopes facing south-west, influenced by the strong foehn winds, are the area of the aerial and linear deflation, totalling less than 0.05 km^2.

Most of these covers is protected against the wind by the compact plant cover. Therefore the slopes covered with a sod, surrounding the discussed valley from

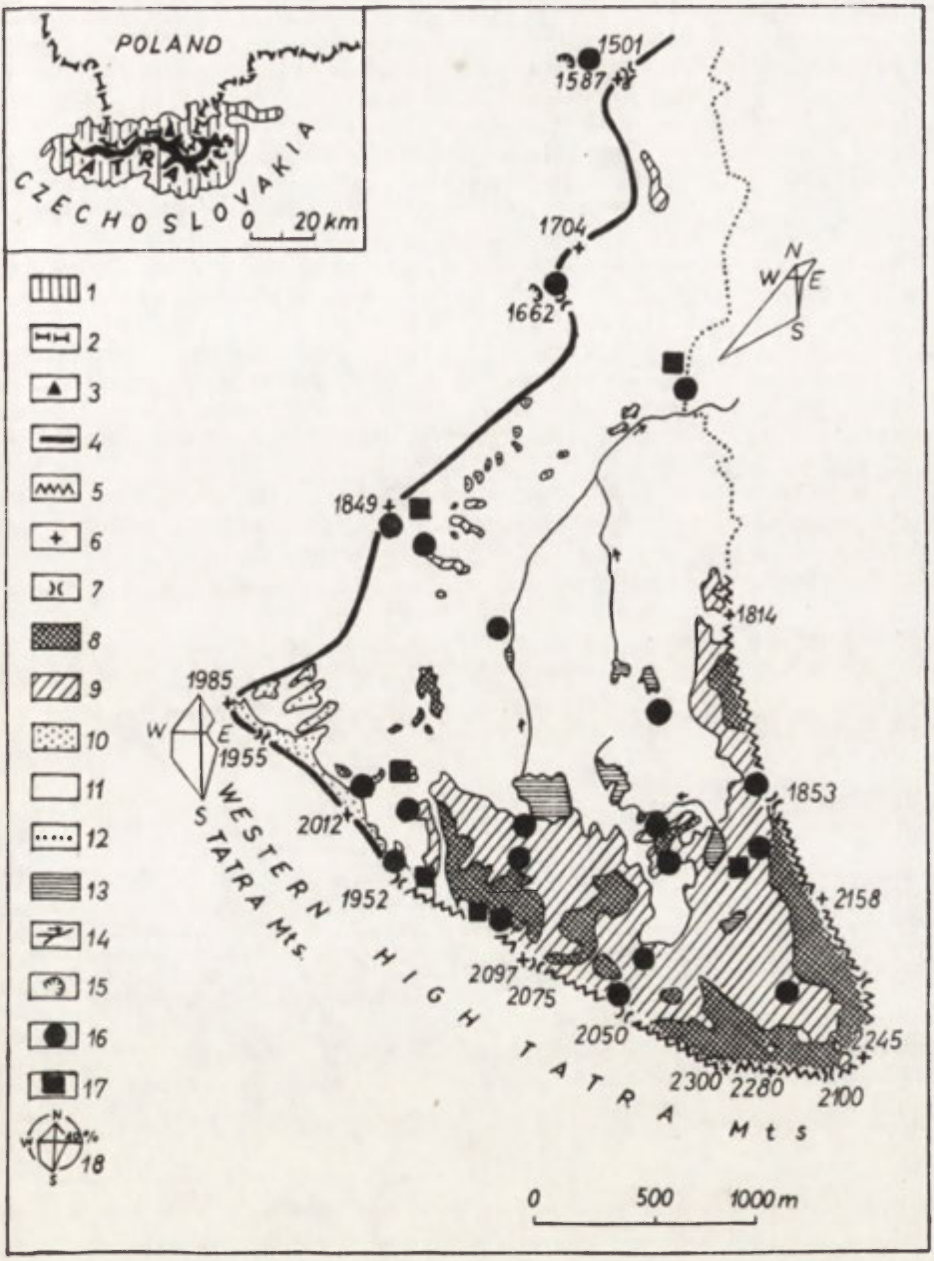

Fig. 1. Sucha Woda Valley: 1 – the Tatra Mts massif, 2 – international boundary, 3 – investigation area, 4 – mountain ridges, 5 – ridge crests, 6 – summits, 7 – passes, 8 – rock-walls (deflation area), 9 – sheet talus and moraines (deflation and deposition area), 10 – solifluction covers with destroyed plant cover (deflation and deposition area), 11 – alpine meadows and dwarf mountain pine thicket (eolian deposition area), 12 – upper timber line, 13 – ponds, 14 – streams, 15 – deflation niches, 16 – measurement sites of eolian deposition, 17 – measurement sites of deflation intensity, 18 – mean annual frequency of the active winds (≥ 5 m/s)

south-west and north-west, and the valley bottom overgrown thickly with dwarf mountain pine may only be a place of eolian deposition over the area of 3.5 km^2. In the Sucha Woda Valley this area is more than thrice greater than that where deflation is possible. This relation is not constant, according to the seasonal changes of the snow cover, to its development and its decline. The snow cover, present here by more than 6 months, limits also the deflation area. The seasonal changes are also observed in the wind action conditions, as they depend on the thermal and moisture state of the ground in the deflation area and on the anemologic conditions, too.

Taking into consideration wind regime and soil properties 4 periods during the year can be distinguished, differing by the conditions of eolian processes course:

1. Period with transient snow cover lasts from the half of September to the end of November. The ground, partially covered by snow, is dry because of the smallest sums of precipitation (mostly snow) in this period of the year. During frequent falls of the air temperature below 0°C the strong frost weathering and the needle-ice activity occur. A predominance of the strong southern winds, mainly of the foehn type, is established.

2. Period with lasting snow cover lasts from the beginning of December to the end of April. Only the rockwalls are free of snow, where with the predominance of the temperature below 0°C, the weak frost weathering occurs. This is the season

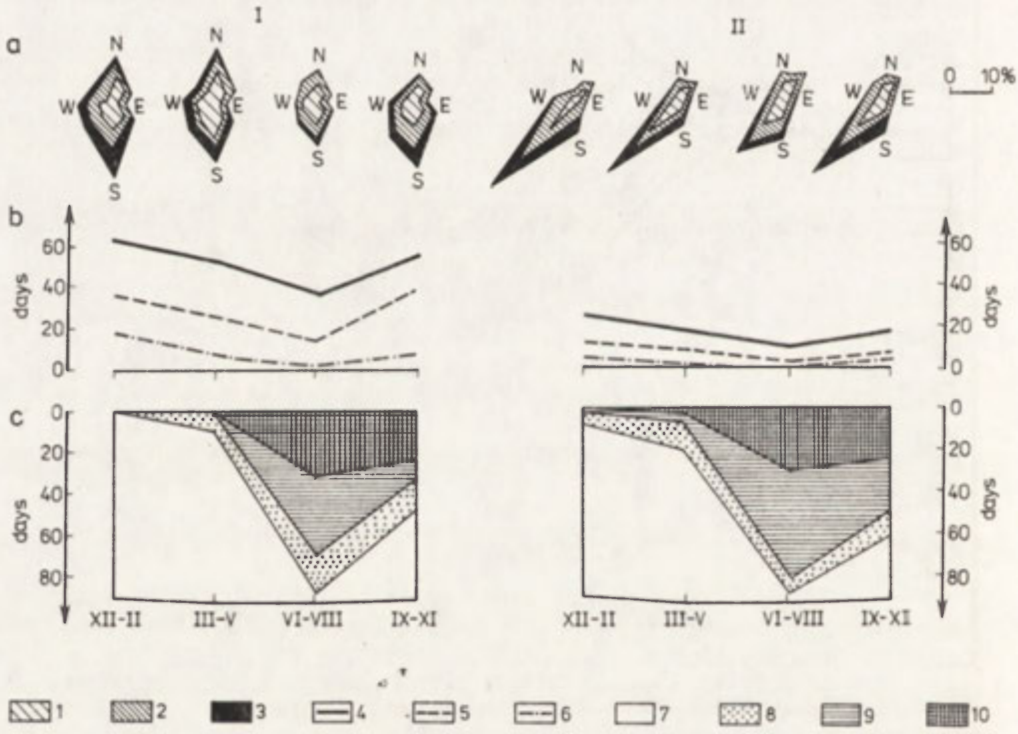

Fig. 2. Changes of deflation conditions in the course of a year on the basis of multiannual data (1938–1960): I – on the summits, II – in the valley bottom, a – frequency of the active winds (≥ 5 m/s) in the intervals of velocity: 1 – 5–9 m/s, 2 – 10–14 m/s, 3 – ≥ 15 m/s, b – number of days with the wind with velocity: 4 – ≥ 5 m/s, 5 – ≥ 10 m/s, 6 – ≥ 15 m/s, c – number of days with: 7 – lasting snow cover, 8 – snow patches, 9 – wet and humid ground, 10 – dry ground

of the greatest intensity of the foehn winds, thus the main direction is the south one. These winds reach their maximal speeds in this period.

3. Period with patches of snow lasts from the beginning of May to the half of June. The patches of the wet snow persist the longest in chutes, glacial cirques at the foot of the rockwalls facing north. The cover deposits unveiled from the snow and strongly imbibed with water from the snow melting, are transformed by the needle-ice action. The ground melts and weathers intensively. The prevailing of the weak northern winds is observed then.

4. Period free of snow lasts from the half of June to the half of September. Its characteristic features are: the maximum annual precipitations falls and its considerable intensity, mainly the rainfalls, causing the great moisture of the ground. The winds have their annual minimum of velocity, most of them are northern.

The surface of the potential deflation area in the Sucha Woda Valley changes together the seasonal distribution of the snow cover from 0.24 km^2 during the period of lasting snow cover to 1.03 km^2 in the period free of snow. A growth of the potential deflation area does not always imply better conditions for the eolian processes. These conditions are different even for the periods when the surface of deflation areas are similar (those of appearing and melting of the snow cover). Especially unfavourable is the annual distribution of the precipitations and that of the wind velocities and directions (Fig. 2). The domination of the strongest, southern winds, falls to the period of the snow cover duration and in the period free of snow the predominance of the weak northern winds coincides with the heaviest rainfalls. During the whole year, the periods when all the conditions needed for the effective wind action are fulfilled are short.

COURSE OF THE EOLIAN PROCESSES DURING THE YEAR

The wind activity above the upper timber line in the Tatra Mts consists in deflation, transport, corrasion and deposition. The net rates of these processes can be defined on the basis of the deflation forms development rate and the quantity of the material deposited by wind. The amount of eolian deposition was defined during 4-years (1975–1979) stationary measurements on 20 sites, located along valley longitudinal profiles and cross-sections (Fig. 1). In selecting these sites, the most important geological, geomorphological and floristic situations were taken under consideration. The frequency of the measurements was adapted to the seasonal changeability of the soil properties as well as to wind regime. The mineral material was collected three times a year: at the end of May, August and November, trom snow and in the period free of snow – from the cylinders filled with water. The same was the frequency of measurements of the retreat rate of the walls of two deflation niches (Fig. 1), using the 1 m^2 frame (Kotarba 1976).

The comparison of the results of the research with the analysis of the seasonal changes of the deflation conditions makes it possible to distinguish 4 periods during the year, when course, amount and intensity of eolian processes are different.

The most effective are the eolian processes when the snow cover appears, between September and November. The intensive frost weathering supplies the deflation with the material. The fresh snow, falling on the dry ground is downy for the long time, thus can be blown off even by the weak winds. This blowing off let the weathering material, dry, deeply frozen and strongly desintegrated by the frost action, be unveiled. During the fall or transport of the snow, the most intensive saltation of the mineral material occurs. The great foehn wind speeds make possible the coarse-grained fraction (a diameter to 32 mm) to be transported. The intensive blowing off and the long transport on the snow cover (to 30 m) give the greatest morphological effects during the whole year. The retreat rate of the deflation niches is the greatest (0.95–1.25 cm) and the quantity of the deposited material too (0.5–130.4 g/m^2) in the various parts of the discussed valley (Fig. 3).

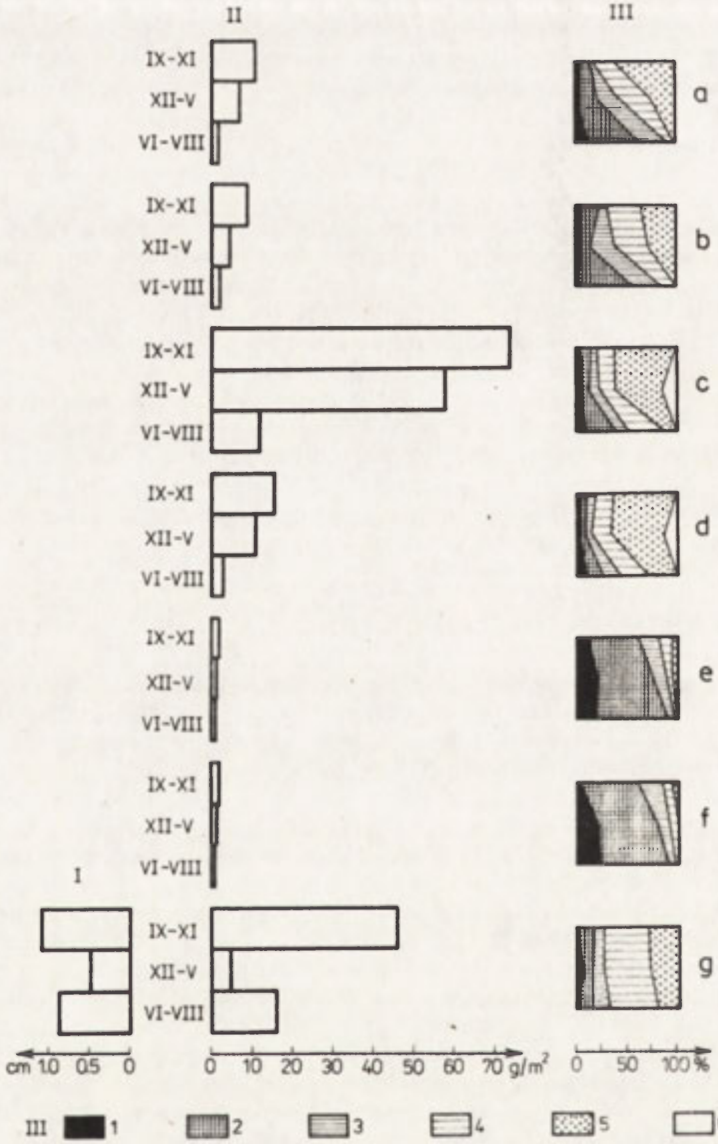

Fig. 3. Mean values from the four-year period for: I – retreat rate of the deflation niches, II – the amount of eolian deposition, III – granulometric composition of the eolian deposits: 1 – fraction < 0.06 mm, 2 – 0.06–0.25 mm, 3 – 0.25–0.5 mm, 4 – 0.5–2.0 mm, 5 – 2.0–10.0 mm, 6 – > 10 mm, for the granitic area: a – on summits of the main crest of mountains, b – on the passes of the main crest of mountains, c – on talus cones facing west-south-west, d – on talus cones facing east-north-east, e – on soddy slopes facing south-east, f – in valley bottom, and for the sedimentary rocks area: g – on the deflation niches foreground

The longest period, that with the snow cover, lasting from the beginning of December to the end of April, shows the small efficiency of the eolian processes. The deflation is limited only to the rockwalls, where weak weathering occurs. The thickness of the snow is so great, that all the ground denivelations are not visible. Over the smooth snow surface the wind reaches the great velocity in the near-ground layer, to 28 m/s in gusts. Therefore the transport of the rock fragments, to 76 mm in diameter, is realized. The snow cover makes the transport long. The single moves of the rock fragments amounts 3 m in maximum and are continued during the particular wind blasts. The saltation zone reaches 30 m. The deposition is selective – deposits are continuously reduced in amount and size as they are moved downwind. Owing the long transport, the material is deposited on the great area, although in the small quantity (0.3–119.6 g/m^2, together with the snow melting period).

Most of deposition of the above mentioned period is connected mainly with the short period (May–June) when the snow melts. During this period the eolian processes are strongly effective in the rockwalls. The strong deflation is connected with the intensive frost weathering and using the effects of the frost action from the previous period. The material is moved in the short distance on the wet, rough ground, thus the great concentration of the deposits close to the deflation areas is observed. As the material is deposited mostly on the snow, it is moved during the snow melting. Although the wind velocities are smaller, one can find in the eolian deposits on the sheet talus the great rock fragments, to 32 mm in diameter. Probably the role of the wind in the transport of such the great rock fragments relies only upon throwing them down the vertical rockwalls. On the edges of the snow patches in the deflation niches the needle-ice action is observed. The retreat rate of the deflation niches is the smallest in the whole year during this period – 0.45–0.46 cm only (Fig. 3), as the cover deposits – poorly permeable and imbibed with water – limit the deflation.

The less effective period in regard to the eolian processes is that free of snow, lasting from June to August. The domination of the weak northern winds and the strong reduction of their velocity made by a friction over the rough ground, let only the smallest grains to 6 mm in diameter, be transported. The roughness of the ground determines the strong air flow turbulence, thus the lowest threshold wind velocity for the given fraction. Thus the deflation occurs often, but the transport, because of the strong friction, is short, to 50 cm in maximum. The deposition is due to the ground denivelation and the grains which were deposited are very seldom set in motion again. The saltation zone does not exceed 4 m. The reduction of the quantity and the diameter of the grains with the growth of the distance from deflation area is violent. As the eolian processes cover during this period the greatest area of the whole year, the deflation and deposition, although weak (deflation niches retreat rate amounts 0.55–0.64 cm, and deposition 0.1–31.7 g/m^2), show the most proportional spatial pattern in the whole year. The wind effectiveness in this period depends considerably on the frequency and the intensity of the rain falls.

The eolian processes do not occur continuously, they are limited to the periods with strong winds, especially to those of the foehn ones, and to the favourable conditions of the ground during their appearance. Such periods occur mostly during winter snow cover appearing. They last shortly but the effects of the eolian processes exceed the ones realized during the remaining, much longer part of the year.

EFFECTS OF THE MORPHOGENETIC WIND ACTION

The forms and deposits are the stable effects of the wind action. They are formed partially with participation of the other morphogenetic factors. Deflation forms appear in the alpine belt, in the fine-grained cover deposits, developed on the sedimentary rock substratum, unveiled in the areas, where the plant cover is destroyed, usually along tourist routes and on the passes. Blowing off the loose material under the turf clumps leads to the niches to appear, of 30 cm depth in maximum. The deflation, which begins with attacking the steep niches walls, during their retreat, contains also their bottoms. Deflation forms are situated singly or in chains, separated by the residual turf clumps, marking successive stages of the degradation. Besides the small forms, the great deflation niches develop, with lengths reaching several metres and the walls heights – 50 cm. The best developed deflation forms are always exposed to the prevailing south-western winds.

The wind takes also part in the remodelling of the cryogenic forms, described in the literature as the gelifluction terraces (Jahn 1958), soil garlands (Midriak 1972) or turf scars (Troll 1973, Soutade 1980). Generally, it is admitted, that those forms are the result of the needle-ice action in common with deflation. These processes form the terraces, bow-like bent with irregular shapes and the lengths up to 1.5 m. They consist of the flat surfaces and the steep walls, separated by breaks. Flattening, covered by the rock fragments with the 2–8 cm in diameter, pass into the convex breaks, surrounding the grass garland, being often the turf hang over the vertical wall of 30 cm height, on which the fine-grained material is seen. The wall passes by the concave break into the flattening of the form lying under. The considerable fact is the connexion between the prevailing wind directions and the pattern of those forms, having the shape of the typical deflation niches. Their walls are the forms the most strongly attacked by the blowing off and stroke by the material transported by the wind Undercutting of the walls by deflation and corrasion causes slumping of the turf hang over, thus the retreat of the whole form. Because of the limited possibilities of the wind transport capacity, the deflation is not the blowing off the whole loose material, but only of the fine-grained tractions. The great rock fragments are lost, forming the deflation pavement, concentrated on the flattenings, on the niches foreground.

The above described mechanism of the wind action is similar to the one observed in the case of the typical deflation niches. The average retreat rate of the walls of both types of the niches is similar, 2.07–2.27 cm/yr. These amounts mean 118–141 cm^3 of the material removed from 1 m^2 during the year. The simultaneous measuring of the eolian deposition show 54–68 cm^3 of the material from the niches walls. A comparison of the eolian deposition amount with that of the niches retreat rate in the various seasons (Fig. 3) shows, that in both cases these processes manifest the greatest intensity between September and November and the smallest one – from December to May. These results prove the dominating role of the wind in the actual modelling of the niches. In the author's opinion, the needle-ice action importance in the development of these forms is not in the moving the material but rather in preparing it for the deflation.

On the rocky and scree slopes of the High Tatra Mts the effects of the superficial blowing off the fine-grained material are not visible among the rocky fragments of the initial material.

The eolian deposits consist of the rock fragments, single minerals and their aggregates. Their mineral composition and granulometric features, depending on the character of the initial material, length of transport and wind velocity, show a great differentiation of the particular parts of the discussed valley. There are rock fragments, sand and dust fractions. The greatest fragments, ⩾ 10–32 mm in diameter, were collected from the sheet talus, lying at the foot of the rockwalls, where the role of the wind in the transport of such great rock fragments is often limited to throwing them down. The grains of 2–10 mm were found in eolian deposits along the whole mountain ridge, near the rocky outcrops and moraine covers. The grains smaller than 2 mm in diameter were not seen on the slope facing south-east, nor in the dwarf mountain pine belt in the valley bottom (Fig. 3). The deposits are weakly sorted ($\geqslant$ 1.0–2.28) and not rounded.

During most of the year the material is deposited on the snow, therefore the deposits are called the niveo-eolian ones. Dislocated during the snow melting, they become the part of cover deposits of another origin. All the slope covers contain in their composition some of the eolian material. Its amount is difficult to measure, because of its lack of structure and grains rounding, and variety of the granulometric composition. The unstable deposition and the small quantity of the material deposited by the wind cause the lack of the stable eolian accumulation forms. Eolian deposition process in the mountains is limited to creating and accreting the cover deposits only.

The annual dimensions of the eolian deposition of mineral material varied from 1.0 to 265.1 g/m^2 in the particular parts of the discussed valley. This quantity depends on the initial deposits character, the length of transport, exposition and relief forms. In the main ridge the greatest amounts of the material were deposited close to the deflation niches (38.0–91.4 g/m^2/yr), developed on the sedimentary rock substratum. The posts situated along the ridge in the cristalline rocks zone (Fig. 3) show smaller deposition (10.7–25.0 g/m^2/yr), greater on the summits than on the passes. The amount of the deposited material grows at the foot of the rockwalls, on their north-eastern side, in the glacial cirques (11.4–47.0 g/m^2/yr). The greatest amount was deposited on the sheet talus facing west-south-westward (88.8–265.1 g/m^2/yr). Down in the valley the deposition is reduced, especially violently in the dwarf mountain pine belt (1.2–2.5 g/m^2/yr). The small amount of eolian material are deposited on the slope facing south-east with the compact turf cover and that of the dwarf mountain pine (1.0–3.5 g/m^2/yr). The above presented data concerning the eolian deposition amount and deflation forms development rate are close to the results of Klapa (1963) and Kotarba (1976) measurings, realized also in the Tatra Mts.

ROLE OF THE EOLIAN PROCESSES IN MODELLING THE HIGH-MOUNTAIN RELIEF

The displacement of the loose material by the wind leads to the degradation of some areas and aggradation of others. The amount of these processes can be defined indirectly, by the quantities of the material deposited by the wind related to the total deflation area and that of the deposition. The annual changes of their surfaces and the difficulties in reconstructing the transport routes make the calculation of the eolian degradation degree of the given area difficult. Its quantitative measurement or rather an estimation is only possible for the rockwalls and the deflation niches.

The rockwalls are only the deflation area for the whole year. They form also a barrier to the eolian transport which moves in discordance with the walls inclination. That is why the material moved from the rockwalls goes down to the sheet talus in spite of the wind direction. This fact limits strongly the displacement of the material through the ridge and restrain the transport process to the valley boundaries. Taking the average value of the eolian deposition on the sheet talus as the base for the calculation, the average quantity of the material moved from the cliff belt by the wind can be estimated at 35 cm^3/m^2/yr. It means, that the rockwalls retreat rate amounts to 0.03 mm/yr. In the alpine belt in the deflation niches, blowing off is more intensive, amounting to 60 $cm^3/m^2/yr$, thus the surface is lowered at 0.06 mm/yr.

The presented values suggest, that the eolian degradation is stronger in the thick fine-grained periglacial covers than on the rockwalls, according to Kotarba's (1976) remark. But it is necessary to consider that the value calculated for the deflation niches refers only to small percentage of the total area of the alpine belt, mostly covered by the turf, thus not destroyed by the deflation. In the author's opinion the eolian degradation is stronger in the cliff belt, where blowing off, greater or smaller, is observed everywhere.

Eolian degradation, advancing along the zones of smaller bedrock resistance and those of the stronger weathering, to which the destruction of the natural vegetation cover is favourable, is selective. Its course depends also on the exposition and the relief forms. This is proved by the results of the deflation intensity measurings, realized 9 times during the foehn winds, simultaneously in 6 sites in the discussed valley (Fig. 1) for the samples of the identical grain-size composition. The strongest blowing off was observed in the upper sections of the windward slopes (Fig. 4)

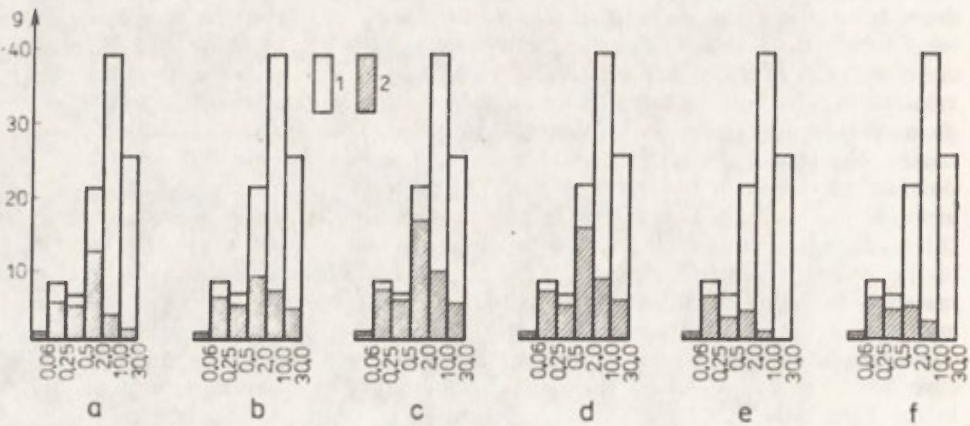

Fig. 4. Mean intensity of deflation during the foehn wind in $g/m^2/h$: 1 – quantity of the material not moved by deflation, 2 – quantity of the material blown away, a – on a summit of the main crest of mountains (2030 m a.s.l.), b – on a pass of the main crest of mountains (1950 m a.s.l.), c – on a slope facing west-south-west (1865 m a.s.l.), d – on a slope facing east-north-east (1845 m a.s.l.), e – on a slope facing south-east (1810 m a.s.l.), f – in valley bottom (1515 m a.s.l.)

from which the greatest quantities of the material of the greatest fraction were moved. The wind attacked more weakly the areas of the ridges, where deflation was marked out much stronger on the passes than on the summits. Beyond the ridge line the deflation amount grew in the upper parts of the leeward slopes. The weakest deflation occurred in the valley bottom, situated along the wind direction and on the slopes parallel to it. The quantities of the material moved from this area were the smallest. The results of measuring are in accordance with Kotarba's (1976) ones, concerning the areas the most strongly degradated. This class should include the upper sections of the slopes situated in the air masses descent zone during the foehn winds.

The lower sections of these slopes, all slopes covered by the plants, regardless their exposition and the valley bottom, are aggradated. Eolian deposition process reaches its maximum on the sheet talus where the average quantity of the deposited material amounts to 26 $cm^3/m^2/yr$ i.e. the aggradation rate does 0.02 mm/yr. But in fact, the increase of the eolian deposits is slower because part of them is displaced again by the wind or other morphogenetic factors.

In the wind action one can notice a tendency of an extremely slow levelling of an area, by moving the loose material from the mountain ridges and upper parts of the slopes and accumulating it in the valley bottoms. This material is not removed then from the post-glacial valleys.

In spite of rather disadvantageous conditions and hardly visible effects of the eolian processes, as remarked Tricart (1970) and Cailleux (1973), the author's research results confirm Paschinger's (1928) and Thompson's (1962) opinion on the great role of the wind in modelling the high-mountain areas. According to Klimaszewski's view (1971) in the cliff and alpine belts the wind is one of the most important morphogenetic factors, although in the Tatra Mts the effects of frost weathering and rock falls are manifoldly greater (Kotarba 1976). The significance of soil creeping (Dobija 1973) and that of debris flows and nival processes is also greater. Eolian action is stronger than that of the needle-ice, the role of which in gelideflation terraces modelling is rather overrated (Troll 1973).

The effects of wind action in the Tatra Mts are similar to the amount of the degradation and eolian deposition in the Pyrenees (Soutade 1980) and in the polar regions (Czeppe 1966; Pissart 1966). But similarities of the scale of the analysed phenomena in the areas distant from the Tatra Mts even with resembling lithological, climatological or vegetational conditions does not allow to make an extrapolation of the values calculated for the Sucha Woda Valley, for other mountain areas and not even for those of the Tatra Mts. The great differentiation of the mountain relief forms determines the instability of the wind action conditions, seen even in the neighbouring valleys (Sokolowski 1934). In the Sucha Woda Valley these conditions are especially favourable, therefore the effects of the morphogenetic wind action are probably greater here than those in the other parts of the Tatra Mts. But the rules concerning eolian processes course will be common for the whole high-mountain areas of the Polish Tatra Mts.

CONCLUSIONS

The wind is an important morphogenetic factor in the high-mountain area, containing in the scope of its differentiated action all the zone above upper timber line. The character of the wind action depends on the vegetation type, accelerating or limiting deflation process and that of the mineral material transport. The loose complexes of the sheet talus vegetation and that of cliffs cannot stop the blowing off deposits, but alpine meadows and dwarf mountain pine cover can only be the areas of eolian deposition. Deflation is the point phenomenon there, observed in the places, where the turf is destroyed.

The great frequency of the active winds, with the lack or scarcity of the loose fine-grained material causes, that the potential of wind action is far greater than its real effects.

The morphogenetic wind action consists of deflation, transport, corrasion and deposition, the effects of which are the degradation and aggradation of the cover deposits. But these effects are barely visible. The only forms are deflation niches. Eolian deposition does not create stable forms, it only produces cover deposits, which cannot be distinguished because of the lack of structure and varying granulometric composition.

By transporting of the loose material the wind participates in the degradation of culminations and in aggradation of the valley bottoms, thus in levelling of the area. But it is a very slow process and its effects are far smaller than those of gravitation processes, dominating in the Tatra Mts.

On the gentle slopes with thick fine-grained periglacial covers, developed on the sedimentary rocks substratum, intensity of deflation is greater than on the rockwalls and sheet talus of the cristalline area, but due to greater area of the wind action, the eolian degradation progress is faster in the cliff belt than in the alpine one.

The character, intensity and effects of the eolian processes depend on the relief forms. The strongest wind action is observed in the mountain ridges and in the upper sections of the windward slopes and in the cases of the foehn winds – in the air descent zone, too.

Eolian processes do not occur continuously. They are limited to the short periods of the strong, southern winds of the foehn type and to the favourable soil properties – the lack of the lasting snow cover and the dry state of the ground. They show a well marked seasonal changeability with maximum effectiveness in autumn and the minimum – in summer.

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GEOGRAPHIA POLONICA 52, 1986

PHYTOINDICATION METHODS IN LANDSCAPE PLANNING AND MANAGEMENT

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1. INTRODUCTION AND THE AIM OF THE STUDY

The recent fast development of processes of industrialization and urbanization which brings about far-reaching structural changes in geographical space makes us seek the most optimal solutions in landscape planning and management. On the one hand, such solutions must protect still existing natural areas whose share in the total area is progressively decreasing and aim at making the anthropogenic impact on the environment as limited as possible, and, on the other, they must take into account dynamic changes of biotopes' characteristics and, thus, determine the strength and pace of degradation of the environment under the influence of intensifying man's activity. To work out a concept which would meet these postulates, it is necessary to have such methods which would make it possible, in a short time, to obtain as many data on the investigated environment as possible, and especially those which characterize potential biotic values of habitats. This makes geographers face new methodological tasks as todate research on the natural environment employing field-laboratory methods requires high expenditure of work and is very time-consuming, and the results obtained from this research not always give full characteristics of habitats' potential values. Therefore, the search for new methodical solutions should be expanded to other branches of science dealing with research on the natural environment, and primarily to different biological sciences. The basis for working out a new method of landscape research should be provided by scientific achievements obtained in those branches.

The aim of this study is to present one of the methods of research on the natural environment which is of an interdisciplinary character, i.e. plant bioindication (phytoindication) which excellently supplements methods traditionally employed in landscape planning and modelling. The analysis presented in this study includes results of Polish studies with particular regard to results obtained on the basis of a method which is even more broadly employed in landscape research in Poland, namely, the Ellenberg method (1950, 1952, 1974, 1979).

2. THE METHOD

Phytoindicative research based on the assumption of a strong interdependence between plants and their habitats makes it possible to quickly find out abiotic and biotic characteristics of the environment with the help of species, groups of species or plant communities which occur in a given area. The first divisions of plants which react to a definite environmental agent were made by geobotanists as early as over a hundred years ago, but one can speak about the birth of modern phytoindication as late as the 1920's. It was brought about by the development of outecological research which describes interdependences between different plant species and their habitats and the rest of the biocenosis. One should mention such geobotanists as: Clements (1920), Olsen (1923), Linstow (1929), Mevius (1931), Sampson (1939) and in the postwar period, Ellenberg (1950, 1952, 1974, 1979), Braun-Blanquet (1951), Boyko (1955), Wagner (1955), Ramienskii (1956) and Landolt (1977) who attached great significance to the edaphic (soil) factor and the influence exerted by the remaining components of the natural environment on plant development.

Still more exact results of research on conditions of the abiotic environment are obtained with the use of not species and groups of species but phytosociologically classified plant units. It is the so-called synecological line of research. Plants, as a significant component of complex ecological systems, are connected with other components of those systems through a number of dependences whose character is that of feedbacks. When the structure of those dependences is known, it is possible – on the basis of plant recognition – to draw conclusions on other components of ecosystems and on changes which occur in them. It also appeared that the so-called ecological amplitude (i.e. the range of tolerance) of plant communities is narrower than that of individual species (Wojcik 1977, Ellenberg 1979, Matuszkiewicz 1981).

Outecological and synecological analyses provided the grounds for working out two, in general, lines of phytoindicative research:

– synthetic and comparative one which consists in stating a statistically credible dependence between the appearance of a given plant or plants and the occurrence of a known characteristic,

– analytic one which consists in research, under laboratory and field conditions, on the relation of a given plant or plants to a definite characteristic which is described quantitatively and dynamically (Kostrowicki and Wojcik 1972). Numerous researches have proved that both methods are very useful in the planning of geographical space, under the stipulation, however, that synthetic bioindication is of particular significance for preparing an initial assessment of abiotic properties of the environment for landscape planning and description of changes occurring in the environment under the influence of anthropopressure, while analytic bioindication supplements synthetic research, providing quantitative results which are statistically credible, close to, and frequently more exact than those obtained by means of traditional methods.

Naturally, as every method, also phytoindication has its shortcomings and limitations on its use in landscape planning. The first shortcoming is the fact that not all the characteristics of the natural environment may be defined with the use of this method, which means that in the complex ecological characteristics they must be supplemented by detailed research; the second one is the fact that not all species preserve their indicative value towards a given characteristic in the total area of their occurrence. Therefore, while using indicative studies from other regions, one must remember to check their indicative value in the investigated area.

3. APPLICATION OF PHYTOINDICATION TO THE ECOLOGICAL CHARACTERISTICS OF THE ENVIRONMENT ON THE EXAMPLE OF POLISH STUDIES

3.1. SYNTHETIC METHODS OF BIOINDICATION

Synthetic methods of bioindication, as the previous chapter has already indicated, make it possible to state simple dependences between the appearance of given plants and the occurrence of known habitat characteristics. Thus, they may be used for indicating the occurrence of many phenomena existing in the natural environment, and also for estimating its qualitative changes taking place mostly due to the influence of intensifying man's activity and resulting in, for example, either air or water pollution with different chemical compounds, changes in the salubrity of the environment, etc. The application of synthetic methods of phytoindication has developed in two directions in Poland so far.

One of them, which is very important in landscape planning, is the so-called lithobioindication, i.e. defining relations between plants and the type of relief, petrographic composition of the underlying ground, pace of contemporary geomorphological processes (mostly accumulative and erosional ones), etc. The dependence of plants on types of relief in mountainous landscape was presented by Wójcik (1977) who pointed to a close dependence of occurrence of a given variety of segetal plants under the same geomorphological conditions. The results obtained by that author make it possible to unequivocally determine – on the basis of the knowledge of plants growing in fields under crop – the morphogenesis of contemporary relief forming processes in mountainous landscape (like, e.g., earthslide, wash-down, erosion and accumulation processes).

Examples of species with an indicative value in determining the pace of contemporary geomorphological processes were presented by Kostrowicki and Wójcik (1972). These authors pointed to the fact that plants were very sensitive indicators in such research. For example, mass occurrence of such plants as: *Festuca rubra*, *Holcus lanatus*, *Anthoxanthum odoratum*, or *Luzula campestris* in sodded areas indicates water erosion (wash-down) with the intensity of 1.7 mm/yr when the slope is 10°, 3.9 mm/yr when the slope is 20°, and 8.3 mm/yr when the slope is 35°. They also pointed to those species which characterize the strength and size of eolian erosion or accumulation processes.

Still another component of lithology which is of significance for the proper organization of geographical space is the petrographic composition of the underlying ground. The possibility to determine mechanical soil groups on the basis of the knowledge of plant species occurring on these soils was presented by Borowiec and Kutyna (1974) for northwestern Poland.

The second aspect of research which makes use of synthetic methods of phytoindication in the cognizance of the natural environment is the environmental science which aims at the protection of natural biocenotic systems and their proper management. In contemporary landscape planning, when man's activity is ever more intensive and the natural environment ever more changing because of this, the determination of the state of degradation of biogeosphere is a very significant problem. Phytoindicative research of the type of environmental science is dominated in Poland by works which determine – on the basis of changes in the structure of plant species – the strength of harmfulness of industrial emissions to the natural environment around highly industrialized places (Chojnacki 1975; Boratyński 1983; Marchwińska and Kucharski 1983). Attempts are also made to prepare regional or macroregional studies. One of them was made by Greszta (1975) who presented the characteristics of changes in plants in the southern Polish macroregion brought about by the industrial emission from the Silesian–Cracow Industrial District. In the investigated area, the author delimited three zones with a different degree of quantitative and qualitative changes in plants, depending on the concentration of substances emitted to the atmosphere by industries. Such research is of colossal significance for the proper organization of spatial management in areas, since the knowledge of plant cover makes it possible to determine ways of land use with regard to health aspect.

In Poland, the health characteristics of given areas are studied on the basis of

Wehmer's work (1935). That work includes the characteristics of those species which produce perfume oils, volatile substances, tanning agents, substances with strong medicinal properties, and also chemical compounds which are components of many vitamins. The valorization of medicinal properties of areas assigned for the construction of a new housing district in Warsaw based on these indicators was presented by Roo-Zielińska (1982).

3.2. ANALYTIC METHODS OF BIOINDICATION

Analytic methods of bioindication which supplement synthetic ones are used mostly for determining climatic, trophic and hydrological properties of habitats expressed quantitatively. All analytic ecological indicators like: Ellenberg indicators (1950, 1952, 1974, 1979), Ramienskii (1956), Zölyomy (1966) and Landolt (1977) indicators were established on the basis of the division of plant species into classes whose relation to selected ecological factors was alike and ascribing rank indicative values to them.

In Poland the most frequently used method of mean ecological indicators is the Ellenberg method (1950, 1952, 1974, 1979) which determines the relation (sensitivity) of plants to: light L, continentality K, temperature T, soil moisture W, soil reaction R, nitrogen abundance in soil N, and, with some species, to soil biological activity G, its salinity and the presence of heavy metal salts. In spite of the fact that in Poland the application of the Ellenberg method to research on the natural environment was introduced relatively recently, it has developed dynamically and those who employed this method took into account all the corrections and supplements introduced by the author. Today, Ellenberg (1974, 1979) has provided characteristics of over 2000 species of vascular plants whose decisive majority occur in Poland. Their indicative value for different areas in Poland has been statistically checked. In the Kampinos National Park, for example, results characterizing trophic and water soil properties obtained with the use of the Ellenberg method have been compared with results obtained by means of field-laboratory methods (Degórski 1982). Results characterizing thermal continentality determined by means of climatological and bioindicative methods were confronted for the total area of Poland (Degórski 1984). The statistical confrontations of the results which determine trophic and water soil properties obtained by means of two different and independent methods was made by the authors in those points where field measurements were carried out for three years, and next relevè protocol was made in the same points. Mean values of Ellenberg indicators and values calculated from a three-year-series of field observations for every phytosociological unit in the investigated area were determined in a similar way. The obtained results were used for a statistical analysis. The strength of correlation and regression functions of investigated dependences were determined. Exemplary results of statistical calculations are presented in Table 1 and 2, while the dispersion of results calculated with the function of regression between R values and exchangeable calcium content Ca^{++} in soil is presented in Fig. 1.

The confrontation of the forming of the degree of continentality was made by the author on the basis of two indicators: the Ewert climatic one (1972) and the Ellenberg bioindicative one (1974) calculated for over 50 macroregions in Poland. The force of correlation obtained in that research was also very great ($r = 0.895$). The shape of the distribution of variables and the regression function of the discussed dependence is shown in Fig. 2.

Characteristics obtained by means of the method of mean ecological indicators are also broadly used in research on the spatial differentiation of habitat condi-

TABLE 1. Indices of linear correlation between the indicators of ecological characteristics and the results of field habitat determinations at research points

R	Ca^{++}	V	pH_{H_2O}
	0.968	0.800	0.778

R – reaction figure, *F* – moisture figure, V – degree of base saturation, f – soil

TABLE 2. Coefficients of Spearman rank correlation between indicators of ecological characteristics and the results of field habitat determinations in plant communities

R	Ca^{++}	V	pH_{H_2O}
	0.929	0.929	0.750
F	h	f	
	0.893	0.920	

R – reaction figure, *F* – moisture figure, V – degree of base saturation, f – soil moisture, h – depth of occurrence of ground waters

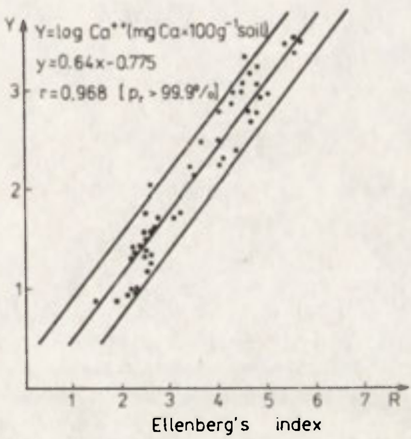

Fig. 1. The regression between *R* indicator values and results of exchangeable calcium content Ca^{++} in soil determined under laboratory conditions

tions, especially in small areas. The results obtained with phytoindicative methods presented on maps correspond to the content of maps which represent the spatial distribution of other components of the natural environment such as: relief, soil cover (Borowiec et al. 1977; Degórski 1982), or climatic components (Degórski 1984).

Such a strong correlation obtained between the results of two independent methods and correspondence between the spatial distribution of the Ellenberg indicative values and the spatial distribution of components of the natural environment points to the full reliability of data on habitats obtained on the basis of plants occurring in a given area, and, at the same time, authorizes us to practically use phytoindication in landscape research.

The practical application of Ellenberg indicators was introduced in Poland less than fifteen years ago. The main research line was pedobiology, i.e. the diagnosing

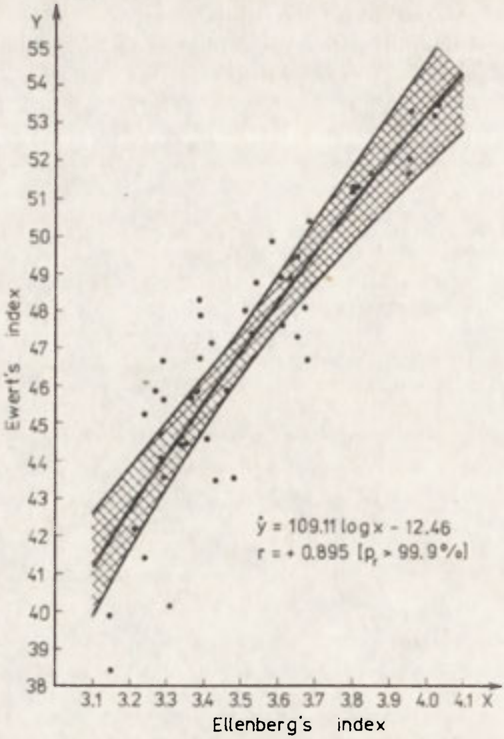

Fig. 2. The regression between continentality indicators (Ellenberg and Ewert) in 46 Poland's macroregions

of water-trophic values of soil for farming (Borowiec 1972 a, b; Borowiec et al. 1971, 1973, 1975, 1977; Wójcik 1974, 1977; Warcholińska 1978, 1980). Good results of research on the natural environment carried out with phytoindicative methods were obtained through determining relations between plants, on the one hand, and soil reaction and habitat water relationships, on the other. To gain a thorough knowledge on water relationships in a given area requires much time and high expenditure of work when traditional methods are employed, while the application of ecological methods makes it possible to obtain fully exact results in a relatively short time. The application of phytoindicative methods is of particular significance in Young Glacial areas, on light soils formed in loose sands where slight differences in true height result in big differences in soil moisture. These differences, which are of great significance in agricultural and silvicultural land management, are practically indetectable with the use of other methods (Borowiec et al. 1971). Similarly, correct results in determining water relationships in Central Polish valleys with the method of ecological indicators were achieved by Degórski (1982). He pointed to the possibility of quick determination of soil water resources and depth of occurrence of ground water on the basis of calculated indicators of sensitivity of plants to moisture *W*.

On the other hand, the application of the discussed method on the Low Beskid Plateau, i.e. in an area with mountainous and piedmont relief (Wójcik 1974, 1977) does not produce similar results in respect of water relationships as on the Lowland. Hydrological phenomena in mountainous landscape depend on a number of environmental factors which are strongly diversified in space. Therefore, as the author

(Wójcik 1977) pointed out, the indicator which best characterizes the quality of mountainous habitats and shows much correspondence to the petrographic composition and total soil fertility is the reaction figure *R*.

A very interesting attempt to estimate the total soil fertility expressed with Ellenberg indicators values, calculated from ecological characteristics of plants occurring on soils of the Western Pomeranian region was presented by Borowiec and Kutyna (1974). The obtained values of ecological indicators *T*, *W*, *R*, *N*, and *G* and characteristics of soil fertility corresponding to them were confronted in a table which makes it possible to unequivocally read the genetic type of soil, complexes of soil farming value, and soil mechanical groups when the Ellenberg figures are known. The application of this type of studies to spatial land management contributes to a more efficient land use, i.e. one that makes use of habitat's biotic potential.

Ellenberg indicators have been ever more broadly used in complex landscape planning recently. An example of this may be provided by a study by Roo-Zielińska (1982) who used the presented method in a detailed physiographic expert's report for planning a new housing district in Warsaw. The characteristics of habitats obtained by means of the method of Ellenberg mean ecological indicators presented by Roo-Zielińska is one of several biological assessments of their value. In the planning of geographical space of investigated areas, the results obtained by the author provide the basis for selection of places for different types of land development, areas left as green belts, areas delimited as ecological passages, etc. In her analysis of the investigated area the author also took into account its health values due to the composition of plant species and microclimatic diversity. A very interesting result of research on the climate of the future housing district is the statement of the impact of a big city like Warsaw on the softening of climatic conditions in the suburban zone where the calculated continentality index ($K = 3.3$) is more characteristic of Brandenburg or Western Pomerania rather than of Central Poland ($K = 3.7$).

To close the characteristics of bioindicative methods, one should also mention an example of improvements in the use of the Ellenberg methods presented by Degórski (1982). These improvements consist in referring the results of bioindicative research to the results of direct research and working out a standard model on the basis of the regression function of two variables (value of Ellenberg indicators, results of direct research). The results calculated on this basis and next confronted in tables would make it possible to quickly read data on habitats on the grounds of the knowledge of ecological demands of plants and plant communities. An exemplary confrontation of results which characterize the exchangeable calcium content Ca^{++} in soil read from the regression function and determined under laboratory conditions is shown in Table 3.

TABLE 3. Comparison of results of Ca^{++} content in soil read from regression function with results of field habitat determinations

Plant community	Indicator *R*	Mean Ca^{++} content in soil (mequiv)	
		1	2
Fresh mixed pine-oak forest (typical variant)	3.30	0.90	0.86
Dry oak-hornbean forest	5.14	12.90	10.18
Flood-plain ash-alder forest	5.80	44.10	40.76

1 – read from the regression function
2 – determined on the basis of field habitat determinations

3.3. PLANT CARTOGRAPHY – MAP OF POTENTIAL NATURAL VEGETATION

Methods presented in the previous chapter are mostly employed in large-scale landscape planning, i.e. for areas at local and regional level. For similar works on a review scale, the source of information on the physicogeographical environment is the map of potential natural vegetation. Such a map is also often used as a basic synthetic geobotanical study for the proper landscape management in smaller areas, but in such cases the information included in the map is broadly supplemented with phytoindicative diagnoses made with synthetic and analytic methods.

The map of potential natural vegetation is a specific source of information on the physicogeographical environment which, at the same time, is of a bioindicative character. Its bioindicative value results from the fact that, according to its concept, this map reflects the ecological and productive potential of the physicogeographical environment, and when compared with the state of actual vegetation, it points to changes introduced to geoecosystems by man. The map of potential natural vegetation makes it possible to read such characteristics of biotopes as: the direction and intensity of the currently prevailing soil process, soil trophic values, i.e. abundance in assimilable nutrients, soil reaction, water relationships, total fertility and richness. It is also possible to determine habitats' flexibility and possibilities of their use. With rapid changes taking place in the environment, it is also useful to know the so-called replacement community circles which are formed in place of destroyed natural communities. On the basis of the map and the knowledge of replacement communities of a given potential community, it is possible to infer the direction of changes in the vegetation and habitats brought about by various processes initiated by human activity and leading to, e.g., changes of water relationships, geochemical character of the underlying ground, mechanical destruction of vegetation itself, etc. That is why the very cognizance of potential natural vegetation makes it possible to fairly exactly determine the economic usefulness of the investigated area and provides a basis for its proper spatial management.

In Poland the mapping of potential vegetation and practical use of maps which are constructed have been of a multidirectional application in geographical space planning for over twenty years. Maps of potential natural vegetation are mostly used in spatial planning and agricultural and silvicultural as well as tourist and recreational management of different parts of the country, starting from the local management of housing developments (Solińska-Górnicka 1971), suburban zones (Roo-Zielińska 1982), and areas of special tourist values (Matuszkiewicz 1968; Solińska-Górnicka 1968; Kostrowicka and Solińska-Górnicka 1973; Wojterski 1973; Wojterski et al. 1973) to the management of entire regions like, for example, the Warsaw Basin (Solińska-Górnicka 1973), the region of south-east Poland (Kozłowska 1982), or ecological-spatial patterns at a supraregional level (Kostrowicki 1971, 1972). In Poland landscape diagnoses and planning are based on the Map of Poland's Potential Natural Vegetation prepared on the scale of 1 : 300 000 under the guidance of Professor Matuszkiewicz. Matuszkiewicz (1974, 1975) pointed to the general information value of maps of the natural environment in the rational landscape use and modelling understood as a structural and functional pattern at a supra-ecosystemic level of the biosphere's organization and characterized by a correct spatial organization.

4. CONCLUSIONS

In spite of the fact that issues presented in this study do not fully answer the questions on applications of phytoindicative methods to the organization of geographical space, they make it possible to indicate new methodic solutions in traditional landscape planning. The presented results of Polish bioindicative studies make it possible to state that phytoindicative research is of particular significance for the ecological diagnosis, interpretation and assessment of the environment on the landscape scale, i.e. at the level of supraecosystemic ecological-spatial patterns of different size. They afford possibilities for a proper organization of geographical space understood as a maximal use of potential biotic values of habitats in all directions, including economic (farming, forestry, the building industry) and health-esthetic one. The scope of results obtained with the described methods makes the planning of geographical space include trophic habitat characteristics and many dynamic components like, e.g., pollution of the environment, geochemical changes taking place in the environment, the course of contemporary geomorphological processes, the shaping of hydrological relationships, etc.

This is the reason why the characteristics of the natural environment for landscape planning should be based (and in many countries are) on the vegetation occurring in that environment and be supplemented only by necessary detailed field-laboratory research. The characteristics of the natural environment obtained through traditional methods require many laborious specialist investigations of every component apart. Therefore, one can state that bioindicative methods are of a complex character because out of one input material in the form of lists of the plants in a given area (releve protocol) we obtain many-sided data on the investigated biotope (e.g. climatic, trophic, hydrological ones, etc.).

An additional advantage of phytoindication is the fact that vegetation is the most perceptible component of all the components of the natural environment because it is always present, relatively permanent and available for direct research. The application of plants in the cognizance of characteristics of the natural environment affords possibilities for omitting work- and time-consuming laboratory research.

The advantages of phytoindication presented in this study point to the fact that ecological methods of landscape research are easy to use, the least time-consuming and require minimal financial outlays out of all the methods employed for diagnosing environmental characteristics and planning geographical space, while the results they produce are statistically credible and, in many cases, more exact than those obtained with traditional field-laboratory methods.

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PINE FORESTS IN POLAND. THEIR PRODUCTIVITY, DISTRIBUTION AND DEGRADATION*

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INTRODUCTION

The present paper considers the basic information we have on the biomass, productivity and distribution of pine forests in Poland and the distribution of air pollution with sulphur in the same area. It is already well known that coniferous forests are particularly susceptible to pollution with sulphur oxides; they disappear from large areas in many regions of Poland and other countries of Central Europe. Air pollution with sulphur is likely to be continued in Poland for a long time since the main source of sulphur is coal combustion, and coal will be the basic source of energy in Poland for a long time. Preliminary estimates of the present situation and some predictions for pine forests in Poland are based on materials from forest inventories made by forestry services, on results of detailed ecological investigations conducted in some stands, and on a comparison of two maps: the most recent satellite map of land use and a prognostic map of air pollution.

THE PROPORTION OF PINE STANDS IN THE FORESTS OF POLAND

This proportion has been estimated on the basis of the inventory of timber in forests. According to Trampler (1982) in terms of wood volume (m^3) coniferous stands account for 78% of timber in the territory of Poland, including 62% pine, 11% spruce and 5% fir; the contribution of pine to the total coniferous stands reaches up to 73%.

Considering biomass, the conifers provide 73% of the entire wood biomass; analysis of productivity shows that up to 78% of annual timber production is given by pine.

Similar proportions are obtained when analysing the size of forested areas in Poland. Coniferous stands cover 79% of the entire forested area of the country, including 69% occupied by pine stands (among coniferous stands pine covers 87% of the area). Thus, in terms of both coverage and timber volume and production the forests of Poland are highly predominated by pine stands. They will be characterized in detail.

* The research forms part of a project MR.I.25.03.

BIOMASS AND PRODUCTION OF PINE FORESTS IN POLAND

BIOMASS

The area covered with pine forests and their biomass are presented in Fig. 1; this figure is based on the results of forest surveys set by Trampler (1982). According to this author, this is the area and biomass of timber in pine forest registered in

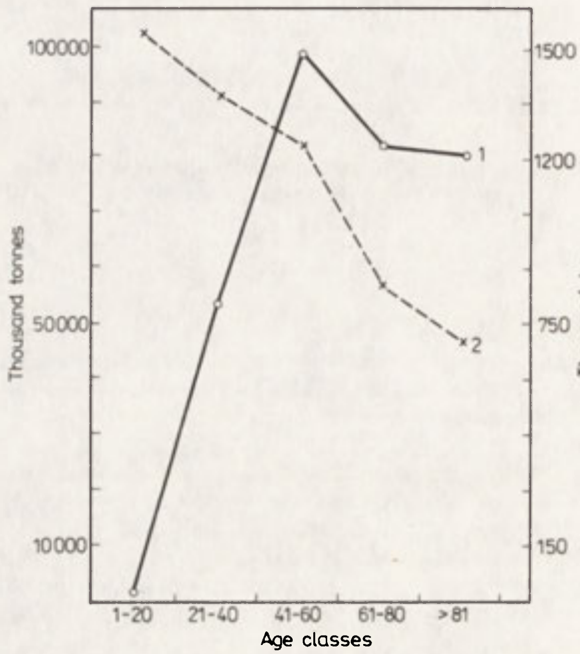

Fig. 1. 1 – Biomass and 2 – area of pine forests in Poland. Data from the 1978 inventory of the forestry service (after Trampler 1982)

the 1978 inventory. As the foresters do not take into account the stock of the roots of trees, the author assumed that roots comprised 20% of the total tree biomass and he increased the inventory results by this amount. The inventory includes all trunks and branches more than 7 cm in diameter. The calculated biomass is divided in five age classes and it can be seen that young forest biomass rapidly increases

TABLE 1. Timber biomass (tonnes of dry weight per hectare) in Polish coniferous forests. Data calculated from Trampler 1982, 1986

Stand according to dominant tree species	Timber biomass					
	mean	in age classes 1–20	21–40	41–60	61–80	81 ≤
pine	84.9	0.89	40.5	80.4	98.8	113.6
fir	121.5	0.74	44.7	113.8	156.8	166.2
spruce	136.0	1.07	24.0	102.7	143.3	162.2
conifers	95.2	0.88	38.9	84.6	108.5	122.5

by an age of about 50 years. This is due to a rapid growth of young trees and to the appearance of new trees. Biomass of the forests more then 60 years old declines as the forests enter the cutting age.

Using the inventory data the amount of timber per 1 ha was calculated. The results are shown in Table 1 and Fig. 2, where pines are compared with the other

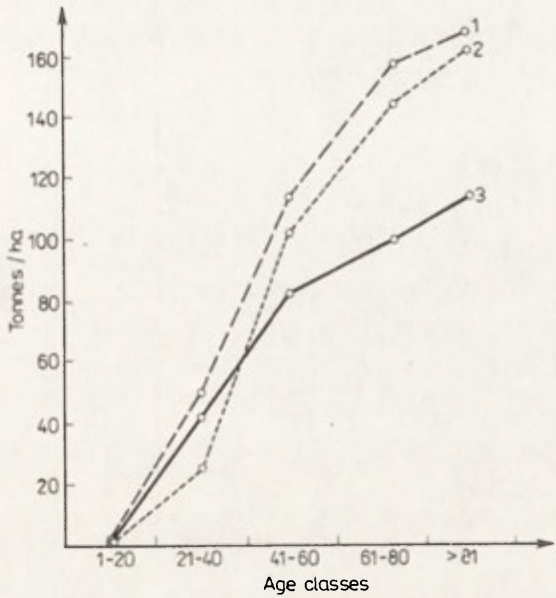

Fig. 2. Timber biomass per 1 ha for three species of conifers in five age classes. Computation for the whole territory of Poland after Trampler (1982): 1 – spruce, 2 – fir, 3 – pine

two conifers, the spruce and the fir. It can be seen that pines produce relatively little timber per unit area, the maximum biomass being 113 tonnes per ha, as compared with 162 and 166 tonnes per ha for firs and spruces, respectively. It should be remembered, however, that pine forests account for 87% of the area occupied by coniferous forests and for 73% of the volume of the timber produced in coniferous stands.

The above data obtained from forestry service will be compared with the results of ecological investigations in pine forests. Table 2 shows the biomass and its structure in some pine forests in the temperate zone. The total aboveground biomass of these forests varies between 65 and 220 $t \cdot ha^{-1}$. Stems, that is, this part of biomass which is included in the inventories of forest service, account for 59–81% of the total aboveground biomass; the remaining 20–45% of the biomass mostly consists of branches and litter. In the data shown in Table 2 litter was recorded only in two cases. More recent materials collected over the ten-year period of the International Biological Programme (1964–1974) were presented by Gardner and Mankin (1981), and they are reproduced in Fig. 3. The curves shown in this graph are based on measurements taken by the same methods at more then 100 points of the globe. These are probably the best comparative ecological data that we have so far. They show, that the organic matter accumulated in litter and soil is higher than that in tree boles, already in 25 year old forests; in forests about 100 years old the organic matter of soil and litter is twice that in tree boles.

TABLE 2. Organic matter accumulation and distribution in various types of pine forest of temperate zone. Biomass in tonnes of dry mass per hectare. After Grodziński et al. (1984). Simmons (1974) and Whittaker and Marks (1975)

Stand	*Pinus silvestris*, South Poland	Oak-pine forest, Brookhaven, USA	Pine-oak woodland, Arizona, USA	*Pinus nigra*, North-east Scotland	*Pinus silvestris*, Eastern England	*Pinus silvestris*, South Poland
age of tress, years	21–40	43	46	48	55	80–100
biomass $t \cdot ha^{-1}$	118.0	65.6	113.7	151.6	164.6	220.1
percentage in biomass:						
stems	79.7	66.3	69.6	62.5	59.0	81.3
branches	15.3	24.0	25.5	13.6	12.5	7.3
leaves	3.4	8.9	1.8	4.4	3.5	1.5
shrubs and forbs	1.6	2.0	1.0	3.7	1.4	10.0
litter	–	–	–	15.8	27.6	–

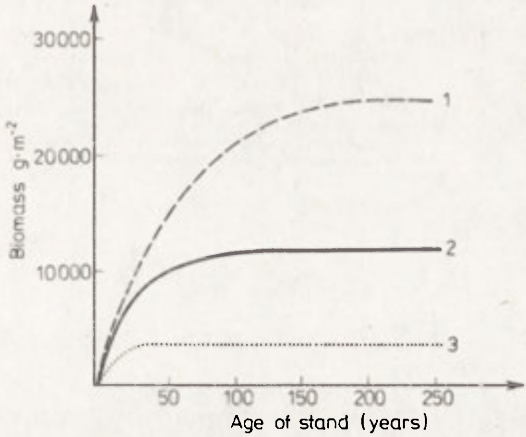

Fig. 3. Biomass of three fractions of plant organic matter in forest ecosystems according to the model based on data from various IBP stands compiled by Gardner and Mankin (1981): 1 — litter and organic matter of soil, 2 — stems, 3 — roots

PRODUCTION

Trampler (1982) estimates that the annual production of organic matter for boles and thick branches (more than 7 cm in diameter) accounted for 3% of the forest standing crop. A detailed ecological study conducted on two plots of a pine forest in Niepołomice (South Poland) yielded the following results (after Grodziński, Weiner and Maycock 1984)

Pine stand	Annual production in per cent of biomass			
	tree layer	undergrowth	leaves	total
20–40 years old	5	5	50	7
80–100 years old	1	1	53	2

Thus, the production of two pine stands differing in age ranged from 2 to 7% (1–5% for timber) of the aboveground biomass. Only leaves were produced in similar proportions in the two forests and this production contributed to half of the annual standing crop. Absolute estimates of the productivity of pine forests known from the ecological literature vary from 4.7 to 14.3 tonnes per hectare (in temperate zone) and in this leaves account for 24–54% (Table 3). A suitable and frequently used measure of the production of green plant parts is organic fall (litter fall). Table 4 shows litter fall for different pine forests in Poland. In relatively natural stands it ranges from 2.6 to 6.6 tonnes per ha. Also the effect of industrial emissions on production of organic fall in these forests is shown: in the region of the Puławy nitrogen fertilizers plant the organic fall decreases to 0.6–0.7 $t \cdot ha^{-1}$. The study carried out by Józefaciukowa (1984) confirm the fact of reduction of green plant parts in forests polluted with industrial emissions. The biomass of leaves and branches in pine stand in Tarnowskie Góry contaminated by industrial emissions is much lower than in pine forests of similar age in two not contaminated areas (Table 5). Instead, the polluted stands develop larger root systems.

TABLE 3. Production of some pine forests in temperate zone (tonnes of dry mass per hectare). After Rieger et al. (1984) and Whittaker and Marks (1975)

Stand	*Pinus silvestris*, South Poland	Oak-pine forest, Brookhaven, USA	Pine-oak woodland, Arizona, USA	*Pinus silvestris*, South Poland
Aboveground production				
total	7.6	8.5	14.4	4.7
trees	4.7	7.9	14.3	2.7
shrubs (and under growth)	1.0	0.6	0.1	0.3
leaves	1.9	–	–	1.7
Percentage in trees production				
stems	61.0	22.0	21.9	53.2
branches	13.0	24.3	20.7	4.3
leaves, fruits, twigs	24.7	53.7	57.4	40.4

TABLE 4 Organic matter fall in pine forest ecosystems in Poland

Forest type	Age of trees in years	Locality	Organic fall $t \cdot ha^{-1} \cdot y^{-1}$	Author
Vaccinio	20–40	Puławy[a]	0.63	Uba, unpublished
myrtylli-	40	Puszcza Piska	5.36	Puszkar, Traczyk and Wójcik 1972
Pinetum	60–80	Puławy[a]	0.73	Uba, unpublished
	85	Puszcza Kampinoska	2.63	Józefaciukowa 1975
	110	Puszcza Kampinoska	3.25	Józefaciukowa 1975
	140	Puszcza Piska	4.65	Puszkar, Traczyk and Wójcik 1972
Pino-	50–70	Puszcza Bolimowska	3.04	Uba, unpublished
Quercetum	60–80	Małogoszcz	2.18	Uba, unpublished
	70	Puszcza Niepołomicka	5.00	Zieliński 1984
	150–200	Las Piwnicki	3.82	Prusinkiewicz, Dziadowiec and Jakubusek 1974
	150–200	Las Piwnicki	3.75	Prusinkiewicz, Dziadowiec and Jakubusek 1974
	70	Puszcza Kampinoska	4.16	Stachurski and Zimka 1977
	150	Puszcza Piska	6.64	Plewczyńska 1970
Cladonio-Pinetum		Puszcza Kampinoska	4.66	Wójcik 1970

[a] Forests under the emissions from the plant of nitrogen fertilizers at Pulawy

DISTRIBUTION OF FORESTS AND AIR POLLUTION

Figure 4 shows the distribution of pine and mixed forests and air pollution with sulphur oxides. Air pollution is expressed in microgrammes per m^3 of the air. According to the standards accepted by the Forest Research Institute in Poland,

TABLE 5. Biomass of three 80 years old pine stands in Poland. Tarnowskie Góry stand is under influence of industrial emissions from zinc and lead meal. After Józefaciuk (1984) and Sikora (1978, 1981)

Stand	Tarnowskie Góry *Vaccinio myrtylli Pinetum*		Puszcza Kampinoska *Vaccinio myrtylli Pinetum*		Las Piwnicki, *Pino Quercetum*	
	$t \cdot ha^{-1}$	%	$t \cdot ha^{-1}$	%	$t \cdot ha^{-1}$	%
leaves and trunks	8.8	13.3	36.0	11.9	18.7	10.7
stems	34.5	51.5	202.2	67.4	126.6	72.3
roots	23.6	35.2	62.3	20.7	29.8	17.0
total	66.9	100.0	300.5	100.0	175.1	100.0

Fig. 4. Distribution of coniferous and mixed forests in Poland and air pollution.
The map has been elaborated at the Institute of Geodesy and Cartography in Warsaw under the supervision of Andrzej Ciolkosz on the basis of Landsat MSS and Salut-6 images acquired in 1978. The isolines delimite the areas with SO_2 mean annual concentration equal/ /higher 50 $\mu g/m^3$. Data on pollution after the map predicting the air pollution in Poland in 1990 by J. Juda et al. 1982, unpublished

three zones of forest endangerment caused by air pollution can be distinguished: zone I, relatively clean, corresponds to a range of 20–50 μg SO_2 per m^3 of the air; zone II, 50–100 μg SO_2 where the changes in pine forests can be observed; and zone III – more than 100 μg SO_2, which is considered as directly devastating the forests. Thus, the map allows us to distinguish zones of the threat to forests and to identify the regions where the danger is most severe.

FINAL REMARKS

According to forest inventories, coniferous forests of Poland comprise 619557 thousand tonnes of timber and they produce 20552 thousand tonnes of new timber per year (all measurements in dry weight). The results of ecological studies show that these figures should be at least doubled to get real amounts of organic matter produced and stored in coniferous forests. In recent years both these processes, production and retention, have been declining. According to calculations of Olson (1975). forests account for 74% of the total aboveground pool of "live carbon"; they provide 80% of the total aboveground production on the globe. Thus, these are the ecosystems determining the aboveground carbon cycling on the Earth. Stable and constant production of organic matter in forest ecosystems ensure the stability of gaseous and nutrient cycling on the Earth. Organic carbon is also directly used by man as a source of energy. A reduced production and retention of carbon in forest ecosystems on a larger scale must be followed by disturbances in all these processes.

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GEOGRAPHIA POLONICA 52, 1986

DEVELOPMENT AND ZONALITY OF CONTEMPORARY GEOMORPHOLOGICAL PROCESSES IN SOUTH SIBERIAN TAIGA AND TUNDRA IN MONGOLIA

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INTRODUCTION

The Khentei mountain massif is situated between the mountains of the South Siberian Mountains and Central Asian Plain.

The study area is situated within the Khentei block, which is part of a Paleozoic folded system. The Khentei block is bounded by deep disrupted faults. There are geosynclinal flysch metamorphic and deformed Paleozoic deposits in the Hercinian and Caledonian orogeneses (Klimek, Ziętara and Tserensodnom 1980). At that time there appeared granitoid intrusions connected with belts of deep disruptions. Due to the appearance of abyssal fissures and to the block uplifting of some sites and to the massive magmatism, the huge synclinorium underwent a fundamental deformation to yield a varied orogen (Klimek, Ziętara and Tserensodnom 1980; Malarz 1980) which is dominated by large tectonic dislocations.

This paper deals with the results of research on contemporary geomorphological processes. The research was carried out in 1975 and 1977 during the Mongolian-Polish Physical-Geographical Expeditions organized by the Polish and Mongolian Academies of Sciences.

Geomorphological explorations in different climatic zones were conducted mainly by geomorphological mapping (Fig. 1), at scales 1 : 100 000 and 1 : 25 000. Attempt was made to show relief correlation with geological structure and to define main development stages associated with climatic variations. In order to evaluate the contemporary relief transformation a map of present-day geomorphological processes for the entire basin was prepared and morphoclimatic zones were distinguished.

The differentiation of landscape belts is related to climatic conditions. Mean temperatures of the warmest month (July) range from 15°C in the middle stretch of the valley to about 5°C in its upper regions (Brzeźniak and Malarz 1980). In summer pronounced thermic inversion is observed in valley bottoms. The yearly precipitation total on the foothills amounts to 250–300 mm and increases to 500 mm on the Baga-Khentei ridges. The heaviest and frequently occurring precipitation is observed in summer towards the end of June and in July. During our stay in the region the precipitation totals were 88 mm in the middle and 133.8 mm in the upper areas of the Sugnugurin-gol valley. In winter a continuous snow cover persists, its thickness increase with the altitude. The thickness and duration of snow cover depends on the morphology and aspect of the slopes. On north-east slopes patches of snow survive in the taiga till around the middle of June, while in the tundra they are still found towards the end of July.

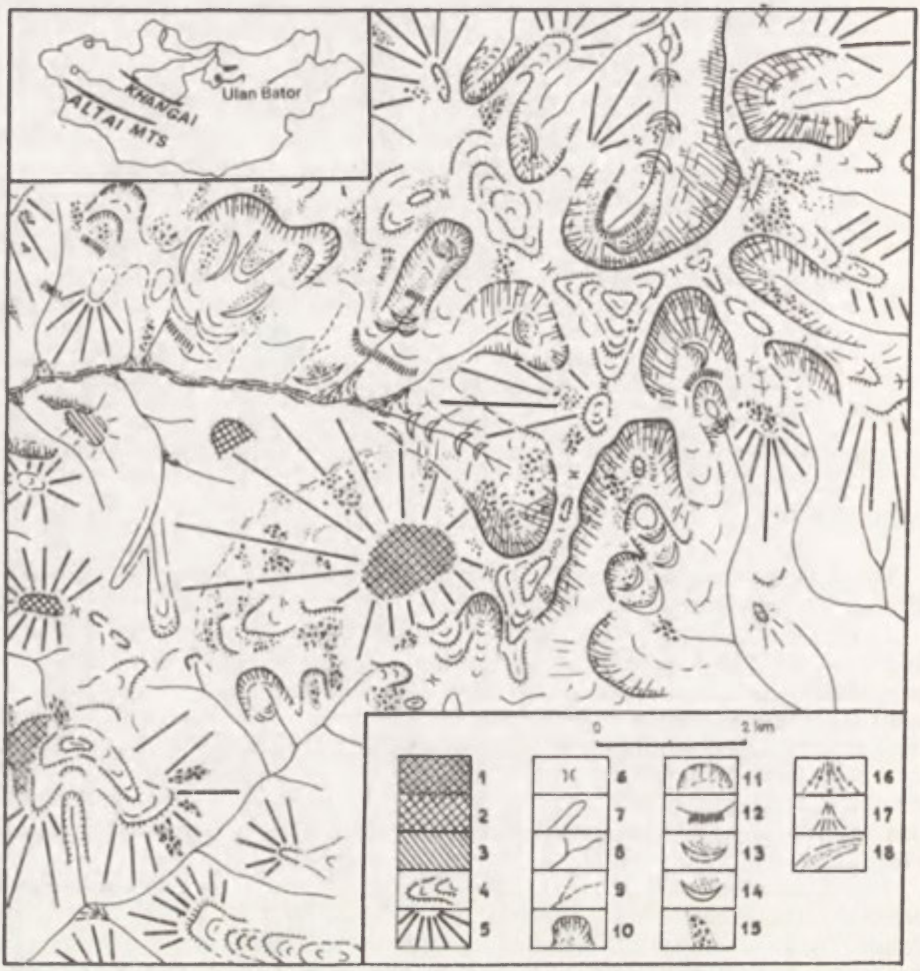

Fig. 1. Geomorphological map of the Baga-Khentei: 1–3 – planation surfaces elevating 500-550 m, 300–350 m, and 120–150 m above the valley bottom, respectively, 4 – cryoplanation terraces and surfaces, 5 – slopes, 6 – passes, 7 – channelled valleys, 8 – continuously drained V-shaped valleys, 9 – episodically drained valleys, 10 – well developed glacial cirques modelled by fall-off and corrasion, 11 – weakly developed glacial cirques modelled by corrasion, 12 – rock faults in postglacial valleys, 13 – older moraine walls, 14 – younger postglacial walls, 15 – rubble tongues, clay-rubble tongues and block-fields, 16 – older rubble cones, 17 – younger clay-rubble cones, 18 – flat valley bottoms

SUMMIT PLATEAUS AND PLANATION SURFACES

The principal ridge of the Baga-Khentei declines in the SE direction in the form of a slope preserved as a huge fault ledge, which is very pronounced in the relief of the Baga-Khentei chain (Fig. 2). It runs over several tens of kilometers dividing the low-inclined top plateaus of altitudes of 2200–2800 m a.s.l. (Asaraltu) which gradually decline to the west from the much lower situated broad ridges into which cut flat-bottomed valleys often wet at their bases. That part of the Khentei is

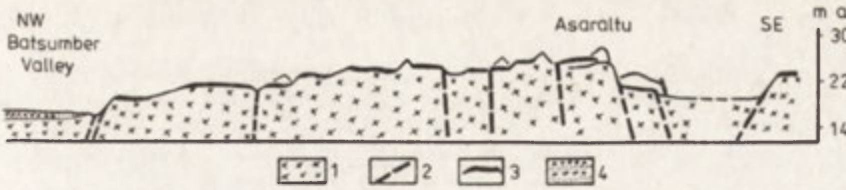

Fig. 2. Geological cross-section through the western slope of the Baga-Khentei: 1 – crysalline rocks, 2 – tectonic dislocations, 3 – planation surfaces, 4 – alluvial formations

drained by the tributaries belonging to the Tola river. The ledge of the Baga-Khentei is imposed on a powerful dislocation along which the central part of the Khentei had been faulted down while the western one had been obliquely uplifted.

Within the western slope of the Khentei there are well-marked planation surfaces at 500–550 m, 300–350 m, 120–150 m and at some 60 m above the valley bottom. The lower planations (120–150 and 60 m) clearly revert to the longitudinal profiles of recent valley bottoms. The higher planations (500–550 and 300–350 m) generally incline westward. Their surfaces truncate both metamorphic and magmatic rock formations (granites, sienites, granodiorites and adamelites). But they are perturbed by dislocations running from the SE to the NW, that is, generally according to the dislocation that truncates the main ridge of the Baga-Khentei from the south-east. The deformation of those planations by dislocations is indicative of the young age of the movements reverting to the old dislocations, often connected with granitoid intrusions.

The highest planation within the Baga-Khentei was transformed by cryoplanation processes (Photo 1). In the longitudinal profile there are many ledges, terraces and

Photo 1. Cryoplanation showing inselbergs of the Baga-Khentei

cryoplanation surfaces that are well developed (Fig. 3). The height of the ridges dividing the various surfaces varies between 20 and 80 m.

On those surfaces there are polygonal soils at different stages of development (Pękala 1980; Ziętara 1981). The cryoplanation surfaces and terraces pass through

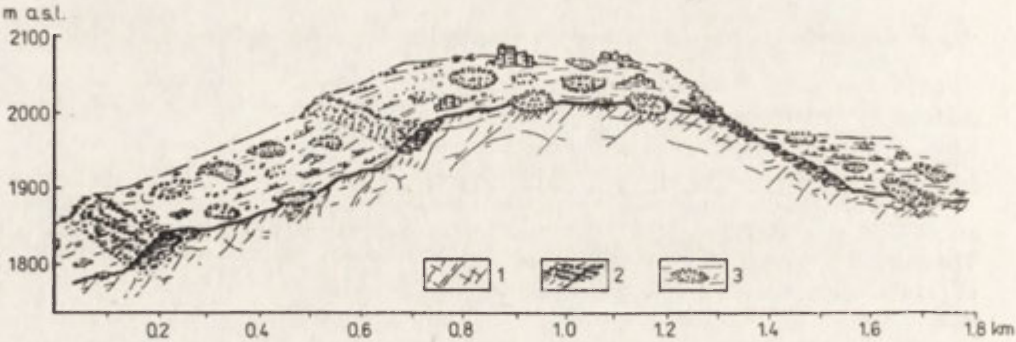

Fig. 3. Cross-section through the cryoplanation surfaces of the Baga-Khentei: 1 – crystalline rocks, 2 – cryoplanation terrace edges built of large rock-blocks, 3 – stony crowns

marked windings into slopes that are mainly modelled by solifluction processes forming huge rubble-clay tongues (Photo 2), which often superimpose on one another and yield a concave-steplike slope profile (Fig. 4). The nival niches were also transformed by solifluction processes and corrasion.

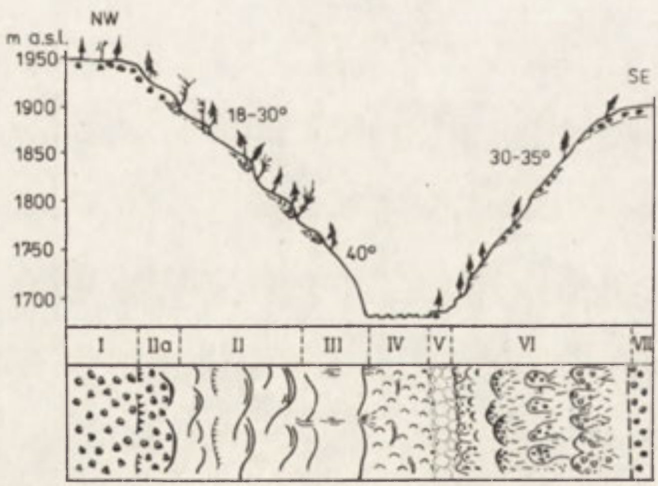

Fig. 4. Valley profile in the stone pine taiga belt (after K. Pękala and T. Ziętara 1980a): I – flat summit crest with block-clayey cover, II – solifluction terraces, IIa – solifluction tongues, III – convex slope transformed by cover creep, IV – flat valley floor with congeliturbation forms, V – debris fields, VI – solifluction slopes with tongues, VII – rubble slope with partly felled forest

Photo 2. Baga-Khentei slopes modelled by rubble-clay solifluction tongues

VALLEY ASYMMETRY

The valley heads cutting into the main chain of the Baga-Khentei were glaciated during the Pleistocene. Numerous cirques and nival niches occur there (Klimek 1980). Generally it can be said that the glaciers were not large and stretched over the highest parts of the valleys only. The slopes of the cirques have recently been modelled by rubble-solifluctional tongues and by mechanical corrasion as evidenced by the numerous troughs and corrasion chutes running in accordance with the directions of the rifts. The glacial drift formations are overlain by numerous solifluction tongues which at places cover the moraine walls.

There is a clear climatic asymmetry in the valley pattern (Photo 3). It is noted both within the valleys of the high-mountain tundra or of the South-Siberian taiga and in the forest-steppe belt. That asymmetry is due to the persistence of permafrost and the Pleistocene and recent processes in its active layer. S- and SW-facing slopes have recently been dried up and permafrost occurs there insularly. They are steeper, especially in their lower parts. On the S-facing slopes, in the taiga belt, there are patches of block-field above which occasionally rise steep rock walls cut by numerous chutes while at their heads there are fresh recent banks. In the upper parts of the valleys, at the boundary between stonepine taiga and high-mountain tundra the rock walls disappear and the slopes are all littered with rock rubble. In the middle parts of the valleys, in the larch-spruces taiga belt but mainly in the forest-steppe belt, rubble-solifluctional tongues occur insularly on the slopes, now inactive (Photo 4). They run onto the terraces at a height of some 15 m, but at many places they occur also on lower terraces. This is evidence of climatic

Photo 3. Asymmetry of valleys cutting the Khentei; steep S- and SW-facing slopes not covered by forest

Photo 4. Rubble tongues recently inactive on S-facing slopes

changes in the Holocene. S-facing slopes were then modelled locally by solifluction processes. N- and NE-facing slopes have recently been modelled by the processes connected with the formation of the active part of permafrost in summer. This is evidenced not only by the large solifluctional tongues along the axes of channelled valleys but also by many "drunken" trees within the taiga covering those slopes.

FROST PROCESSES IN VALLEY BOTTOMS

Apart from the structure-dependent forms, in the western part of the Khentei there are also forms that are strongly determined by climatic conditions. These include valley bottoms modelled by different process groups occurring in the particular landscape zones (Ziętara 1981). In the taiga belt they are flat and pass through a marked winding into the slope. The longitudinal profile of those valleys is even. They are covered with scrub birch and in winter the icings extend over the entire bottoms (Photo 5). The processes connected with the occurrence of icings are decisive for the contemporary bottom morphology (Photo 6).

As a consequence of the permafrost occurrence and of the varying bottom morphology, they are modelled by different groups of frost processes. Basing on this criterion, four types of the valley bottoms were distinguished (Fig. 5).

The first type is represented by the higher sections of trough valleys within the higher portion of South-Siberian taiga. At present, an important role in modelling the river beds is played by the processes associated to icing occurrences and in summer the trough bottoms are modelled by piping (Photo 7).

The second type is represented by taiga valleys. Their longitudinal profiles are levelled and the river beds are winding. The valley bottoms are overgrown with

Photo 5. Plain bottom covered with dwarf birch in the South-Siberian taiga belt

Photo 6. Frost segregation structures. The clayey vegetation-covered terraces have cryogenic windows

Photo 7. Linear thermoerosion in the valley bottoms of South-Siberian taiga

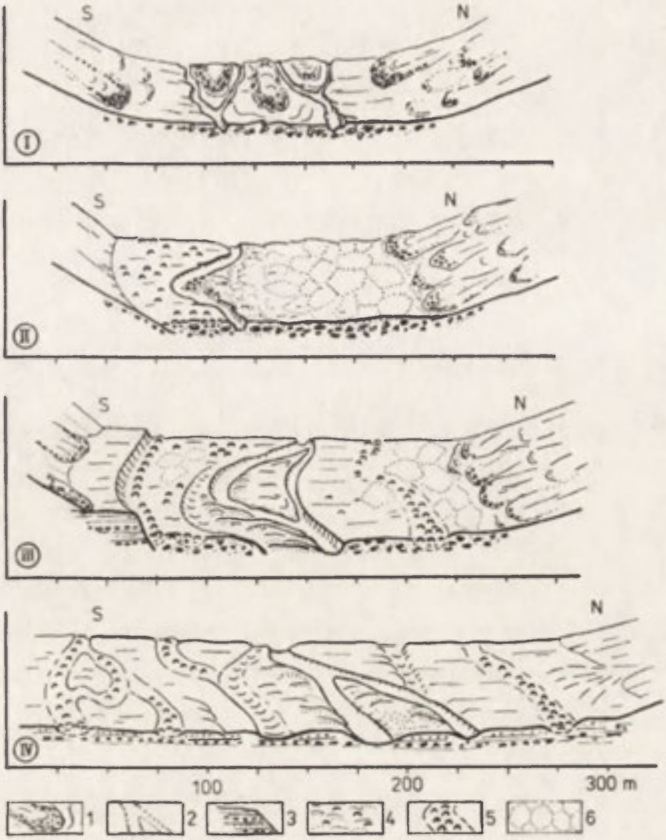

Fig. 5. Evolution of river beds in the south taiga of Syberia: 1 — solifluction slopes with tongues, 2 — river and stream beds, 3 — river terraces, 4 — flat valley floor with congeliturbation forms, 5 — floor river beds with congeliturbation forms, 6 — debris fields

scrub birches and single larches. The whole bottoms are covered by the permafrost, the occurrence of which is most often associated with big hydrolaccoliths arising. The biggest ones are located at the lateral valley outlets.

Icing crusts in winters are deposited on the flat valley bottoms and the processes associated with their occurrence decide about the present bottom morphology.

The third type of valleys has a system of well developed bottom terraces. Wide, braided troughs are present accompanied by numerous petrified shoals, flood terraces and higher terraces which are best preserved at the lateral valley outlets as cones (Photo 8). Frost effects, thufurs mainly, are present within lower terraces at the bases of taiga-overgrown N- and NE-facing slopes. In these valleys an evident asymmetry of phenomena associated with permafrost can be observed. The valley beds are modelled by processes connected with icing formations.

The fourth valley type is featured by wide flood terraces, having often a form of vast talus and it includes also the flood terrace of the Chara-gol valley in the Batsumber Valley. Numerous old river-beds in various development stages are present here indicating often alterations of the river-bed. The permafrost is of insular type here and the forms associated with its occurrence are related to the old river-beds which are shaped by frost heave processes and by thermal erosion.

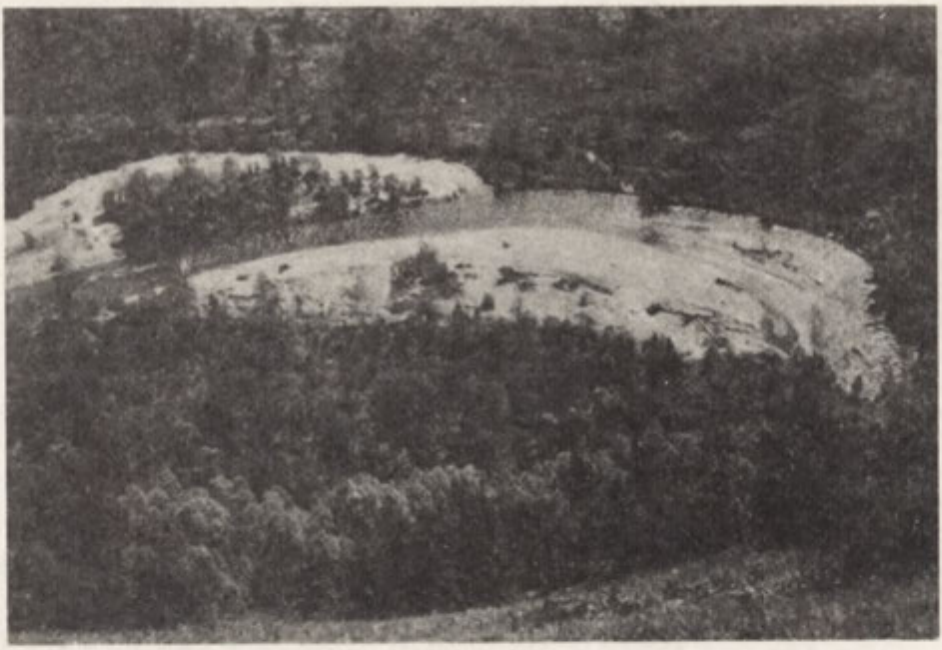

Photo 8. Braided rivers are modelled by processes connected with icing crusts

MORPHODYNAMIC BELTS

Quality and quantity analysis of contemporary geomorphological processes made it possible to distinguish the following morphodynamic belts (Pękala and Ziętara 1980a; Ziętara 1984) according to climate (Brzeźniak and Malarz 1980), vegetation (Pacyna 1980) and soil (Skiba 1980) relations (Fig. 6):

1. steppe belt, below 1100 m above sea level,
2. forest-steppe belt, between 1100 and 1400 m,
3. mountain taiga belt, from 1400 to 2100 m,
4. high mountain tundra belt, above 2100 m.

Morphodynamic belts of the Khentei mountains are similar to those distinguished in the Eastern Siberia mountains. Influence of steppe which surrounds the Khentei can be seen mainly in its lower parts. The belts can be characterized by different processes and of various intensity (Ziętara 1980a, 1981; Kowalkowski and Starkel 1984).

Forest-steppe belt is the most man-changed (Lach 1980; Ziętara 1980a; Pękala and Ziętara 1980b) mainly by clear-cutting. Talus cones at gully outlets are the driest biotopes. These areas have been taken over by meadow vegetation and birch forests. It has not been explained in what extent forestless south-facing slopes are natural (Ziętara 1980a). Some examples like single trees or groups of them might point out that the slopes were over-grown by forests. There was a marked shift in the course of relief modelling, washing out emerging as the most important process with erosion and deflation increasing their importance. Erosion is connected with man's economic activity and it is being developed along steppe and roads. There are torrential fans in valley outlets which are on older covers of the same origin. Periodically frost-creeping is being developed. Wind-fallen forest slope saltation, corrasion and piping show small intensity.

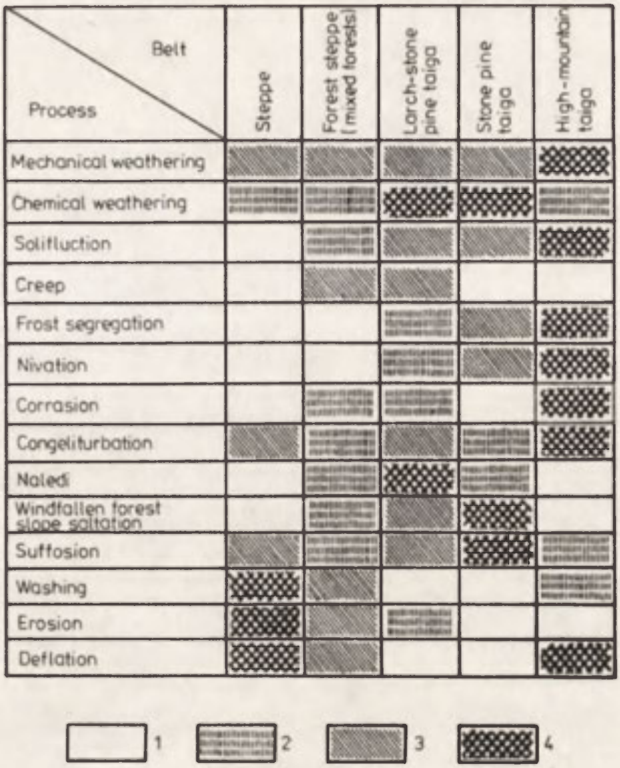

Fig. 6. Distribution and intensity of present-day processes in the individual morphodynamic belts: 1 – zero intensity, 2 – small intensity, 3 – medium intensity, 4 – high intensity

The mountain taiga belt is grown by natural forests not changed by man. They are not coherent and bushes are rare. Undergrowth is well developed and there is a lot of mosses and lichens. The ground is frozen and seasonal thawing reaches about 2 m of thickness. Rivers are frozen in winters and there are icing covers in flat valley bottoms (Russian term – *naledi*). Processes connected with their existence influence contemporary morphology of the bottoms. Within this zone two subzones have been distinguished because of the peculiar differences in soil and plant covers.

Subzone of mountain taiga with *Larix* and *Pinus sibirica* is modelled by processes of which chemical weathering is the most important. Solifluction, mechanical weathering, uprooted trees saltation and soil creeping are of less importance. Processes connected with icing development and frost heaving predominate in valley bottoms.

Subzone of *Pinus sibirica* taiga covers slopes and plateaus of lower ranges. Small areas of block fields remain forestless. Undergrowth is homogeneous and rather poor. Timberline moves down to about 1800 m above sea level on steeper and skeletal slopes. Piping and uprooted trees saltation processes dominate. Waste material is moved by saltation and it is washed during summer rainfalls. Chemical weathering which is connected with peat plant development is also of great importance. Physical weathering, solifluction and nivation are of medium intensity.

High mountain tundra is characterized by the most dynamic processes connected with frost phenomena (Pękala 1980; Pękala and Ziętara 1980a; Ziętara 1980b). Physical weathering, frost segregation, nivation, corrasion and deflation play the most important role in slope and plateau modelling. These processes co-operate with each other and lead to cryoplanation terraces, plains and step-like solifluction forms on slopes (Photo 9).

Photo 9. Sorted polygons on a cryoplanation surface occurring on the central ridge of the Baga-Khentei

Subalpine subzone is located above the upper timberline. Single trees or groups of them, often dwarfish, grow above the line. The zone is about 200 m wide and it is a transitional one between forest and goletz zones. There are plots of taiga and tundra. Soils are connected with periglacial relief. Slopes are fragmented by periglacial basins in which there are rubble-solifluction lobes.

Alpine or goletz subzone covers wide areas of upper parts of slopes and cryoplanation terraces. Severe climatic conditions of Siberia caused that these areas are covered by high mountain tundra. Plants are small usually one-ply, and reach more or less the same height. Vegetational period is short and lasts about 2 months. It makes that development of all species is nearly simultaneous and the phenological phases are not distinguished.

Subnival subzone can be noticed on slopes of Asaraltu over 2500 m above sea level. Slopes are covered by block fields and these areas can be described as blocky high mountain tundra (Photo 10). Vascular plants are represented by some arctic-alpine species. There are few plants but mosses and lichens are very common.

Photo 10. A cryoplanation terrace edge with imbricated granitic block

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GRANITE HILLSLOPE MORPHOLOGY AND PRESENT-DAY PROCESSES IN SEMI-ARID ZONE OF MONGOLIA

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The Middle-Khalkhasian Upland which exists on the southern foreland of the Khentei in Mongolia separates these mountains from the Gobi Plain. Even if this plateau is actually riverless the landscape is characterized by a net of broad and long valleys. Period of valley formation is correlated with the Pleistocene when the area was modelled by large permanent rivers flowing from the North to the South under humid and severe climatic regime. Soil covers on slopes contain features of the ancient humid climate as well as of dry continental climate (Kowalkowski and Lomborinchen 1975). They indicate very advanced slope evolution and infilling of tectonic undrained depressions of this tectonically active region in the Holocene. Discontinuous permafrost which exists at present was also responsible for the Holocene morphogenesis.

The programme of field works was concerned mainly with the manner of slope development after the phase of Pleistocene pluvio-fluvial erosion and contemporaneous geomorphic processes. Periglacial slopes located in higher elevations were excluded from this study as they have been analysed separately (Kotarba 1980).

PHYSICAL BACKGROUND

The Middle-Khalkhasian Upland area belongs to the Khangai-Khentei Paleozonic fold system (Sonenschein 1973). Lithological foundations are largely of granites, fine acide intrusives, metamorphic and volcanic rocks (Dżulyński 1983), emplaced during late Paleozoic and Triassic. The granites were intruded in the metamorphic rocks, mainly of gneisses, amphibolites and biotite schists and marbles. Volcanic rocks, chiefly of Jurasic age, were less widespread. The basalts forming lava flows are localized along tectonic trough representing the Graben valley. This tectonic feature has been formed even during the Quaternary (Dżulyński 1983).

Flat-floored tectonic basins and valleys are filled with Neogene lake deposits as well as the Quaternary fluvial gravels.

The main relief features are controlled by both lithology and fault lines (Kotarba and Nowaczyk 1983). An extensive Paleogene planation surface rising to 1500 m a.s.l. has developed in the zone of granite and metamorphic rocks. This pediment-like surface was dissected by dense valley pattern and drained into the Graben valley under humid conditions prevailing during the Pleistocene. More recently broad, flat-floored valleys have been dry. Only sporadically during summer storms waste products are reworked by episodic water flows. Small residuals and residual hills dominate locally above the planation surface. Tors are relatively common on the valley sides.

Central Mongolian steppe is characterized by severe continental climate. During long winter season, for the most part snow free, cold Siberian anticiclone favours extremely low thermal and humidity conditions. Main features of short summer season are as follows: great daily temperature ranges, little cloudiness and low rainfall totals. Mean annual temperature is −2.7°C while on the ground surface temperature is as low as 0°C or even −1°C (Zabolotnik 1974). The absolute minimum air temperature falls below −45°C, maximum air temperature approaches 45°C (Kowanetz and Olecki 1980). Climatic parameters favour cryogenic processes in winter and spring and insolation involve thermal disintegration in summer. Discontinuous permafrost is to be found in undrained hollows or basins filled with alluvial deposits and ancient valley bottoms with dry channels and periodic lakes (Gravis 1974; Nowaczyk 1984).

Mean annual precipitation ranges from 200 mm to 250 mm, of which more than 90 per cent falls over the period June-September. Summer rainfall intensity is low (0.01–0.1 mm/min), while short term downpours are characterized by momentary intensities 0.3–0.6 mm/min and were recorded only sporadically once in ten years. The highest intensity of rainfall recorded in the period of 1976–1978 was 1.7 mm/min in Gurvan Turuu Station (Chelmicki 1983, 1984).

Three types of plant communities are distinguished in the area: dry steppes on deep chestnut deluvial soils (on granite and metamorphic rocks), halophytes growing on solonchak soils in undrained depressions and shrub-meadow-steppe vegetation on stony chestnut soils on granitic residual hills.

Scientific programme was realized in the vicinity of the Geographical Research Station at Gurwan Turuu ($\varphi = 47°03'N$, $\lambda - 107°38'E$) by Mongolian and Polish earth scientists.

DESCRIPTION OF SLOPES

Three essential slope categories were distinguished in the study area, connected with fragmentation of the Paleogene planation surface. These are as follows: rockwalls, straight debris-covered slopes and convex slopes (Fig. 1).

Rockwall. This category is relatively very rare and is to be found in the middle and lower reaches of erosional valleys jointing with tectonic Graben valley. They formed from the Lower Pleistocene under humid and severe climatic conditions by erosion accompanied with periglacial weathering and denudation. Cryogenic processes related to permafrost caused deep weathering penetration and decomposition of granite rockwall into big boulders at the bases of cliffs. Vertical and even overhanging rockwalls were formed (Fig. 1). The deposited cobby gravels (pebbles and boulders) were transported from the cliff bases by rivers during early Pleistocene along tributary valleys to the main Graben valley and now they crop out in the scarps of fluvial terraces several kilometers faraway from the source areas. Only sporadically they still exist directly under the cliffs.

Under the conditions of progressing aridity in the Holocene and less severe thermal regime slopes were affected by granular breakdown due to frost penetration into bedrock and continued chemical weathering. Contemporaneous weathering on vertical cliffs goes shallow below the surface. Rock fragments are quickly reduced to grus. The loose grains fall down on the foot-slope area and make up a significant proportion of the bedload in dry channels. This process is especially intensively going on steep rock surfaces only with south and southwest aspects.

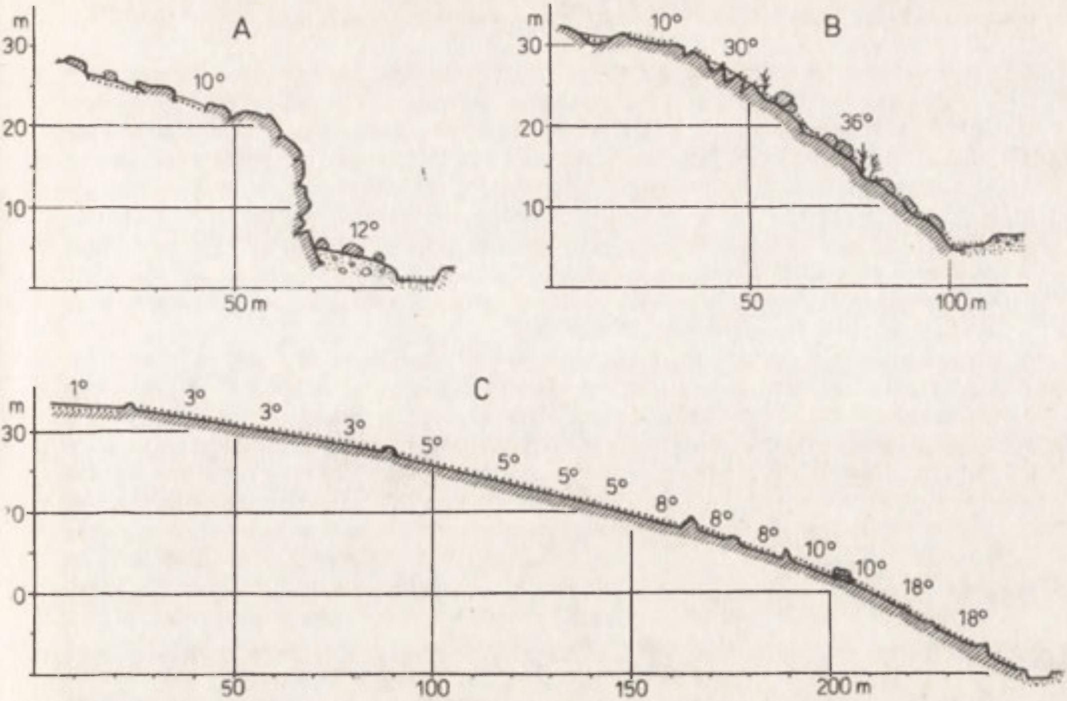

Fig. 1. Three main slope categories on the Central Mongolian Upland: A – rockwall, B – debris covered slope, C – convex wash slope

During summer seasons the absolute daily maximum of ground temperatures on such slope surfaces were registered (even +60°C) and deep cooling in nights was observed. Mean amplitudes of temperatures are 30°C and extreme as high as 50°C. Such thermal changes cause loosening of minerals and granular disintegration. During winter south-facing cliffs are affected by insolation and thermal changes across 0°C are frequent. At the same period north-facing cliffs are frozen for many weeks and even months. Ground surface freezing begins in October and lasts to mid-April (Hess, Kowanetz and Olecki 1983). Therefore strongly degraded cliffs are these with south and southwest aspects

Straight debris-covered slope. This slope category which was distinguished by Melton (1965) in the Sonoran Desert of Southern Arizona makes up a relatively larger fraction of the total relief of valley sides. Such slopes were classified earlier by Bryan (1923) in a genetic sense as "boulder-controlled slopes". On Central Mongolian Uplands the angles of debris covered slopes on granite rocks are ranged from 3° to 36°, and the mean was found to be 18°, i.e. much lower than this on slopes of the Southern Arizona Desert (see for comparison Melton 1965). This phase of rocky slope evolution was produced by intensive Quaternary weathering under humid and later semi-arid to arid cold climates with monsoonlike precipitation distribution. Morphologically they are similar to slopes described by Bryan (1925) who has stated that fresh abundant boulders on the surface are produced from bedrock. Weathering penetrating bedrock along joint planes down to 1.5–2.0 m below the surface was leaving the core stones behind. Due to such selective weathering cobble-sized or larger block were separated from the bedrock. These fragments are buried in highly weathered mantle produced from less resistant jointed parts of granite characterized by the high soil air capacity (more than 50% of soil porosity).

There is no evidence for gravity sorting of boulders even if some fragments of slopes have boulders which moved down in the past. As it was stated by Melton (1965) in Arizona, also Mongolian slopes cannot be classified as "boulder-controlled slopes". Angles of slopes are lower than the angles of repose of boulders. Intensive chemical and thermal weathering and decomposition connected with semi-arid conditions were supplemented by processes related to dry permafrost. Relict frost fissures filled with materials of the chestnut soil were found on the crystalline slopes (Kowalkowski 1975). Removal of granite regolith by slope wash, splash transport and probably solifluction was responsible for further slope evolution — into a convex, gentle wash slope covered by relatively thick waste mantle.

Convex slopes which are most common on Mongolian dry steppe zone have development by wearing back and wearing down of the upper element of previously described slopes. Lengthening of the convex element is caused by lowering of the crest due to removal of deeply weathered regolith and transportation to valley bottom. There is no accumulation of waste products at the footslope because the lower element constitutes a transition zone between the middle element and valley bottom. Valley floors are seasonally affected by flows connected with discontinuous permafrost degradation in spring and in summer by catastrophic downpours forming once in several tens of years flash floods in channels of *sair* valleys. Thickness of waste mantle is approximately uniform along the whole slope profile as the granites are profoundly weathered. Mean thickness of waste mantle with chestnut soil on it is of 30–50 cm. Only sporadically rocky knobs or small tors are to be seen on the slopes (Photo 1). They indicate reaches of most resistant granites

Photo 1. Small tors developed in the granite as a result of repeated microfracturing and grus removal. Convex gentle slope of the upper element of valley side

related to lithological differentiation or joint-spacing in the bedrock. The bigger tors on the upland are built of granites which were subject to metasomatic alteration (albitization) (Dzulyński 1983). Under present-day climate, convex wash slopes are affected mainly by splash and slow mass movements, even if they seem to be very stable. Successive stages of slope evolution are shown on Fig. 2.

Photo 2. Residual rounded joint blocks or tors have been produced on slopes through weathering in the massive granites

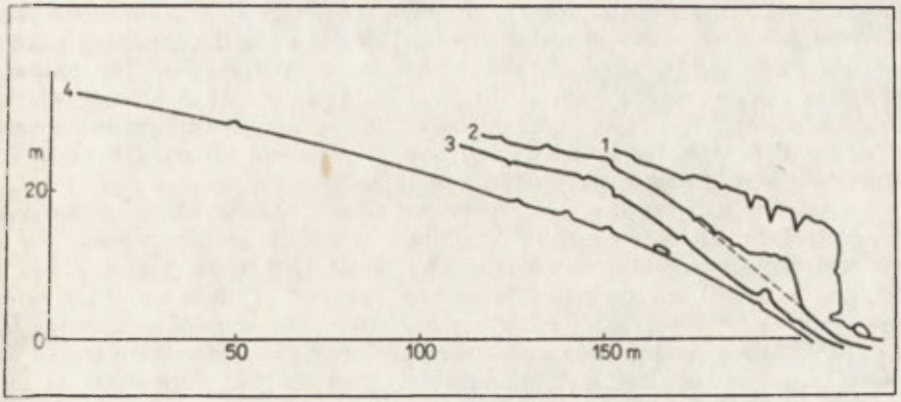

Fig. 2. Successive stages of granite slope evolution

RATE OF SPLASH AND SLOW MASS MOVEMENTS

During the 1977 field studies within the programme of the Polish-Mongolian Geographical Expedition were carried out on the slopes. Splash transport of granite grains 2.0–2.5 mm and 2.5–15.0 mm in diameter on the experimental plots was measured for a whole rainy season. Plots had the inclination 12° and 15°, typical for middle element of convex slopes (Kotarba 1980). Surficial movements of painted grains were measured after every rainfall, although in no case overland flow was recorded. Sporadical thunderstorm rains were characterized by low totals but high erosive capacity. Every rain of low intensity was generating saltation and downslope transportation of the particles. The longest distance for the summer season, practically equal to the yearly value, was 50 cm, while the average was 2–4 cm. During the next year (1978) overland flow occurred three times. Extraordinary wet spring and summer were characterized by rain totals of the order of 36–37 mm/day with the highest intensities of 1.5–1.7 mm/min. Such rainfall is able to generate negligible (0.1%) overland flow and short-distance (several cm) slope wash. Recurrence interval of rainfall intensities of this order is relatively long (about 10 years) and spatial impact of falling raindrops strongly limited when rainfalls originate mainly from *Cumulonimbus* clouds. Taking into account the above data the author's impression is that slope wash cannot be responsible for presentday slope transformation. It is suggested that splash detachment as a dominant process is accompanied only sporadically by slope wash on Mongolian dry steppe.

The existence of slow mass movements in the semi-arid Mongolian Uplands is not to be determined by field evidences such as outcrop curvature, soil accumulation at the foot slope, cracks in the soil, terracettes, etc. Regolith cover with the chestnut soil on the top, of the mean depth of 50 cm, on gentle convex slopes has generally uniform granulation on a large area. Man-made field evidences held to be indicative of soil creep were found in the study area; These are *balbali* — stone lines installed across slopes or in valley bottoms in around the 8th c. In 550 migration of Turkish tribes to Central Asia began. In the 8th c. Mongolian territory was included into Turkish Empire. At that period stone lines were constructed. These vertical standing boulders depicted a defeated enemy (Godlowski 1966). Straight lines with W–E orientation were found both on convex slopes and on pediment-like slopes within the upland crest. The *balbali* stone lines installed on pediment-like slopes with waste mantle no more than 10 cm thick were not disturbed while these built on convex slopes with 50 cm thick regolith covers are visibly disturbed. On gently sloping surface (3–4°) precise levelling of one stone line, 225 m long, was made. For 105 m long reach (46%) of this line stones were displaced downslope over different distances (Table 1) while the remaining reach is not disturbed, i.e. boulders are still on an initial straight line. The following information was recorded: size of the boulders (axes *a* and *b* in cm), whether the boulders were lying loose or were buried in the soil, downslope displacement of all boulders from the zero line, and zero line was reconstructed by extension of the undisturbed line to the mobile zone (Fig. 3).

Size of displaced boulders is differentiated from 24 cm to 82 cm in maximum diameter (Table 1). It is significant that there is no relationship between size of boulders and total downslope movement for about 1200 years (Fig. 4). Most of displaced boulders were buried in the soil to the depth of 10–15 cm. They moved downslope together with the surrounding soil cover. This is evidenced by the fact that they did not produce microtopography characteristic of ploughing blocks well known from periglacial or high mountain environments. No earth banks at their front and troughs behind them were observed. Therefore it can be stated that the rate of boulders displacement is a measure of soil creep for 1200 years. Calculated

TABLE 1. Deformation of stone line "balbali" by slow mass wasting on gentle convex slope in Gurvan Turuu, Central Mongolia

Boulder size (axes *a* and *b*) in cm	Total displacement (mm per 1200 yr)	Calculated yearly displacement (mm)
30 × 17	600	0.50
50 × 45	630	0.52
27 × 20	610	0.50
32 × 32	820	0.68
60 × 25	1130	0.94
47 × 25	2200	1.83
75 × 20	2600	2.16
39 × 20	2280	1.90
48 × 30	2600	2.16
82 × 65	2250	1.87
40 × 25	2750	2.29
40 × 35	2830	2.35
30 × 20	3130	2.60
30 × 18	3600	3.00
40 × 30	3800	3.16
32 × 18	4150	3.45
55 × 37	4200	3.50
45 × 40	4270	3.55
30 × 30	4230	3.52
56 × 30	4130	3.44
24 × 19	4050	3.37
24 × 22	4020	3.35
35 × 22	3900	3.25
40 × 33	4200	3.50
30 × 18	2700	2.25
45 × 18	3400	2.83
30 × 30	3290	2.74
30 × 30	2900	2.41
42 × 23	2350	1.95
35 × 30	1750	1.45
40 × 35	2360	1.96
65 × 56	1750	1.45
35 × 20	200	0.16

Mean displacement 2.26 $mm \cdot yr^{-1}$
Absolute max. displacement 3.55 $mm \cdot yr^{-1}$

mean rate of soil creep is very low 2.26 $mm \cdot yr^{-1}$ as well as maximum value (3.55 $mm \cdot yr^{-1}$). Values of this order (1–2 $mm \cdot yr^{-1}$) were estimated for semi-arid and arid environments by Jahn (1984): and they were lower than these calculated by Lewis (1975) from Puerto Rico (2–6 $mm \cdot yr^{-1}$). Saunders and Young (1983) show that rates of soil creep in semi-arid climate range between 3 and 8 $mm \cdot yr^{-1}$ but these data refer to steep slopes above 25°, and are not comparable with the rate of creep on gentle slopes in Mongolia. It should be also considered that Mongolian data give idea of maximum rate of soil creep. Very large areas are not affected by slow mass movements as some stone lines were never disturbed.

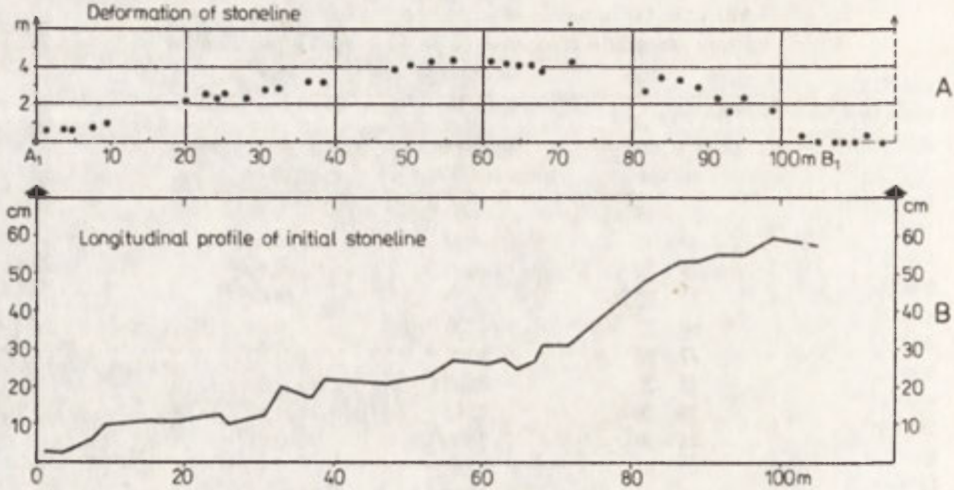

Fig. 3. Stone-line deformation in relation to reconstructed initial line

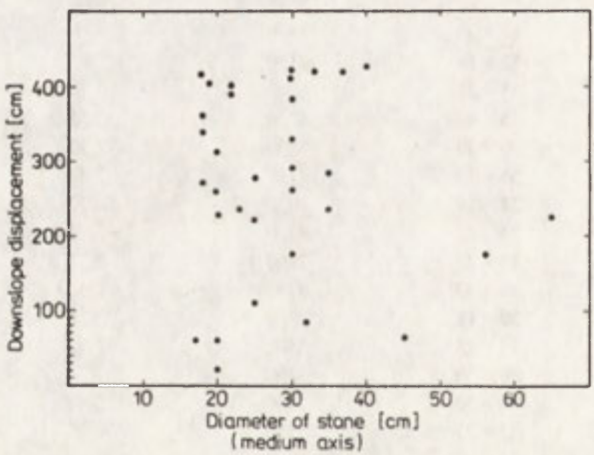

Fig. 4. Relationship between diameter of boulders and their downslope displacements

CONCLUSIONS

Within Paleogene surface of planation fluvial valleys with rocky slopes were formed during the Pleistocene. Holocene morphogenesis of valley sides produced three slope categories which vary considerably in shape, regolith mantle and geomorphic processes. These are: cliffs, straight debris-covered slope and gentle convex wash slope. They represent on evolutionary sequence of slope profile changes under dry and severe continental climate of Central Asia. The gradual reduction of slopes to gentle inclination and parallel recession is a result of deep weathering penetration in the past and creep, splash and wash processes which are acting till nowadays. Geomorphological field experiment show relatively low rates of these processes. Downslope transport is achieved by rainsplash alone without any surface runoff for most of the recorded events.

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STABILITY VERSUS COMPLEXITY IN SELF-ORGANIZING SPATIAL SYSTEMS

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1. INTRODUCTION

This paper investigates the variation of stability connected with the process of complication of the organization of spatial systems.

Two basic notions used in the investigation are conceived here in a different way than in standard systems analysis, although we base ourselves on it. Hence, they require new definitions. The notions are: stability and equilibrium. Stability is meant as the convergence with the state of equilibrium. A system is less stable if it diverges more from the state of equilibrium. By the equilibrium of a system we understand mutual adjustment of its subsystems (elements, connections). The equilibrium, as it is conceived here, cannot be defined, however, in a unique way. It can be determined only by the comparison with the assumed reference system. We assume that the system is in equilibrium if its subsystems are adjusted in the same or higher degree than that of reference system. In spatial context, the equilibrium means the same or lesser spatial differentiation in comparison with the reference system.

Defined in this way, the equilibrium can be a desired state of spatial organization of a system, and the investigation of instability can be essential for the determination of intervention needed to direct the system towards the state of equilibrium.

Spatial systems considered in this paper are self-organizing in the sense of Prigogine's theory. They are open and linked with the environment, far from uniformity, and the interactions between their elements reveal nonlinearities.

Spatial organization complicates as the system develops. This implies the change of its stability. The investigation of stability gives insight in important properties of spatial systems.

Although the investigation of stability against complexity was the starting point of this paper, its final result turned out to be more significant from other point of view. It enabled the modification of an acknowledged theorem of regional science.

2. THE INCREASING COMPLEXITY OF SPATIAL ORGANIZATION

Five alternatives of increasing complexity of spatial organization are considered in this paper. The initial states of individual alternatives are presented in Table 1–3. The alternatives are differentiated with regard to: distribution of population, migrations, and the level of incomes. Individual cities are also differentiated with

TABLE 1. Number characteristics of alternatives in initial state t_1

Alternative City	Population in thousands	Migrations in thousands	Incomes in billions
Reference system			
City 1	500	10	100
City 2	300	6	55
City 3	60	0.6	7.5
City 4	150	2.2	25
City 5	50	0.5	6
City 6	170	2.5	30
City 7	70	0.7	9
Alternative 1			
City 1	500	10	100
City 2	300	6	55
City 3	60	0.6	7.5
City 4	350	14	70
City 5	50	0.5	6
City 6	170	2.5	30
City 7	170	5.5	30
Alternative 2			
City 1	500	10	100
City 2	425	11	85
City 3	135	2.7	20
City 4	200	5	30
City 5	50	0.5	6
City 6	170	2.5	30
City 7	120	2.4	18
Alternative 3			
City 1	500	10	100
City 2	300	6	55
City 3	60	0.6	7.5
City 4	150	2.2	25
City 5	50	0.5	6
City 6	170	2.5	30
City 7	70	0.7	9
City 8	100	3	18
City 9	200	8	40
Alternative 4			
City 1	500	10	100
City 2	300	6	55
City 3	60	0.6	7.5
City 4	150	2.2	25
City 5	50	0.5	6
City 6	170	2.5	30
City 7	70	0.7	9
City 8	50	0.75	7.5
City 9	50	0.75	7.5

TABLE 1 cont.

City 10	100	2	17
City 11	100	2	17
Alternative 5			
City 1	500	10	100
City 2	300	6	55
City 3	60	0.6	7.5
City 4	220	5	38
City 5	50	0.5	6
City 6	170	2.5	30
City 7	150	3	23
City 8	50	1.3	9
City 9	100	2.5	18

TABLE 2. Distances between cities in km

	City 1	City 2	City 3	City 4	City 5	City 6	City 7	City 8	City 9	City 10	City 11
City 1		150	90	140	80	130	100	40	60	35	50
City 2			180	290	230	280	100	110	210	185	150
City 3				120	170	220	190	130	150	55	140
City 4					100	180	240	180	80	175	190
City 5						80	180	120	140	115	130
City 6							200	170	190	165	180
City 7								140	160	135	50
City 8									100	75	90
City 9										95	110
City 10											85
City 11											

TABLE 3. Quality of environment in cities (1.0 denotes satisfactory quality)

City 1	1.5
City 2	0.8
City 3	0.5
City 4	1.0
City 5	0.9
City 6	1.2
City 7	1.1
City 8	1.2
City 9	1.1
City 10	1.0
City 11	0.9

regard to the quality of environment (but in the same way in each alternative).

Reference system. It develops by the interaction of endogenous forces. No exogenous factor affects its development. All alternatives are compared with it. The alternatives are compared also between themselves.

The population of the reference system in its initial state amounts to 1.3 million inhabitants. The alternatives are being complicated by the following change. The population is higher, but in all alternatives equal to the same number (1.6 million inhabitants). Its distribution, however, is different in each alternative. Here are the basic characteristics of consecutive alternatives in their initial state.

Alternative 1. The whole increment of population (in comparison with reference system), i.e. 0.3 million inhabitants is located in two existing cities: no 4 and 7. Such a concentrated growth implies intensive migrations. The incomes of growing cities are increasing too.

Alternative 2. New population is distributed in four existing cities: no 2, 3, 4 and 7. Dispersed growth involves moderate migrations as well as moderate increase in incomes of cities.

Alternative 3. Two new cities appear: no 8 and 9. They absorb whole increment of population. Both migrations and incomes of these cities are high.

Alternative 4. The increment of population is located in four new cities: no 8, 9, 10 and 11.

Alternative 5. The difference in population is distributed partly in existing cities (no 4 and 7), and partly in new cities (no 8 and 9).

3. MODEL SIMULATING SPATIAL ORGANIZATION

State variables:

P_i – population of city $i\,(i = 1, \ldots, n)$;
M_i – net migration of city $i\,(i = 1, \ldots, n)$;
T_{ij} – interaction between city i and j (interpreted also as the volume of flows);
s – standard deviation of city sizes.

Parameters:

r – population growth rate, constant in the system ($r = 0.01$ has been used in the simulations);
h – income growth rate of cities, constant in the system ($h = 0.02$ has been used in the simulations);
d_{ij} – distance between any two cities i and j; $d_i = \sum_{i<j} d_{ij}$;
D_i – accessibility of city $i\,(i = 1, \ldots, n)$; it assumes low values both for the largest city (traffic congestion), as well as for new cities (underdeveloped transport connections);
I_i – incomes of city $i\,(i = 1, \ldots, n)$;
Q_i – quality of environment of city $i\,(i = 1, \ldots, n)$.

Functional relations

$$m_i = \frac{\dfrac{I_i}{P_i}}{\dfrac{\sum_k I_k}{\sum_k P_k}} \; \frac{\dfrac{T_i}{d_i}}{\dfrac{\sum_{i<j} T_{ij}}{\sum_{i<j} d_{ij}}} \left(1 - \frac{P_i^2}{\sum_k P_k^2}\right) D_i \; Q_i - 1, \tag{1}$$

when $m_i < 0$, then $m_i = \dfrac{m_i}{m_i - 1}$

$$M'_i = \frac{\frac{1}{2}\sum_k |M_k|}{\sum_k P_k} m_i P_i, \tag{2}$$

$$P'_i = (1+r)P_i + M'_i, \tag{3}$$

$$I'_i = (1+b) I_i, \tag{4}$$

$$T_{ij} = \frac{P_i P_j}{d_{ij}^2} \quad i, j = 1, \dots, n; \quad i \neq j, \tag{5}$$

$$T_i = \sum_{j \neq i} T_{ij}. \tag{6}$$

In order to include negative externalities caused by traffic congestion, the term T_{ij} was modified by the introduction of a reduction factor $\left(1 - \frac{P_i^2}{\sum_k P_k^2}\right)$ and assumed therefore the form

$$T_{ij} = \left(1 - \frac{P_i^2}{\sum_k P_k^2}\right) \frac{P_i P_j}{d_{ij}^2}. \tag{7}$$

The term m_i denotes the attractiveness of city i for migrants. It depends on relative per capita incomes, economies of mass transportation, negative externalities caused by population overcrowding, accessibility, and quality of environment. This term expresses the influence of local factors modifying an average spatial mobility of population in the whole system. The terms M'_i, P'_i, I'_i denote migrations, population, and incomes in iteration $t+1$ subsequent to iteration t.

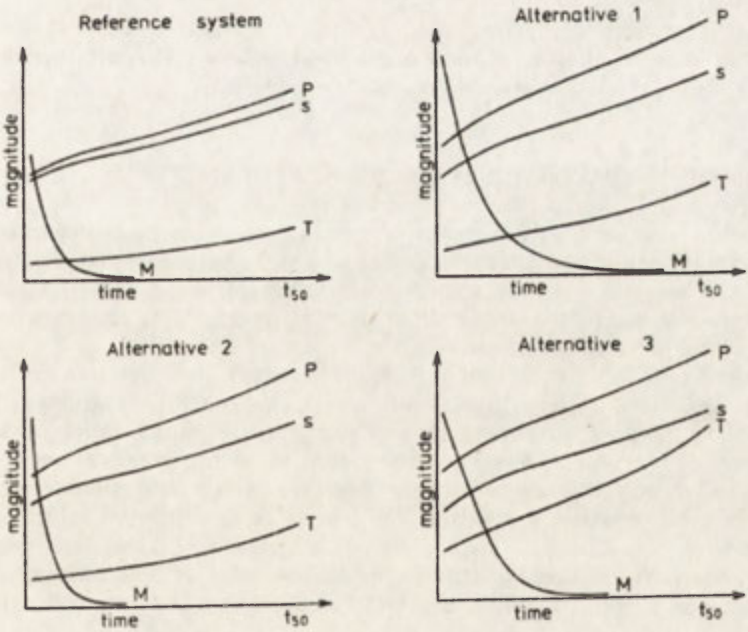

Fig. 1. State variables. Results of simulations: P – population, M – net migrations, T – interactions, s – standard deviations

Output

The computations were carried out for 50 iterations.[1] The state of spatial organization of the system in each iteration is described by the variables P_i, M_i, T_{ij} and s. Their values are presented in the form of diagrams (Fig. 1–2), and partly illustrated in the form of maps (Fig. 3).

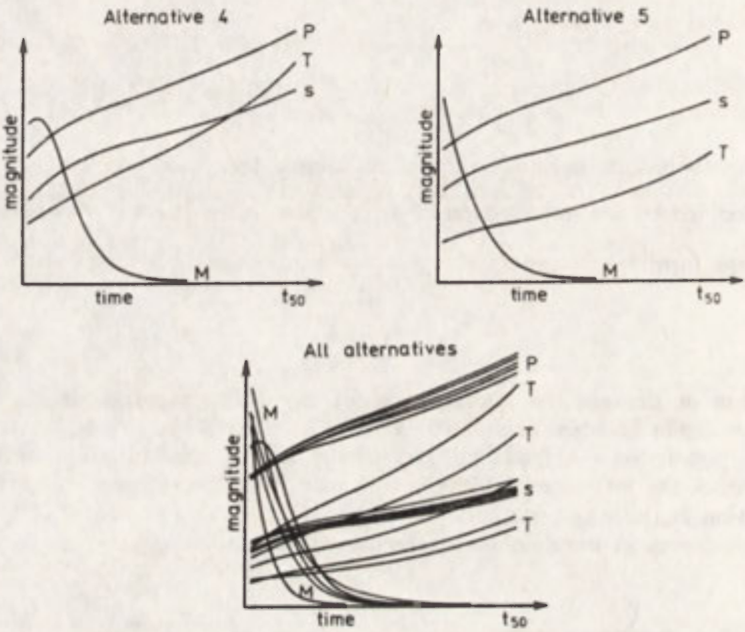

Fig. 2. State variables. Results of simulations: P – population, M – net migrations, T – interactions, s – standard deviations

4. STABILITY OF SPATIAL ORGANIZATIONS WITH INCREASING COMPLEXITY

The below analysis uses the results of simulation, and aims at determination of the changes of stability of spatial organizations with increasing complexity.

It is not assumed that the spatial organization of the system is stable in its initial state. We accept the organization as it is, and analyze the variation of its stability in the development process.

In order to identify the changes of stability we must apply relevant criteria. Here they are: trends of relative growth of various subsystems, centrality of spatial organization, standard deviations of city sizes, compensatory flows of migrants, connectivity of the system, hierarchical structure of spatial organization, congestion of cities and roads, differences between reference system and alternatives as well as between the alternatives themselves. The criteria assume different values depending on: degree of concentration (dispersion) of the growth of subsystem, location of growth centers in relation to central region, intensity of interactions, effects of large scale and agglomeration, strenght of compensatory and cumulative feedbacks

[1] Algorithm and computations were implemented by Jan Dawidowski, Center for Data Processing, Poznań School of Economics.

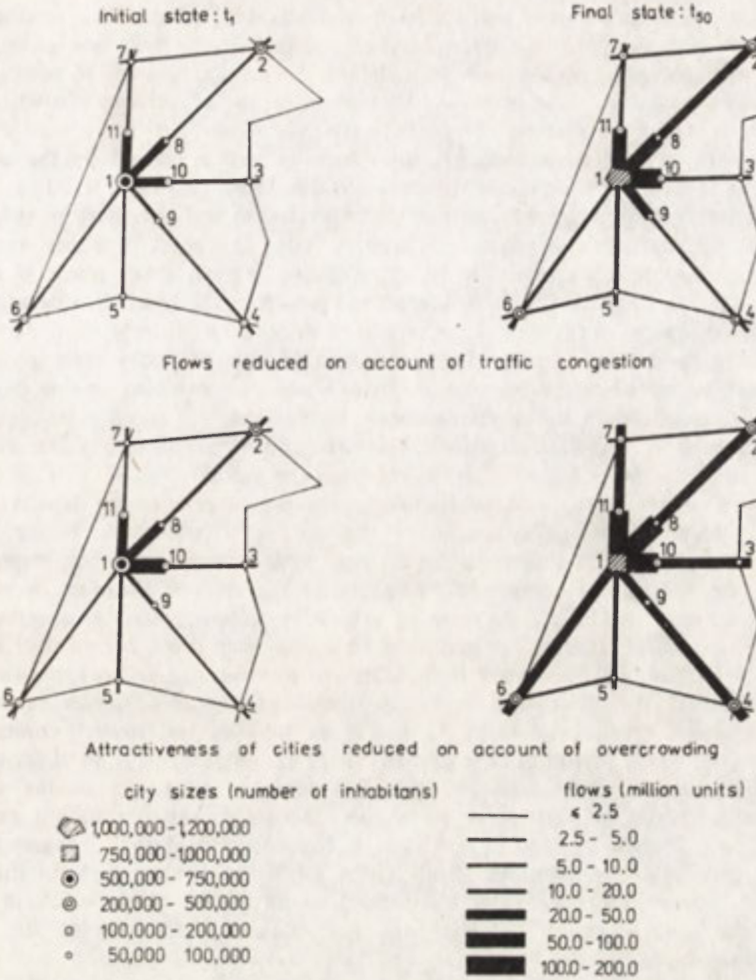

Fig. 3. Spatial organization. Results of simulations. Alternative 4

and their interrelation. Using these criteria, we can define and evaluate how the stability changes as the initial conditions change and the system develops.

Stability is a specific case of ergodicity. The system is stable if it tends towards certain state, which is the state of equilibrium. This is its specific feature. The system is ergodic if it tends towards the states which are convergent to certain law of development. It is essential to identify this law. In social sciences we can do that by the identification of dominant trend.

Let us consider population growth at first. Individual alternatives compared with the reference system show two deviations: 1) the slopes of the curves of growth are a bit steeper, and 2) the lines are somewhat curved in the initial segments. These deviations can be observed more clearly (Fig. 1–2) in the alternatives with concentrated growth of population in few existing cities or in new cities (alternatives 1, 3, 4). This is the result of higher incomes and consequently higher positive net migrations of these cities. In alternative 4, the addition of four new cities improved the accessibility to opportunities and reduced the friction of space. This resulted in higher growth of population in comparison with alternative 3 (two new cities).

Thus, the spatial organization complicated by concentrated growth of population is somewhat less stable, if stability is defined in terms of relative growth and deviations from reference system.

The instability of spatial systems, like all other systems, is caused by the action of cumulative feedbacks. Cumulative processes differentiate the size of cities. Two measures of differentiation can be used: standard deviation and the share of primary city in total population. The share of primary city changes depending on the distribution of population growth. It is higher if the growth takes place in areas less distant from the primary city, and lower if the growth is distributed in peripherial areas. Shorter distances strengthen the influence of interactions (flows) on the growth of primary city. As could be expected, the standard deviations of city sizes increased in the highest degree when the population growth was concentrated in few existing cities, and decreased when it was more evenly distributed.

Thus, the shift of population growth towards central region makes the system less stable, whereas the policentric trends increase the stability.

Let us now consider the reverse feedback, i.e. the compensatory feedback. It weakens the deviation of the system from the state of equilibrium. Hence, it is the necessary condition of stability. In the system considered in this paper, migration movements play the role of compensatory feedback. The steepest decrease of migration curve, meaning the fastest decrease of migration volume, can be observed in alternative 2. In this alternative population growth has been most evenly distributed among existing cities. This favoured the adaptative process and self-organisation of the system. Besides, the alternative shows also the shortest time of achieving migration balance (zero net migration in 12 years) as well as the lowest volume of migrations in the whole period of development ($t_1 - t_{50}$). The longest time of achieving migration balance (27 years), and the highest volume of migration in the whole time interval occurred in alternative 1. In this alternative the population growth took place only in two existing cities. Such a concentrated growth advanced the cities to higher class of incomes. Both cities advantaged also high quality of environment. These factors increased the attractiveness of the cities, which in turn lengthened the time needed to achieve migration balance, and enlarged the total volume of migrations.

The question arises, whether equilibrating processes are being revealed in the standard deviations of city sizes. The answer to this question cannot be univocal. On the one hand the absolute level of standard deviations increased, on the other hand differences in standard deviations between individual alternatives and the reference system decreased. The increase in the absolute level is easy to explain. It is due to the higher numbers of population assumed in alternative systems. The decrease of differences (see Fig. 1 and 2), which is evident particularly if we relate standard deviations to the numbers of population, can be interpreted as the effect of equilibrating processes (compensatory feedback).

Let us now pass to the interactions between cities. It results from Fig. 1–2 that the inclusion of new urban centers increases the level of interactions as well the rate of growth. In the curves which depict the growth, there appear upwardbends. They can be observed particularly in alternative 4, and to less extend in alternatives 3 and 5.

It is worth noticing that the shape of curve of interactions differs from that of population (see Fig. 2). The first curve T, in its initial segment, is approximately a linear function, but then it is increasing at an increasing rate and becomes convex-downward. The second curve P, in its initial segment, is increasing at an decreasing rate, becomes convex-upward, but then passes gradually into approximately straight line. This divergence of trends means that the system becomes less stable in terms of accepted criteria. It results in the increase of the number of interactions per capita.

The increase in both the volume as well as the rate of growth of interactions can be interpreted, in terms of the systems theory, as the rise in connectivity. It caused disturbances in the former hierarchic structure and made it less legible.[2] That prompted statements that hierarchic patterns in spatial connections have lost their significance. Such statements are probably exaggerated. Anyway, the more connective is the system, the more sensitive it is to disturbances in the functioning of its elements and couplings. Therefore, it is also less stable.

Rise in connectivity is not the only tendency taking place in modern spatial systems. It may be easiest to notice and, therefore, it is best known and described. Parallel to it, however, another process that is more difficult to notice takes place. It is a process of reducing the connection networks (simplifying organization). No system can function and grow harmoniously if corresponding with a rise in connectivity, its organization is not simplified. An unlimited rise in connectivity would diminish the socio-economic efficiency of the system and lead to a state of spatial chaos. From the rule of simplifying organization, the conclusion may be deduced that what is happening in spatial connections now is not an elimination of hierarchy, but a change in its character. At present it is still difficult to see the new shape of the hierarchy. However, the following three tendencies changing the spatial organization can be already singled out: the agglomeration, the unitization,[3] and the incomplete decomposition. These tendencies deviate the spatial organization from regular and equilibrium patterns. Hence, they are also destabilizing it. Our computations confirmed these hypotheses. For that purpose we computed the share of the largest cities in total population, the share of connections with the heaviest flows in total flows, and the shift of connections to the higher levels of flows.

We are now in the position to sum up the characteristics of individual alternatives of spatial organization. All alternatives can be divided in two distinctive groups. The first group embraces alternative 2 and 5, the second group – alternative 3, 4 and 1. The alternatives belonging to the first group satisfy the criteria of stability in higher degree than the alternatives of the second group. The initial growth impulse was with that the same in all alternatives. This means that spatial organization is more stable if the growth of system is more evenly distributed between cities (regions), and less stable if it is concentrated in few existing or in new cities. Such a conclusion could be expected. Now, however, we are able to confirm this supposition to some extent. The conclusion can be treated as a consecutive element in the process of cumulating arguments for the theorem which is being added to the stock of knowledge. Another conclusion, which is more significant, can be also drawn from the above analysis. It does not confirm an earlier supposition, but sets up a new one. If it had been justified by more arguments than we present here, it could become a new element of knowledge.

Let us remind that we observed some differences in the development of the subsystem of cities, and the subsystem of interactions (flows). They revealed in: 1) the diminishing differences in standard deviations of city sizes, 2) the growing number of interactions per capita. On this basis one can state that the subsystem of cities is more stable than the subsystem of flows.

These differences, though not very high, are, however, inspiring. Their disclosure

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[2] Less sharp distinction of hierarchical levels due to the growth of direct connections will be called the incomplete decomposition.

[3] Unitization denotes the process of separation of very strong connections from the whole network of connections.

enables us to extend our conclusion and modify an acknowledged theorem, which states that both subsystems are strongly interdependent. The theorem has sound justification. It is evident that the development of the subsystems is mutually interrelated. The growth of cities implies increasing interactions between them and, consequently, requires new transport facilities. Improved transportation, in turn, creates possibilities for further growth of cities. Thus, feedback mechanism develops, and defined proportions establish.

What, then, our modification of the theorem can rely on? It is the following. Even small differences in stability of city subsystem and interaction subsystem create an interstice in the interdependence between them. It can be then broadened through cumulative feedback. Thus, in longer period of time, particularly in the advanced stage of development process, the interdependence may weaken. One can expect that this trend will not be an unbroken continuum. Great innovations may change the underlying processes, both subsystems may take a new course, and new interrelations between them may be established, not excluding reverse ones. Setting up our conclusion and modification, we are obliged to present at least their tentative rationale in terms of theories applied in regional science. Our reasoning runs as follows. Spatial organization of city and interaction subsystems is being shaped by various technological and socio-economic processes. Some of these processes overlap, else cross each other. In this ravel of processes, some affect spatial organization stronger, other weaker. It is necessary to disclose the processes, which are the resultant of various forces or dominant forces. We set up a hypothesis that in the advanced stage of long-term processes, that shape both subsystems, compensatory feedbacks prevail over cumulative ones in the development of city subsystem, and cumulative feedbacks prevail over compensatory ones in the development of interaction subsystem. We can explain this difference in the following way. Both subsystems are being shaped by the processes of agglomeration. But their sensitivity to agglomeration effects is different: stronger in case of industry and services (economy), and weaker in case of population. Stronger sensitivity of economy leads to its greater spatial differentiation and, consequently, to increasing flows of goods. This property of industry and services occurs if the economies of agglomeration outweigh the diseconomies of transportation.

The mobility of population is higher than that of economy. The migrations, then, are more effective compensatory movements than the relocation of economy. Thus, they can lead, in longer period of time, to the diminishing of spatial disparities and the decrease of deviations of city sizes. Let us note, however, that both higher mobility of population, as well as more inert economy, though they reveal in different spatial trends, act in the same direction in one respect: they imply more flows in socio-economic systems. Similar relations can be observed also on local level, i.e. in individual cities, particularly in large cities.

As already mentioned, great innovations may change the trends of the development of spatial organization. The change of relation between agglomeration effects and transportation costs will exert particularly great influence. Also, the changes of the system of values will be essential. On the other hand, the divergence of trends of city and interaction subsystems may last longer than underlying processes because of delayed adaptation of spatia organization.

5. CONCLUSIONS

The analysis of spatial organization in terms of stability enabled us to make several observations. As the system develops, the spatial organization complicates, which implies the change of its stability. Increasing complexity of spatial organization can exert different influence on its stability depending on the way of complication. Five alternatives of developing system were examined in this respect, and compared with the reference system. Simulation method was used to trace the paths of development of the system.

It turned out that the concentration of growth, the growing centrality of spatial organization, the rise in connectivity, and the restructuring of hierarchical order make the system less stable, whereas the policentric growth and the migrations favor its stability. Other factors affecting the stability are: the differences in sensitivity to agglomeration effects, the differences in spatial mobility, and the delay in adaptive processes.

The most significant observation concerns the difference in stability between city subsystem and interaction subsystem. Though the difference is small, it may increase owing to cumulative feedback. Thus, the interdependence of both subsystems may weaken, particularly in the advanced stage of development process. The observation modifies an acknowledged theorem concerning this interdependence.

GEOGRAPHIA POLONICA 52, 1986

STRUCTURAL CHANGES OF ECONOMY AND REGIONAL DEVELOPMENT INEQUALITIES

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The subject of the present paper is the effect of changes in the sectoral structure of activities on the spatial structure of the economy in the stage of transition from traditional agricultural to modern industrial society. The structural changes in the national economy, constituting both the conditions and the outcome of the process of economic development, comprise — in broad categories of sectors of economy and in terms of employment — the increasing share of employment in industry and services as well as the decreasing share of employment in agriculture, resulting from relatively high rates of growth in the two former sectors and low, or negative, growth rates in the agricultural sector.

These structural changes in the national economy originate normally in conditions of the already existing differentiation of economic structure of regions[1] and thus produce defined tendencies of interregional shifts in the distribution of population and employment. In particular, provided that the growth rates of individual sectors are uniform throughout the national territory, there arises in these conditions a shift of total employment towards more developed regions which have lower share of agricultural employment.

This is the structural component of the tendency towards the concentration of economic activities, which in most cases — at least in countries with market economies — is accompanied by the differential effect of the faster growth of dynamic activities in the more developed regions. So far, the attention of students of regional growth was focused on this differential effect while the structural factor hardly seemed to merit special treatment, especially since both factors worked, as a rule, in the same direction, i.e. towards greater concentration and growing regional disparities.

Yet, it is the structural effect which largely determines the intensity of the concentrating forces which are extremely difficult to check, independently of the existing social and economic order and independently of the type of regional development policy — or its absence — on the part of the authorities. In this context, of special interest might be the case of the post-war Poland, where in the conditions of centrally planned economy, the dynamic activities were deliberately developed at faster rates in less developed regions of the country. The consequence of these faster

[1] In extreme cases — like in many former colonial nations — this differentiation may take form of the existence of one big city in the otherwise agricultural country.

rates were the shifts of nonagricultural employment towards the less developed regions, constituting the forces working towards the deconcentration and towards diminution of the interregional development inequalities.

In the recent study (Wróbel 1983) covering the period of 1950–1978, these processes were analysed in the broad framework of the division of Poland into two parts nearly equal in areal extent: more developed West and underdeveloped East. According to the calculations using this highly generalized but convenient scheme of differentiation of regional development level, for the total nonagricultural employment the value of the shift towards the East for the period 1950–1978 was equal to about 380,000 persons; for industrial employment alone, the value of the shift was about 280,000 persons. The comparison of these two figures indicates that the relative weight of the tertiary sector in the eastward shift of nonagricultural employment was rather insignificant (although the social, cultural and in the long run also economic significance of accelerated development of such functions as education, health care, communication etc. was incontrovertible).

The heavy relative importance of industry reflected by the above figures is easily understood in view of the accepted strategy of economic policy guided by the principle of accelerated industrialization based on the expansion of heavy industry. In this situation it was obvious that the surest way to achieve faster economic growth of regions was industrialization, and the most important instrument of such a policy was the industrial location policy exercised by the State Planning Commission.

The shift of industrial employment towards the East, as defined above (using population census data) constituted about 20% of total industrial employment growth in that area in period studied (or 27% over the hypothetical increase corresponding to the national growth rate). A closer examination of this figure was provided by the same study, presenting the results of the 'shift-share analysis' for the set of 22 Polish provinces and 22 industrial groups, covering the period of two decades: 1950–1960 and 1960–1970; this detailed study was supported by the generalized analysis according to 9 industrial groups for the period of 1970–1978 (Wróbel 1983).

The summary results of this shift-and-share study in reference to the division of Poland into East and West were the following:

The general tendency was the shift of the total industrial employment towards the East, and in the western part of the country towards the North. This shift occurred at the cost of a relatively slower growth of the traditional industrial areas and particularly the province of Katowice and the city of Łódź. Slower growth resulted there mainly from the restrictions imposed by the locational policy, and in lesser part also from the changes in the structure of Polish industry, namely the relative decline of the role of the industries which played a dominant part in these areas (coal mining in case of the province of Katowice and textile industry in case of Łódź). Negative shift characterized also other big cities; this phenomenon resulted even more from restrictions created by locational policies, since local industrial structure was here a favourable factor.

Three of these big cities, i.e. Warsaw, Łódź and Cracow were located in the East. Thus, the total shift towards the East was the outcome of two tendencies: negative shift for the big cities and positive for the remaining areas. These tendencies reflected two directions of locational policy: propulsive in relation to underdeveloped areas and restrictive in relation to big cities.

The total positive shift for the East in the period of 1950–1970 amounted to 203,000 persons and for the same area but without the big cities (where the sum of shifts was negative) – 260,000 persons; in the last figure, 233,000 represented the differential shift, considered by the author as an approximate measure of the results of industrial location policy.[2]

Similar tendencies characterized the decade of the 1970s. Exact comparison is impossible due to the changes of administrative division in 1975. Nevertheless, the analysis of the data on total industrial employment for 1970 and 1978 for the grouping of the new provinces corresponding together roughly to the area of the East as defined for the previous period, indicate that in those eight years there occurred again a shift of total industrial employment towards the East equal to 100,000 persons; this sum resulted from a negative shift for the three big cities equal to −70,000 persons and a positive shift for the rest of the area of 170,000. These dimensions indicate the continuation of the previous tendencies shaped by the location policy which fostered the industrialization of less developed areas and at the same time curbed the growth of industry in the big urban agglomerations. The above considerations confirm the primary role of the industrial location policy in the shaping of the interregional shifts of nonagricultural employment.

What was the relative weight of these shifts when compared with total employment shift? The negative structural effect of the high share of the agricultural sector in the economy of the East was so high that the total shift of economically active population for this area was highly negative, equal to about −740,000 persons, i.e. almost twice as high than the positive shift of nonagricultural employment totalling 380,000.

This negative shift of total employment had its counterpart in the negative shift of population, which amounted to about 1.2 million. It must be pointed out that the latter shift occurred not only as a result of interregional migrations but was also due to the differentiated rate of natural increase, consequent upon earlier migrations.

As might be seen from the comparison of the relevant figures presented above, the effort of locational policies did not offset entirely the structurally determined tendency towards greater concentration of population in the developed regions; however, it succeeded in curbing this tendency and diminished the interregional income differences,[3] and thus permitted to reach a considerable degree of 'regional balance' in the process of economic growth.

On the other hand, these achievements must be seen in the context of the actual intensity of the structually determined tendency towards concentration. As the comparison of the figures of interregional population and employment shifts with the national growth figures of relevant variables demonstrate, this tendency was not very strong – in contrast to the processes occurring in most European countries.

A particularly appropriate object of comparison seems to be Spain, a country of roughly the same population size and divided into nearly the same number of provinces (50) as Poland (49). Moreover, Spain experienced a similar process of rapid industrialization although it begun only in 1960 – a decade later than in Poland; both countries also experienced serious development problems and a change in previous growth tendencies in the second half of the 1970s (not considered here). Yet, these similarities were accompanied by quite different intensities of interregional

- East as a whole, with some regional exceptions and an obvious exception of extractive industries, offered less favourable conditions for industrial location than the more developed West so that in the absence of deliberate location policy the value of the differential shift might have been rather negative.

[3] For the documentation of the latter process see: Wróbel 1980.

concentration trends, which can hardly be attributed only to the differences of social and economic order of the two countries.

The existence of similar sets of administrative units permits the recourse to direct comparison of the magnitudes of interprovincial population shifts which may serve as an indication of the strength of the tendency towards concentration. In the decade of 1960s the volume of these shifts was in Spain more then four times higher than in Poland (the total of positive shifts for Spain was equal to 2,600,000 persons, for Poland 580,000).

The greater intensity of interregional migrations in Spain was reflected also by the fact that in the same period, 23 provinces actually lost population while in Poland only one; likewise, in the first part of the decade of the 1970s, the number of provinces loosing population was the same in Spain, while in Poland it was only 3. The apparent reason for these differences was opposite trends in the regional distribution of industry: whereas in Poland, due to the locational policies described earlier, the spatial concentration of industrial employment was constantly decreasing in the entire period after the second World War (see: Misztal and Kaczorowski 1980), in Spain the industrial concentration increased (see: Precedo 1981). Yet, it was not the only factor explaining the differences of the intensity of population concentration in both countries.

The comparison with Spain reveals that the 'regionally balanced' growth in Poland was achieved in specific conditions related to the structural characteristics of growth processes which were determined mostly by economic policies. These conditions can be grouped into two sets.

The first one is composed of those conditions which resulted in the relatively low rate of outflow of labour force from agriculture. The importance of the above variable is self evident, since it was the high rate of decline of agricultural employment combined with the high share of agriculture in the economy of less developed regions, which was described earlier as the structural component of the tendency towards the concentration of economic activities.

Decline of agricultural employment is a variable related to other components of employment structure and growth. More specifically, the yearly rate β_a of decline in agricultural employment (in the conditions of full employment) is related to the rates of change in total employment β_t and nonagricultural employment β_n, as well as the ratio of nonagricultural to agricultural employment $i = n/a$ as existing at the beginning of the year – in a way described by the equation

$$\beta_a = i(\beta_n - \beta_t) - \beta_t.$$

In the Polish case, the yearly rate of decline of agricultural employment in the 1960s (as in the proceeding decade), was very low (−0.8%), although the rate of growth of nonagricultural employment was high (3.5%). Yet, the high demand for labour outside agriculture was neutralized by the very high rate of growth in the supply of labour originating from: a) high natural increase of population in the preceeding years (postwar population boom); and b) high, and growing, activity rate, i.e. the share of employed persons in the total population (0.467, 0.503 and 0.514 in 1960, 1970 and 1978 respectively). The latter factor, in turn, besides its demographic determinants, was associated with the type of economic development model adopted (i.e. the model of extensive character, relating the growth of production mainly to growth of employment and massive investments, and to a more limited degree to increases in productivity).

The case of Spain may serve as an example of quite different tendencies of changes in the total volume of employment and its components (see Table 1). The yearly rate of decline of agricultural employment in the 1960s was there much

TABLE 1. Poland and Spain: Yearly rates of change of total employment and its components (in %)

Sectors	Poland		Spain	
	1960–70	1970–78	1960–69	1969–75
Total Employment	1.7	0.8	0.7	0.35
Agriculture	−0.8	−2.8	−3.0	−3.8
Nonagricultural sectors	3.5	2.6	2.6	1.8
Industry	3.6	2.0	1.9	0.8
Other sectors	3.3	3.0	3.0	2.3

Sources: for Poland – Population Census data, for Spain – *Renta nacional de Espana*...

higher (−3.0%). The rate of employment growth in nonagricultural activities was lower than in Poland, and in the same period the volume of total employment grew very slowly. The latter fact was not determined by demographic factors since the rate of the natural increase of population was not significantly lower than in Poland; however, the share of employed persons in the total population was here much lower and decreasing (0.406, 0.387 and 0.376 in 1960, 1969 and 1975 respectively). The total employment growth was lesser than the growth of labour force supply, which was evident from the fact of the vast emigration in search of employment to countries of Western Europe, and, especially in the 1970s, from growing unemployment.

The existence of external migration and unemployment indicates that the absorption power of the demand for nonagricultural employment was not the only force explaining the outflow of labour force from agriculture. The tendency of rapid outflow must be seen also as the necessary prerequisite for reaching higher per capita incomes in agriculture, whereas the strength of this tendency was determined largely by the rate of per capita income growth in nonagricultural sectors (which was definitely higher in Spain than in Poland).

The differentiation of employment growth rates between Poland and Spain described above was maintained in the 1970s, although the magnitude of respective variables changed. The rate of decline of agricultural employment has increased both in Poland (−2.8%) and in Spain (−3.8%) due to the changes in total employment and nonagricultural employment growth rates (see Table 1) as well as due to the fact that in both countries the share of agriculture in total employment was then smaller (and the ratio i higher).

The spatial reflection of these changes in terms of interprovincial population shifts was different in the two countries: whereas in Poland, where the rate of decline of agricultural employment has risen considerably, the sum of interprovincial shifts has increased by about 15%, in Spain, where the decline of this rate was relatively gentle and where the share of agriculture in total employment was lesser, the sum of interprovincial population shifts decreased by about one third.

The second group of 'specific conditions' related to structural characteristics of economic growth processes, which helped to achieve the 'regionaly balanced' growth in Poland, refers to the relative role of industry in economic development of the country as well as its employment growth rate as compared with the service sector. While both in Poland and in Spain industrialization was the driving force of economic development and in both countries the rate of industrial production growth was high, the rate of industrial employment growth was in Poland much higher (see Table 1) due to the model of extensive-type development mentioned above. Thus, the share of the industrial employment increase in the increase of the total volume of nonagricultural employment was in Poland equal almost to one half (46%) in the 1960s, and in the 1970s it was still equal to one third (34%), while in Spain it hardly exceeded one quarter (27%) in the 1960s, and in the first half of the 1970s dropped to 16%.

The above figures help us to understand why in Poland, in contrast to Spain, the regional distribution of additional industrial employment determined in the 1960s (as in the preceeding decade) to a high degree the distribution of the increments of tertiary employment (the same is true also of the distribution of investments in the two sectors). In other words, the industrial location policy, favouring the less developed regions, was determining at the same time to a large extent the regional shifts of the total volume of nonagricultural employment.

In the decade of the 1970s, when the rate of growth of industrial employment as well as its share in the total employment growth decreased, the spatial correlation of changes in industrial and service employment diminished. While the policy of industrial location still favoured the less developed provinces, it was much less effective as means of determining the changes in the regional distribution of total employment.

Thus, one of the conditions of the efficiency of regional development policy in terms of 'balanced regional growth' was the severe sectoral bias in the distribution of investment funds in favour of industry and general underdevelopment of services (as well as all types of infrastructure) — a bias which over the years was negatively conditioning the efficiency of the national economy and later constituted an element aggravating the economic crisis of the late 1970s.

The above consideration lead to the conclusion which is, of course, not new in the literature of the subject, that in order to reach a better understanding of regional development processes one must take fully into account the structural relations determined on the level of the national economy.

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A STATISTICAL APPROACH TO MODELLING INTERACTION IN A FUNCTIONAL SPACE

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Spatial interaction systems by reason of their complexity are considered as statistical systems. To explain their behaviour adequate statistical hypotheses are needed. Geographers often borrow such hypotheses from physics — the science which provides numerous examples of statistical approach. The precondition when making analogies to concepts of physics is to assume a structural isomorphism between physical and social systems. When this isomorphism takes place the analogue of the law describing the behaviour of the physical system can be employed to explain the behaviour of the system of social interaction in space. This analogue is then treated as a rule (theoretical generalization) of the spatial interaction theory after its empirical confirmation in terms of the subject matter of this theory.

The purpose of the present paper is to use analogy of one of the fundamental concepts of quantum mechanics to derive a negative exponential random variable distribution defining the statistical character of the relationship between distance and the intensity of interaction in a functional space. The functional space in the context of the paper is the space in which distance is measured in terms of intervening opportunities. The random variable distribution obtained will play the role of distance decay function in the intervening opportunities model of spatial interaction.

The concept borrowed from quantum mechanics to derive the above mentioned distance decay function is the so-called Schroedinger wave equation. Its application is possible owing to the formal similarity between the structure of systems investigated by quantum mechanics and the theory of spatial interaction (see Griesinger 1979). Both kinds of systems are statistical in nature and the behaviour of a statistical system is described formally in terms of a random variable distribution. The aim of the argument which follows is to prove that the distance decay function has the form of such distribution. The argument is based on the analogy to the physical situation that is described by the Schroedinger wave equation. This equation will first be outlined.

The Schroedinger equation is used in quantum mechanics with certain variants. The variant which will be adopted in the spatial interaction context is the so-called nonrelativistic timeless Schroedinger wave equation or, the Schroedinger equation for short. The equation deals with the motion of elementary particles within a field of physical forces and describes this motion in terms of the average behaviour of particles, that is, as a statistical generalization of particular behaviours presented by individual particles the number of which is very great. Formally this average behaviour is expressed by a random variable distribution. This distribution is related to the so-called wave function, the central notion of the Schroedinger equation. The wave function is interpreted in such a way that the probability of a particle being found in any point of the field is proportional to the square of the absolute value of this function. The shape of the function is unknown and to give it an explicite form the equation should be solved (see Wichmann, 1971, chapter 7).

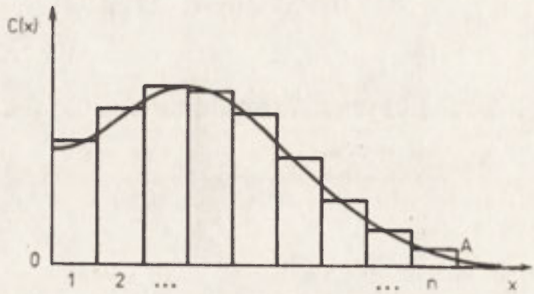

Fig. 1.

Assume for simplicity a one-dimensional field of physical forces. The Schroedinger wave equation describing the average behaviour of elementary particles in this field can be written as follows (Wichmann, 1971, chapter 7)

$$-R\frac{d^2}{ax^2}\Psi(x) = (E-V)\Psi(x) \tag{1}$$

where R is a specific constant, $\Psi(x)$ denoted the wave function, and E and V are the total and potential energies, respectively, of an elementary particle. The wave function can take two possible forms when equation (1) is being solved. Which of them takes place depends on the value of the bracketed expression $(E-V)$. The value of this expression can be greater or less than zero. The first case corresponds to the situation where an elementary particle has a certain kinetic energy and moves freely along the one-dimensional field. The solution of equation (1) is an oscillating (sine) form of the wave function. On the other hand, a negative value of $(E-V)$ implies the situation where a particle incident upon a potential barrier whose height is larger than the kinetic energy of the particle will penetrate a certain distance into the barrier. The wave function representing the solution of equation (1) in this case decays exponentially with distance into the barrier (see Wichmann, 1971, chapters 7 and 8).

An analogy is made in the present paper to the latter physical situation. A geographical equivalent of this situation is spatial interaction where there exists movement cost which plays a role similar to the height of the potential barrier in the physical example. (The geographical analogue of the former physical situation is social interaction in spaces where no cost of movement exists.) Thus, to explain the movement pattern in space, the version of the Schroedinger wave equation is adopted which describes the behaviour of an elementary particle when it crosses the potential barrier. The Schroedinger equation, like every physical hypothesis, refers to an idealized physical situation. To apply the analogue of this equation in a spatial interaction context, the concept of an idealized movement pattern should be introduced. This concept is defined with the use of four simplifying assumptions as follows:

1. There exists a one-dimensional space in the form of coordinate x, where $x\,(0 \leqslant x \leqslant \infty)$ denotes the distance from the origin point $x = 0$ of this coordinate.

2. At the point $x = 0$ a very great number M of human individuals identical in every respect are localized. They are able to make movements and terminate in any distance x. One movement is made by any one individual and hence M denotes both individuals and movements. The movement phenomenon is independent of time.

3. Space is homogeneous in the sense that at every its point the same number of opportunities are localized.

4. The cost of movement per unit of distance is denoted as C, and can be measured as the number of intervening opportunities passed.

The spatial interaction version of the Schroedinger equation relating to the movement pattern in the above space has the form

$$\frac{d^2}{dx^2} f(x) = (kC)^2 f(x) \tag{2}$$

where k is the constant of proportionality and $f(x)$ denotes the wave function which, as has been mentioned before, is interpreted in such a way that the density of probability $r(x)$, of an individual's movement terminating at distance x is proportional to the square of the absolute value of this function, that is, to $|f(x)|^2$.

There are two independent solutions of equation (2):

$$f_1(x) = \exp ax, \quad \text{or} \quad f_2(x) = \exp(-ax), \tag{3}$$

where $a = kC$ is a parameter proportional to the cost C. The former solution with the positive exponent must be rejected since it implies that the probability of movement terminating increases as the distance becomes larger. The only possible solution of equation (2) is therefore the latter one.

The density of probability $r(x)$ is, according to the assumption made previously, proportional to the square of the absolute value of the function $f(x)$ and hence

$$r(x) = |\exp(-ax)|^2 = \exp(-2ax) = \exp(-hx) \tag{4}$$

where $h = 2kC$.

Let the simplifying assumption (3) concerning the uniform distribution of opportunities be now removed and postulate that within every element of space dx a different number of intervening opportunities is localized. The cost of movement per unit of distance changes now with x and has the form of the density function $C(x)$. To define the probability of an individual terminating at distance x in terms of changing movement cost let the area under the curve $C(x)$ be divided into a number of subareas (strips) each with the height $C(x_i)$ and the width dx_i, $i = 1, 2, \ldots, n$, where n is the number of strips within a certain distance interval $0 \leqslant x \leqslant A$. The problem is illustrated on the graph (p. 154).

The probability $r(x)$, given by equation (4), is assumed now to be interpreted as that of moving individual passing distance dx_i or, what amounts to the same, not terminating within this distance. The new probability is denoted as $r\,dx_i$ or simply r_i. Thus

$$r_i \sim \exp[-LC(x_i)\,dx_i] \tag{5}$$

or

$$r_i = b\exp[-LC(x_i)\,dx_i] = \exp[g - LC(x_i)\,dx_i] \tag{6}$$

where g is a constant.

Using equation (6) it is possible to calculate the total probability $r(x = A)$ or $r(A)$ of moving individual not choosing any point within distance $0 \leqslant x \leqslant A$ as a place of destination and continuing beyond this distance interval.

The probability $r(A)$ can be estimated by the product of particular probabilities r_i. So

$$r(A) = r_1 r_2 \dots r_n \tag{7}$$

or

$$\ln r(A) = \ln r_1 + \ln r_2 + \dots + \ln r_n \tag{8}$$

where

$$\ln r_i = g - LC(x_i) dx_i . \tag{9}$$

When dx_i in equation (9) is assumed to tend to zero and the division considered so far is replaced by a very large number of infinitesimal subareas $C(x)dx$ the the sum given by equation (8) can be treated as the integral such that

$$\ln r(A) = g - L \int_0^A C(x) dx \tag{10}$$

or

$$r(A) = b \exp \left[-L \int_0^A C(x) dx \right] \tag{11}$$

where $r(A)$ is the probability of moving individual passing the interval $0 \leqslant x \leqslant A$.

The integral in equation (11) can be written in a simpler form

$$D(x) = \int_0^x C(z) dz \tag{12}$$

where $D(x)$ denotes the cumulative cost of overcoming distance x in the functional space. On the basis of equations (11) and (12) one can write

$$r(x) = b \exp[-LD(x)] \tag{13}$$

where $r(x)$ is the probability of moving individual continuing beyond distance x.

Using equation (13) the probability $q(x)$ of moving individual terminating at any point within distance interval $(0, x)$ can be defined as follows

$$q(x) = 1 - r(x) = 1 - b \exp[-LD(x)] . \tag{14}$$

For any two points in space x_1 and x_2, such that $x_1 < x_2$, the probability $p(x_1, x_2)$ of moving individual terminating between these points can be derived in the form of the following equation

$$p(x_1, x_2) = q(x_2) - q(x_1) . \tag{15}$$

Substituting equation (14) into equation (15) gives

$$p(x_1, x_2) = 1 - r(x_2) - 1 - r(x_1) \tag{16}$$

or

$$p(x_1, x_2) = b \exp[-LD(x_1)] - b \exp[-LD(x_2)] . \tag{17}$$

Multiplying equation (17) by M, the total number of movements made in the functional space, provides to

$$M(x_1, x_2) = bM \{\exp[-LD(x_1)] - \exp[-LD(x_2)]\} \tag{18}$$

and the common form of the intervening opportunities model of spatial interaction is obtained in which $M(x_1, x_2)$ denotes the number of movements terminating at distance between points x_1 and x_2.

Parameter L in the above model can be calculated using empirical data. As seen from equations (10) and (12) this parameter is represented by the ratio, when dropping the constant g, which has the following form

$$L = -\frac{\ln r(x)}{D(x)}. \tag{19}$$

The above parameter can be estimated when the proportion $r(x) = M(x)/M$ of movements continuing beyond distance x as well as the number of intervening opportunities within this distance are known. As x increases both parts of the fraction (19) become larger (in the sense of their absolute values) but the proportion between them remains constant being equal to the value of the parameter L. Parameter L is always positive since $\ln r(x)$ takes only negative values. When both $D(x)$ and $r(x)$ are known from empirical data (the latter in the form of percentage of trips made beyond particular distances) then values of expression (19) can be calculated for a given number of successive x- es and the parameter L is estimated on the basis of the set of these values.

The parameter was estimated and the model verified on the basis of movement data related to the Lublin commuting area. The data used was collected for the year 1973. The commuting field was divided into eight twenty-minute distance rings. The size of rings was determined by the mean distance of intra urban work-home trips. The intraurban and extraurban ring sizes were assumed to be the same because the former and the latter were each the places of movement termination. The results have been obtained using equation (17) and are presented in the Table 1

TABLE 1. Empirical and best-fitted expected theoretical distribution of trip terminating probabilities related to the Lublin commuting area

Distance ring	Empirical distribution	Expected distribution
1	0.8168	0.8022
2	0.0625	0.0698
3	0.0378	0.0411
4	0.0501	0.0549
5	0.0175	0.0196
6	0.0110	0.0103
7	0.0028	0.0016
8	0.0015	0.0005

in the form of trip terminating probabilities. As intervening opportunities an economically active population localized in distance rings was used. The parameter value estimated was $L = 5.569 \cdot 10^{-6}$.

The approach proposed in the paper is another example of statistical method of spatial interaction modelling. The essential assumption underlying this approach is identical with that related to the entropy maximizing method: the distance travelled by a moving individual is a random variable, and the distance decay function describing the statistical character of the relationship between distance and the intensity of spatial interaction is a random variable distribution. The entropy maximizing principle as well as the wave equation theory are only convenient concepts which help to define this function and also allow the derivation of the related spatial interaction models.

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GEOGRAPHIA POLONICA 52, 1986

CONCEPTION D'UNE ANALYSE INTÉGRALE DES SYSTÈMES RÉGIONAUX

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Le caractère généralisant des études géographiques exige une analyse intégrale passant des phénomènes simples aux phénomènes de plus en plus complexes et allant d'une approche quantitative vers une approche qualitative. Cela concerne avant tout l'étude des systèmes régionaux. Afin de procéder à leur analyse intégrale il est nécessaire:

— d'établir un schéma de recherche divisé en étapes analytiques, fondées sur la généralisation de la structure spatio-économique des systèmes étudiés,

— de sélectionner les principaux éléments de recherche et de les regrouper selon une hiérachie définie conformément au schéma précedement retenu.

L'auteur présente un projet d'analyse intégrale des systèmes régionaux et d'une nouvelle division des éléments de l'économie nationale, qui constituent le point de départ d'une étude analytique.

Les systèmes régionaux nodaux, formés autour des villes et agglomérations, se composent de diverses unités élémentaires groupées en entreprises, institutions, localités, etc. Cette approche constitue le point de départ d'une analyse intégrale des systèmes régionaux. Nous retenons les principes suivants:

— conformément à la théorie de la région économique nous acceptons la division en régions nodales et zonales; notre analyse concerne le premier type de ces régions,

— l'analyse prendra en considération les éléments de l'économie spatiale avec leurs connexions dans l'espace et leur position dans l'ensemble hiérarchisé,

— il est évident que lorsque les aspects pris en considération sont plus nombreux, les phénomènes spatiaux deviennent plus complexes.

L'analyse intégrale exige trois approches successives: morphologique, fonctionnelle et intégrante. La phase d'identification des éléments de base et de leurs relations dans le système nodal précède ces trois approches. Conformément à la construction adoptée (tabl. 1) la procédure de recherche consiste à suivre les étapes successives de l'analyse.

Etape 1 englobe l'analyse de la structure du système, étudié sous sa forme simplifiée, divisé en éléments et relations de base. Après leur identification et leur regroupement selon une hiérarchie déterminée, il est possible d'examiner la structure morphologique du système (1.1). Cette interprétation exige d'abord un examen des objets et des voies de communication qui les lient, ensuite une approche fonctionnelle qui analyse cette structure en profondeur. Elle démontrera les corrélations et le rôle joué par les diverses unités socio-économiques dans l'ensemble étudié (1.2). L'approche intégrante vise les relations entre la structure morphologique et fonction-

TABLEAU 1. Construction de l'analyse intégrale des systèmes régionaux

Etapes	Approches Identification (0)	morphologique (1)	fonctionnelle (2)	intégrante (3)
Structure du système (1)	Eléments: individus installations techniques institutions Relations: personnels substances techniques substances économiques	Unités spatiales: a) suivant le lieu de travail b) suivant le lieu d'habitation Trajets: de communication de transport conventionnel de transport spécial	Unités fonctionnelles: (I) de décision (II) de création culturelle (III) de production spécialisées standardisées Relations: de commande financières créatives culturelles matérielles	Corrélations entre les structures morpho — fonctionnelles selon: les éléments les liaisons les (sous) systèmes
États du système (2)	Relations entre les éléments: personnes — flux des personnes installations techniques — flux des substances techniques institutions — flux des substances économiques	Formes morphologiques: simples: maison, filiale d'entreprise composées: centre urbain, centre de production surcomposées: agglomération, région économique	Formes fonctionnelles: simples: fonctions standardisées composées: fonctions standarisées et spécialisées surcomposées: plusieurs niveaux de fonctions	Systèmes morpho — fonctionnels Structure: ordonnée, régulière, stable, infaillible, autonome, etc. simples composées surcomposées
Changements d'états du système (3)	Cycles: journaliers — hebdomadaires — saisonniers Changements stables: aléatoires planifiés Processus: démographiques techniques économiques	Processus morphologiques: régression stagnation progression	Processus fonctionnelles: régression stagnation progression	Processus morpho-fonctionnelles: intégration désintegration

nelle (1.3). La phase finale de la première étape consistera à définir des sous-ensembles morpho-fonctionnels et leur hiérarchisation.

Etape 2 a pour but la définition des "états" extérieurs et intérieurs du système régional. On pourrait trouver ici une analogie avec les états physiques et psychiques des organises vivants. A cette étape de l'analyse on passe alors d'approche quantitative à une approche qualitative. Au cours de la phase d'identification, après avoir déterminé les éléments et relations de base (2.0), il est possible d'examiner les formes morphologiques illustrant les états "physiques" du système. Ces formes peuvent être simples, composées et surcomposées. Dans les recherches concrètes cette division sera plus développée (2.1). L'approche fonctionnelle se réfère aussi à cette division, en sélectionnant des sous-ensembles fonctionnels de complexité variable. Ils se forment autour des centres de décision comme résultat de la formation de nombreuses relations socio-économiques (2.2). La troisième et dernière phase de la deuxième étape est plus synthétique. Les sous-ensembles, plus ou moins complexes dans leur forme et leur fonction, sont examinés du point de vue de la stabilité et de l'ordonnance de leur structure, de l'infaillibilité de leur fonctionnement, etc. (2.3).

Etape 3 contrairement aux étapes précédentes, est une étude dynamique des phénomènes qualitatifs dans un système régional. Dans la phase d'identification on détermine les principaux changements cycliques (diurnes, hebdomadaires, saisonniers) et les changements permanents qui résultent des processus démographiques, techniques et économiques (aléatoires et planifiés). Les formes morphologiques ainsi que les fonctions socio-économiques se transforment continuellement avec la régression, la stagnation ou la progression économique du système (avec la baisse ou l'accroissement des spécialisations, des relations, du nombre d'instances, de la complexité, etc.). La troisième étape, ainsi que l'ensemble de l'analyse intégrale, se termine par l'évaluation des processus morpho-fonctionnels du système, qui peuvent conduire soit à une plus grande intégration de sa structure soit à sa décomposition.

La recherche ainsi conçue diffère des analyses fondées sur la division en industrie, transport, habitat, etc. Elle exige donc une classification différente des éléments de base qui constituent le point de départ des études empiriques.

La classification de l'économie nationale, appliquée dans les pays socialistes, place en premier lieu les secteurs de production (avec l'industrie en tête) et en dernier lieu les unités de l'administration nationale et les organisations politiques. Si le rang de chaque secteur est fixé en fonction du nombre d'employés, se trouveront ou sommet de la pyramide les branches à forte main-d'oeuvre, tandis que les branches comptant moins de personnel se placeront tout en bas, même si leur rôle est capital pour l'économie. Cette division, peut-être valable du point de vue des préférences d'investissement dans l'industrie, est trompeuse pour la recherche. Par contre la division de l'économie nationale en quatre secteurs, appliquée dans les pays occidentaux, donne la préférence aux services, sans signaler les systèmes de relations et de subordinations. Les deux conceptions ne comportent pas une structure hiérarchisée et pour notre analyse ne sont donc pas valables.

CLASSIFICATION DE PRINCIPAUX ÉLÉMENTS DE L'ÉCONOMIE NATIONALE

Avant d'effectuer cette classification il faut souligner que:

— l'administration politique et économique exerce une influence décisive dans le fonctionnement et le développement de l'économie spatiale; cette influence aussi bien dans le cadre territorial que sectoriel est la plus diverse,

— dans tous les domaines de la vie économique du pays se manifestent deux processus interdépendants: celui de la production et celui de la distribution. Le premier de ces processus se manifeste à toutes les échelles hiérarchiques de l'économie spatiale. Il s'agit aussi bien de créations intellectuelles, (nouvelles conceptions politiques et de planification, réalisations scientifiques, créations artistiques) que de la production matérielle.

Adoptant ce raisonnement on peut procéder à la division de l'économie nationale en deux sections: de production *A* et de distribution *B*, et en trois domaines: d'organisation et de gestion I, d'activité culturelle II et de production de biens matériels III.

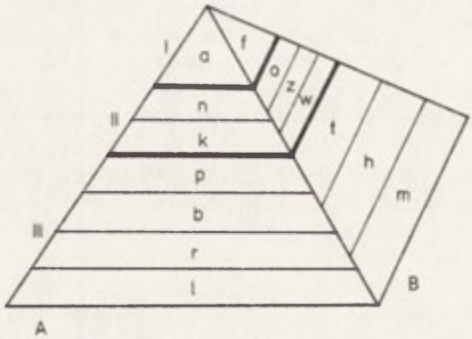

Fig. 1. Division hiérarchique des personnes employées dans l'économie nationale: I — Domaine d'organisation et de gestion: *a* — administration et justice, organisations politiques et sociales, *f* — finances et sécurité sociale, communication; II — Domaine d'activité culturelle: *n* — science, *k* — culture et art, *o* — éducation, *z* — protection de la santé et assistance sociale, *w* — culture physique, tourisme et récréation; III — Domaine de production matérielle: *p* — industrie, *b* — bâtiment, *r* — agriculture, *l* — économie forestière, *t* — transport, *h* — échange de marchandises, *m* — économie urbaine et habitat; *A* — production, *B* — distribution

Le modèle graphique de cette conception se présente sous forme d'une pyramide des unités économiques rappellant la pyramide d'âge, mais possédant le caractère tridimensionnel et une hiérarchie déterminée (fig. 1). La section de production se compose des domaines suivants:

I A. *Domaine de prise de décisions* englobe les centres administratifs nationaux, régionaux et locaux ainsi que les organisations politiques, sociales, économiques, etc. qui coopèrent avec ces centres. Leur activité "créative" décide du développement de l'économie spatiale. C'est pourquoi leur insertion dans le secteur tertiaire semble erronnée.

II A. *Domaine de production de biens culturels* — dans le sens large du terme, englobe la science, la technique, la culture et l'art. Il s'agit des unités qui créent des théories, développent de nouvelles technologies et contribuent à la formation de l'esprit artistique d'une époque: divers centres de recherches, mais aussi institutions musicales, théâtres, ateliers cinématographiques etc. et centres de radiodiffusion et de télévision.

III A. *Domaine de production des biens matériels* englobe les secteurs de l'économie nationale qui produisent des biens matériels concrets: industrie, bâtiment, agriculture et industrie forestière. Ainsi donc, la section de production, assemblant les capacités d'organisation et les forces intellectuelles et productives de la nation, illustre son potentiel créatif.

La section de distribution, qui détermine la capacité de diffusion des produits intellectuels et matériels, est également composé de trois domaines:

I B. *Distribution des finances et des informations* (et des décisions) est placée au sommet de la pyramide. Dans les pays développés le fonctionnement efficace des établissements financiers et la diffusion rapide des informations (par l'intermédiaire des centres postaux, de télécommunication, centres de radiodiffusion et de télévision avec installations annexes) constituent la garantie de leur essor. Le domaine I B dans l'économie spatiale peut être comparé au système nerveux et à la circulation du sang.

II B. *Domaine de distribution des biens culturels* (au sens large du mot) englobe trois secteurs de l'économie nationale conditionnant l'éducation, la santé publique, et les loisirs. Le niveau et l'efficacité du fonctionnement des unités de distribution II B déterminent l'éducation, la culture et l'état de santé de la population, et indirectement le niveau de production du pays.

III B. Domaine de distribution des biens matériels englobe avant tout les entreprises de transport et de commerce. Elles constituent le dernier maillon du processus de production, mais elles ne produisent pas de biens matériels, jouant un rôle intermédiaire dans leur répartition et dans tout les contacts et relations.

Notre classification diffère tout à fait de la division en secteurs d'activité et s'éloigne de l'interprétation utilisée dans la littérature géographique des pays occidentaux et dans certaines études effectuées en Pologne (E. Nowosielska 1972, A. Werwicki 1982). La notion du secteur tertiaire a été introduite par A. G. B. Fisher (1935), mais la division de l'économie en trois secteurs a été élaborée par C. Clark (1940, 1957). C. Clark, ainsi que d'autres auteurs (p.ex. M. Wolfe 1955, J. Fourastié 1958), classent dans le secteur primaire l'agriculture et l'économie forestière, dans le secondaire — l'industrie, et dans le tertiaire — les services matériels et non matériels. On note des différences dans le classement de l'exploitation minière (primaire ou secondaire) et du bâtiment et transport (secondaire ou tertiaire). J. Gottman (1961) a même distingué le quatrième secteur englobant l'activité administrative, financière, scientifique et culturelle.

Contrairement à la classification de l'Office polonais de statistique, la division sectorielle comporte certains éléments d'une hiérarchie. On y observe d'abord la production liée étroitement au milieu naturel, puis la transformation, et enfin les services de base et les services de niveau plus elevé.

A la lisière de ces deux conceptions de classification il y a des divisions introduites dans la littérature économique polonaise. A titre d'exemple Cz. Niewadzi (1979) a distingué: l'activité économique et socio-économique (les services et la production des biens matériels) et l'activité non économique: l'appareil de pouvoir et d'ordre public, les services non économiques (organisations sociales, justice). Contrairement aux classifications sectorielles, où le tertiaire englobe tous les domaines de l'économie en dehors de la production matérielle, Niewadzi a mis en valeur l'appareil administratif. Mais il n'a pas proposé de système hiérarchisé dans sa division. Il n'existe pas non plus dans la conception sectorielle (tabl. 2).

APPLICATION DE LA CLASSIFICATION HIÉRARCHISÉE DANS LES ÉTUDES EMPIRIQUES

Les résultats du recensement de 1978 ont permis la vérification de la division hiérarchisée de l'économie nationale. Les données statistiques concernant les personnes employées dans les 77 branches ont été regroupées en domaines et sections et présentées dans les 49 voïévodies (fig. 2). Ces données supposaient certaines limitations (le domaine I n'a pu être divisé en sections A et B), mais il a été possible d'introduire une classification supplémentaire entre les employés et les travailleurs

TABLEAU 2. Différences dans les divisions de l'économie nationale

<table>
<tr><th rowspan="3">Ordre</th><th rowspan="3">Sections de l'économie nationale</th><th colspan="5">Divisions selon différents auteurs:</th></tr>
<tr><th rowspan="2">C. Clark 1940, 1957
J. Gottman 1961</th><th colspan="2">Cz. Niewadzi 1973</th><th colspan="2">J. Dębski 1984</th></tr>
<tr><th></th><th></th><th></th><th></th></tr>
<tr><td>I A</td><td>Administration et justice*
Organisations politiques et sociales</td><td rowspan="2">Secteur IV</td><td>Activité dans la sphère hors production</td><td>Appareil de pouvoir et d'ordre publique, sphère des services hors production</td><td rowspan="3">Domaine d'organisation et de gestion</td><td>Prise de décisions</td></tr>
<tr><td rowspan="2">I B</td><td rowspan="2">Finances et sécurité sociale
Communication</td><td rowspan="7">Activité économique et socio-économique</td><td rowspan="4">Sphère de production des services</td><td rowspan="2">Distribution de finances et d'informations</td></tr>
<tr><td>Secteur III</td></tr>
<tr><td>II A</td><td>Science, culture et art</td><td rowspan="2">Secteur IV</td><td rowspan="2">Domaine d'activité culturelle</td><td>Production des biens culturels</td></tr>
<tr><td>II B</td><td>Education
Protection de la santé et assistance sociale
Culture physique, tourisme et loisirs</td><td>Distribution des biens culturels</td></tr>
<tr><td rowspan="2">III A</td><td rowspan="2">Industrie
Bâtiment**
Agriculture
Economie forestière</td><td>Secteur II</td><td rowspan="2">Sphère de production des biens matériels</td><td rowspan="3">Domaine de production matérielle</td><td rowspan="2">Production des biens matériels</td></tr>
<tr><td>Secteur I</td></tr>
<tr><td>III B</td><td>Transport
Echange des marchandises
Economie urbaine et habitat (avec l'artisanat de service)</td><td>Secteur III</td><td>Sphère de production des services</td><td>Distribution des biens matériels</td></tr>
</table>

* comprenant les institutions d'ordre publique ** dans le secteur II ou III

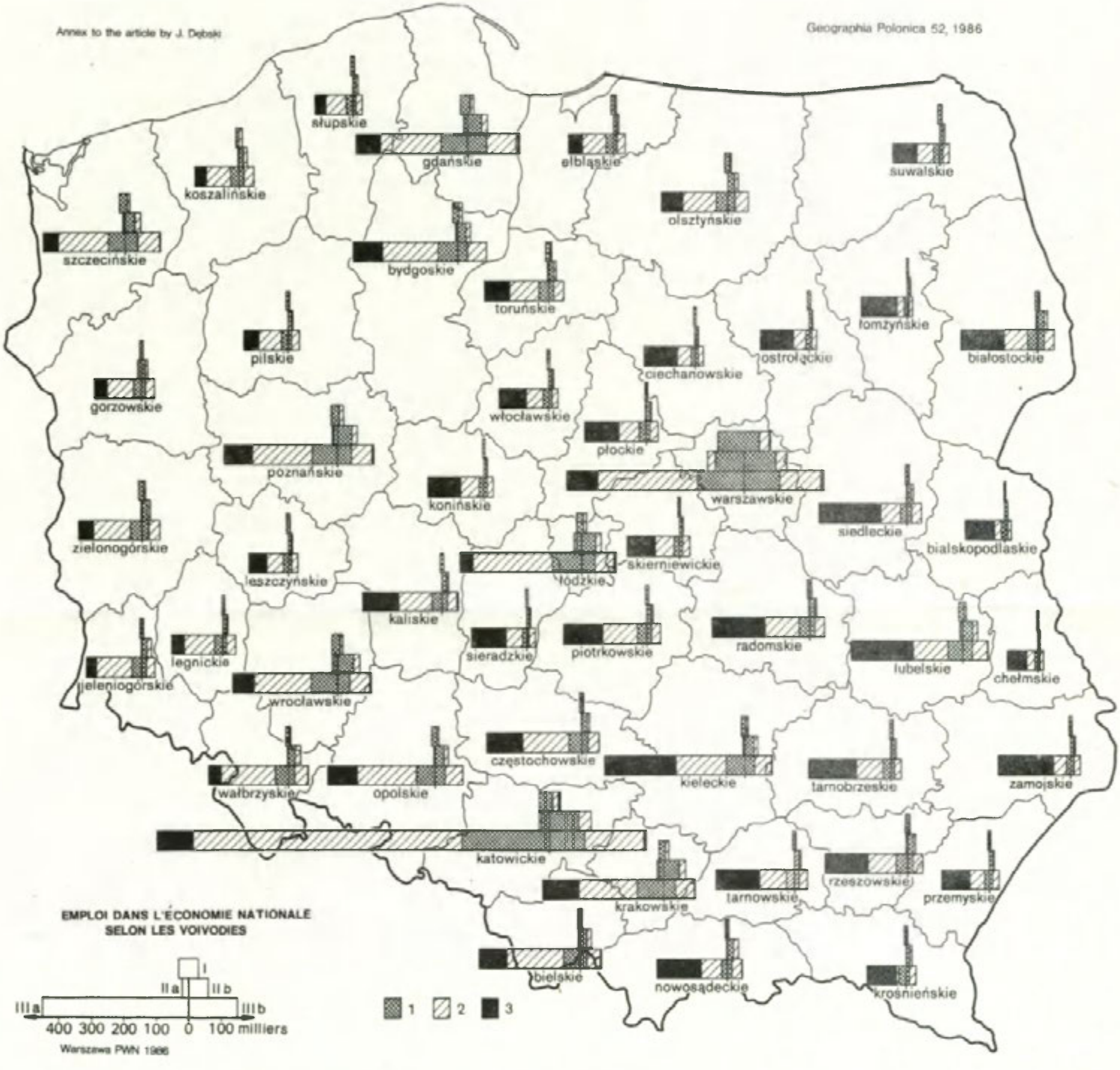

Fig. 2. I — Domaine d'organisation et de gestion, II — Domaine d'activité culturelle: *a* — production des biens culturels, *b* — distribution des biens culturels; III — Domaine de production matérielle: *a* — production des biens matériels, *b* — distribution des biens matériels; 1 — Employés dans l'économie socialisée, 2 — Travailleurs manuels, 3 — Personnes travaillant dans l'économie privée

manuels de l'économie socialisée et ceux du secteur privé. Ce dernier comprend 1/4 du nombre total d'emplois en Pologne (tabl. 3).

Le taux relativement élevé (6,5%) se rapporte au domaine de prise de décisions (IA). Il s'agit des associations religieuses et de l'Eglise Catholique romaine en premier lieu. Ces associations, apparement séparées de l'économie nationale, possèdent leur propre organisation, maisons, lieux du culte et constituent un facteur important

TABLEAU 3. Structure d'emploi dans l'économie nationale polonaise en 1978 suivant les domaines et les sections

Domaines	Sections	Emploi dans l'économie socialisée			Total pour l'économie nationale	
		employés	travailleurs manuels	total		
I. Organisation et gestion	A. Prise de décisions	691610	210029	901639	963456	a)
		76,7	23,3	100,0	–	b)
		71,7	21,7	93,5	100,0	c)
	B. Distribution de finances et d'informations	63655	86954	150609	150609	a)
		42,2	57,8	100,0	–	b)
		42,2	57,8	100,0	100,0	c)
II. Activité culturelle	A. Production des biens culturels	242761	73522	316283	323992	a)
		76,7	23,3	100,0	–	b)
		74,9	22,6	97,6	100,0	c)
	B. Distribution des biens culturels	1030998	460145	1491143	1494271	a)
		69,1	30,9	100,0	–	b)
		68,9	30,7	99,7	100,0	c)
III. Production matérielle	A. Production des biens matériels	1939735	5698515	7638250	12206752	a)
		25,3	74,7	100,0	–	b)
		15,8	46,6	62,5	100,0	c)
	B. Distribution des biens matériels	1012289	1713596	2725885	2823048	a)
		37,1	62,9	100,0	–	b)
		35,8	60,7	96,5	100,0	c)
Total	Domaine I	755265	296983	1052248	1114065	a)
		71,8	28,2	100,0	–	b)
		67,7	26,6	94,4	100,0	c)
	Domaine II	1273759	533667	1807426	1818263	a)
		70,4	29,6	100,0	–	b)
		70,0	29,3	99,4	100,0	c)
	Domaine III	2952024	7412111	10364135	15029800	a)
		28,4	71,6	100,0	–	b)
		19,6	49,3	68,9	100,0	c)
	Total	4981048	8242761	13223809	17962128	

a) valeurs absolues, b) pourcentage des personnes employées dans l'économie socialisée, c) pourcentage des personnes employées dans l'économie nationale dans l'organisation de l'espace géographique par leur influence sur la population. Le pourcentage le plus élevé de personnes employées dans l'économie privée se rencontre dans le domaine des biens matériels (III A) et concerne évidemment l'agriculture et dans une moindre mesure, l'industrie privée (37,5% en total).

La division en travailleurs manuels et employés, bien que determinée de façon imprécise dans les statistiques polonaises, donne une certaine image de la structure des différents domaines. Dans les deux premiers domaines le pourcentage d'employés dans l'économie socialisée dépasse considérablement les valeurs moyennes du pays (I domaine – 71,8%, II – 70,4%, moyenne nationale – 37,6%). Dans le domaine III un quart d'emplois appartient à ce groupe.

L'analyse par sections dévoile des disproportions plus accusées. Dans la section de prise de décisions (I A) et de production des biens culturels (II A) le taux s'eleve à 76,7%. Dans la section de distribution il est moins important et oscille de 42,2% (I B) à 69,1% (II B). La situation est inverse dans le domaine III où la participation d'employés est moins importante dans la production (25,3%) que dans la distribution (37,1%).

En généralisant, dans la section de production le passage du travail intellectuel à l'exécution manuelle est très net. Dans la section de distribution cette image est assez floue (l'interprétation libre de classification en employés et travailleurs manuels). Le taux élevé d'employés dans l'ensemble de l'économie dévoile l'hypertrophie de l'appareil administratif et bureaucratique.

La répartition des personnes employées dans les différents domaines (fig. 2, tabl. 3) est la suivante:

– dans le domaine administratif (I), le pourcentage le plus élevé d'employés apparaît bien sûr dans la voïévodie de Varsovie et dans le Nord-Ouest (institutions liées à l'économie maritime et probablement à la protection des frontières),

– le domaine II A caractérise les voïévodies avec les plus grandes agglomérations (surtout Varsovie). La concentration des institutions scientifiques et culturelles donne lieu à des différences très nettes entre les voïévodies. A titre d'exemple la voïévodie de Varsovie possède le taux d'employés dans le domaine de production des biens culturels trois fois plus grand que les voïévodies suivantes,

– le domaine II B englobe, à côté de l'éducation et de service médical, la récréation et le tourisme. Ainsi, en tête de la classification on retrouve deux groupes de voïévodies: celles où sont situées les grandes villes équipées en hôpitaux, écoles supérieures, etc. et celles qui se caractérisent par leurs valeurs touristiques au bord de la mer et dans les régions montagneuses,

– le domaine III A concerne l'activité productive au sens strict du terme – ainsi les dix premières places sont occupées par les voïévodies agricoles, en voie d'industrialisation. Le sous-développement des autres secteurs de l'économie explique le pourcentage très élevé des personnes employées dans la production (80% environ), ce qui prouve l'existence des disproportions dans le développement de l'économie. Les voïévodies en question sont situées dans l'Est et le Centre de la Pologne,

– le domaine III B c'est le transport et la distribution des biens matériels. Dans la première dizaine nous retrouvons donc les voïévodies situées au bord de la mer, les voïévodies où se trouvent les grandes villes (avec les grandes entrepôts, bases de transport) et les voïévodies situées près des frontières.

La concentration très forte des personnes employées dans les domaines I et II A se manifeste donc dans la voïévodie de Varsovie. La zone littorale et frontalière est aussi caractéristique. Les grandes villes dominent dans la section de distribution, et les voïévodies agricoles et en voie d'industrialisation – dans la production matérielle.

La division des personnes employées dans l'économie nationale porte dans une

TABLEAU 4. Voïévodies avec le pourcentage le plus élevé des personnes employées dans les différents domaines (dans l'ordre de grandeur)

Ordre	Domaine I	Domaine II		Domaine III	
	A + B	production A	distribution B	production A	distribution B
	Voïévodie de:	Voïévodie de:	Voïévodie de:	Voïévodie de:	Voïévodie de:
1	Varsovie 13,7	Varsovie 9,4	Wrocław 12,5	Zamość 81,5	Gdańsk 26,0
2	Koszalin 8,2	Łódż 3,8	Nowy Sącz 11,4	Tarnobrzeg 81,3	Szczecin 24,4
3	Słupsk 7,4	Cracovie 3,5	Jelenia Góra 11,3	Łomża 80,5	Varsovie 20,3
4	Szczecin 7,2	Poznań 2,8	Cracovie 11,2	Radom 78,0	Koszalin 20,0
5	Gdańsk 7,0	Wrocław 2,8	Varsovie 11,0	Siedlce 77,9	Poznań 19,5
6	Elbląg 6,8	Gdańsk 1,9	Koszalin 11,0	Piotrków 77,9	Olsztyn 19,4
7	Zielona Góra 6,7	Katowice 1,8	Poznań 10,7	Ostrołęka 77,9	Wrocław 19,1
8	Poznań 6,6	Lublin 1,5	Szczecin 10,7	Konin 77,8	Zielona Góra 18,7
9	Olsztyn 6,4	Szczecin 1,4	Wałbrzych 10,3	Sieradz 77,7	Bydgoszcz 18,4
10	Wrocław 6,2	Bydgoszcz 1,3	Gdańsk 10,2	Tarnów 77,1	Gorzów 18,2

certaine mesure le caractère fonctionnel. La première section remplit le rôle actif dans la structure spatio-économique sous forme de prise de décisions, créativité scientifique et culturelle et production des biens matériels. La seconde section a la fonction passive, servant d'intermédiaire et transmettant les informations, l'argent, les biens culturels et matériels aux personnes et aux institutions. Son fonctionnement consiste aussi à la protection de la santé, à l'entretien des installations et des bâtiments, etc.

La proposition de diviser l'économie nationale en deux sections et trois domaines a eu pour but:

— de rejeter l'approche actuelle qui consiste à n'attribuer le caractère productif qu'à la sphère de production matérielle — alors que l'activité créatrice, bien que diversifiée se refère à l'ensemble de l'économie nationale,

— de mettre en valeur une hiérarchie dans le classement élaboré; elle pourrait ouvrir de nouvelles possibilités dans l'étude des relations spatiales,

— de créer un modèle (pyramide) dont les éléments différent en fonctions d'activités économiques et du caractère d'influence. Dans ce modèle on a placé au sommet les unités économiques de caractère unique, relativement peu nombreuses, mais possédant la force d'influence décisive et universelle dans l'espace. En bas de cette pyramide sont groupées les unités faibles et d'une portée restreinte; dans l'ensemble elles constituent pourtant un potentiel considérable.

Il faut ajouter qu'en Pologne les unités de caractère unique ne sont pas si peu nombreuses. Comme l'indique le tableau 2, le domaine I regroupe 6,2% d'employés (dont 5,3% dans la section I A), le domaine II — 10,1%, et le domaine III — 83,7%. Dans le domaine d'organisation et de gestion il y a 1 million d'employés, ce qui constitue une charge importante pour l'économie nationale, surtout que les autres domaines, à l'exception de celle de la production matérielle, sont nettement sous-développés.

Notre classement ne constitue que le point de départ (1.0 dans le tableau 1) des recherches qui permettront d'élargir et de vérifier les différentes étapes de l'analyse. Il y a lieu néanmoins de croire que la proposition d'abandonner les divisions "verticales" (industrie, agriculture, habitat, services, etc.) utilisées dans les études régionales, au profit d'une approche hiérarchique des structures, peut contribuer au changement des paradigmes de recherche dans la géographie économique.

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GEOGRAPHIA POLONICA 52, 1986

LABOUR MOBILITY, URBANIZATION AND DEVELOPMENT: SELECTED CONCEPTS AND ILLUSTRATIONS

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1. INTRODUCTION

If recent trends continue, the extent of inter-regional migration in Europe will drop, by the mid-1980s, far below the level of the mid-1970s.[1] This may be solely due to the evolving age structure of the population, and in particular to the diminishing proportion in the total of those age groups traditionally characterized by the highest propensity to move. If the increase in the demand for labour continues to be slow, the turnover of jobs on the regional scale may also decrease, thus reinforcing what may be viewed as a period of relative stability in urban and regional patterns.

Contrary to the situation prevailing in the developed countries recent experience throughout the Third World suggests an acceleration of population flows between individual regions and from rural to urban areas.[2] Such intensive migrations are generated both by continuous demographic dynamics and by the inevitable economic structural change, which results in large-scale transfers toward centers of secondary and tertiary occupations.

Section 2 of this paper enumerates some of the major policy issues related to interregional as well as international migration, with particular references to the developing countries. This section is mainly based on a series of papers and statistical material prepared by various United Nations agencies in connection with the International Conference on Population, held in Mexico City in 1984.[3]

In Section 3 an attempt is made to match these individual policy areas with the present research on offer – a set of concepts and empirical generalizations that refer to these phenomena which represent serious concerns to national and regional planners the world over.

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[1] A. Rogers and F. Willekens, eds., *Migration and settlement: a multiregional comparative study*, D. Reidel, Dordrecht, 1986.

[2] United Nations Department of International Economic and Social Affairs, Patterns of urban and rural population growth, *Population Studies*, 68, New York 1980.

[3] International Conference on Population, 1984, Expert Group on Population Distribution, Migration and Development, Hammamet (Tunesia), 21–25 March 1983.

2. LABOUR MIGRATION: SELECTED POLICY ISSUES

Four problem areas will be briefly discussed under this heading: (a) the importance of interregional population mobility within the broader context of population-development planning, (b) primate-city expansion and the costs of urbanization, (c) the "brain drain", (d) the magnitude and use of migrants' remittance flows. Although far from exhaustive, this list is sufficiently representative, and can be used to provide points of entry to a number of other pressing issues, such as housing or employment and unemployment.

INTERREGIONAL POPULATION MOBILITY

A survey conducted in 1978 indicated that population distribution was viewed as a major source of development problems more often than was population growth *per se*. This type of response came from national planning agencies in a number of developing countries. Unlike a decade earlier, when both policy-oriented and research efforts were directed toward the question of interdependence between aggregate population dynamics and economic growth at the national level (for an early study see Coale and Hoover[4]), more recent work and policy statements have focused on population distribution and migration as significant development issues.

The growth of highly mobile young population cohorts was one of the factors that prompted this change of emphasis. The polarization of population densities – the emergence of highly concentrated as well as increasingly underpopulated areas – was another factor which suggested that maldistribution was a serious issue. Finally, the growing appreciation and recognition of the heterogeneous nature of interregional population flows, and of the complexity of the cost and benefit accounts for both the sending and receiving areas, has led to an expansion of research and educational programs dealing with migration, and to increasing public attention to these phenomena.

PRIMATE-CITY EXPANSION AND THE COSTS OF URBANIZATION

According to a view prevalent at least until the mid-1970s, the consequences of rural-urban migration are mostly negative for the receiving communities. The accelerated growth of large cities was generally considered as imposing heavy social (health hazards, unemployment) and economic (provision of housing and infrastructure) costs on urban areas, and draining scarce resources at the national level. As a consequence of such negative assessments, many Third World countries have adopted policies aimed at curtailing the inflow of migrants to the large cities.

However, it is now well known that these policies have been successfully circumvented and have lost their initial appeal. At the same time, studies have proliferated which point out that migrants tend on average to be somewhat better off than their rural counterparts, and generally not much worse off, in terms of access to employment, than are long-standing urban residents. Furthermore, the mounting demographic pressure in the rural areas cannot be practically contained other than through out-migration. With opportunities for international migration generally decreasing, one has to look at urbanization as the only acceptable way of accomodating rapid population growth. (Even with an instantaneous fertility decline down to the replacement level, the population of a typical Third World country would be greater by some 75 per cent in the year 2050 as compared with 1980.)

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[4] A. J. Coale and E. M. Hoover, *Population growth and economic development in low income countries: a case study of India'a prospects*, Princeton University Press, Princeton, N.J. 1958.

Hence, current policies in an increasing number of developing countries aim to create "counter magnets", i.e. middle-sized and even large cities that are attractive alternative destinations for the city-bound migrant. Since migrants, however, tend to follow economic opportunities, the real issue is to attract job-creating activities to second- and third-ranking urban locations. Policies towards squatter settlements within and around large cities have also been evolving in more accommodationist directions.[5]

THE BRAIN DRAIN

The concept of a brain drain has passed into common knowledge, but the changing magnitude of the phenomenon and measures taken to counteract it are not so widely known. Most of the facts and estimates that do exist pertain to international migration, while the interregional dimensions may in fact be of greater significance. The question of brain drain is particularly relevant here owing to the interdependence between migrants' skills and their access to local information (for example, educational grants) prior to the move, as well as the impact of their successes or failures upon the migration propensity of the "population at risk" in the places of origin.

Concern over brain drains and the resulting losses to the out-migration areas has been reported for many developing countries and several United Nations agencies, including UNESCO and UNCTAD, have launched studies aiming at measuring and evaluating these flows in terms of their economic significance. Comments on these concepts and methods are left for Section 3 of this paper; here it is sufficient to quote a few data on the extent of the phenomenon, which in itself is extremely difficult to measure. One study estimated the world total number of foreign students as 390,000 in 1968, but fell short of discriminating between "... these students who were merely studying abroad prior to returning to their home countries and those who intended to settle in the country where they had studied."[6] According to another study, the estimated gross imputed capital value of skilled in-migration into the United States, Canada, and the United Kingdom, combined, was equivalent to 5.4 billion US dollars in 1975.[7] Regardless of how exact these figures are, the policy issue is one of the reverse transfer of technology, and it has precipitated various measures by the sending and also by some of the receiving countries. (One example of the latter is the creation of research and university centers in the developing countries.)

MIGRANTS' REMITTANCES

While the previous issue was concerned with the losses to the sending communities, as a result of the outflow of their highly-skilled members, the question of remittances is one of at least potential benefits accruing to the out-migration areas as a consequence of interregional and international flows of the labour force. A United Nations report indicated that the developing countries received 8.1 billion US dollars

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[5] A. Laquian, Review and evaluation of urban accomodationist policies in population redistribution, in: *UN – UNFPA Workshop, Population Distribution Policies in Development Planning*, New York 1981, 101–112.

[6] United Nations Educational, Scientific and Cultural Organization, Migration, Population, Distribution and Development. Paper prepared for Expert Group Meeting on Population Distribution, Migration and Development, Hammamet (Tunesia), 21–25 March 1983.

[7] United Nations Conference on Trade and Development. The feasibibility of measuring international flows of human resources. Paper prepared for Expert Group Meeting on Population Distribution, Migration and Development, Hammamet (Tunesia), 21–25 March 1983.

from their workers abroad in 1975.[8] For some countries remittances represented a significant contribution to their balance of payments. Consequently, numerous mechanisms have been devised in order to attract such monetary resources to migrants' communities of origin.

The controversial questions pertain not so much to the levels of remittance flows, as to their uses and consequences. Many authors claim that inflationary pressures tend to develop in the out-migration regions (and countries) and that remittances tend to be used primarily for imported consumer goods and the purchase of real estate, rather than as inputs to improve the productivity of local industry and agriculture. For example, it has been found for Turkey that workers returning from Western Europe tend to settle in large cities rather than in their (rural) communities of origin. Remittances have also been shown to cause income polarization in the out-migration areas[9] and to contribute to further out-migration.

3. POPULATION MOBILITY: CURRENT RESEARCH DIRECTIONS

Recent migration studies have contributed a number of concepts and generalizations that are of relevance to the policy issues outlined in the previous section. These concepts concern, *inter alia*, the selectivity of migration, the role of large cities (and hence, of rural-to-urban migration) in the development process, and the impact of migration on the communities of origin.

MIGRATION SELECTIVITY

Many recent studies have focused on variations within the stock of migrants and on the composition of various types of population flows.[10] For example, the propensity to move is found to vary systematically with age, and the migration distance appears to depend on the reason for moving. The role of the individual as a decision-making unit has been questioned in favour of family decisions to migrate.

In the context of the developing countries, the myth of the dominance of permanent rural-to urban migration has been questioned and the widespread nature of various forms of circular, seasonal, and return migration acknowledged. Perhaps the most interesting development concerns the composition of migrants with respect to their socioeconomic characteristics. Traditionally, two competing hypotheses were firmly established, one of which attributed the out-migration from rural areas in the Third World to such factors as land scarcity and natural disasters, while the other invoked the growing aspirations of the rural youth, who move to urban areas in search of better working opportunities and living conditions. Thus, the former hypothesis suggested that migrants are predominantly recruited from the low-income and low-education groups. According to the latter hypothesis, migrants originate disproportionally from the better-off families who, as the theory of human capital tells us, make early educational investments for the benefit of their offspring,

[8] Quoted in: Migration and Human Settlements, United Nations Conference on Human Settlements. Paper prepared for Expert Group Meeting, Hammamet (Tunesia), 21–25 March 1983.

[9] United Nations Department of International Economic and Social Affairs, International migration policies and programmes: a world survey, *Population Studies*, 80, New York 1982.

[10] See: W. A. V. Clark, Recent research on migration and mobility: a review and interpretation, *Progress in Planning* 18, 1, 1982, 1–56.

and may also support them during the period of accommodation in the city. Needless to say, this latter hypothesis also interprets the decision to move in terms of the quality and quantity of information available to the potential migrant.

In a paper published in 1981, R. Urzua[11] outlined the notion of bi-modality in the distribution of migration rates versus the socioeconomic status of the migrations. The peak on the left-hand side of his curve represents those who, for one reason or another, are pushed out of the rural areas; their decisions to move are interpreted by R. Urzua as a type of survival behaviour. The high rates on the right-hand side correspond to the larger share of those who are somehow better prepared for city life and are driven by socioeconomic mobility behaviour.

This simple concept which, since it was first formulated, has been supported by a considerable amount of empirical evidence,[12] introduces some clarity into otherwise apparently confusing and mutually contradictory findings concerning factors and consequences of migratory moves. It throws more light on the results of work by C. L. Choguill[13] and others, who have found that a number of factors are at work and that each individual theory offers only a partial explanation of the migration mechanism. The bi-modality concept can also help us understand why, according to some information, the recently arrived migrants tend predominantly to join the ranks of the urban unemployed, while other sources show them to fare no worse, or even slightly better than the average urban resident.

LARGE CITIES IN THE DEVELOPMENT PROCESS

Once in the city, the migrants are faced with a segmented and non-transparent labour market. Some authors, including H. Rempel,[14] carry the orthodox interpretation of the economic duality problem so far that they speak of complete separation between the labour markets oriented toward the formal and informal sectors. In contrast to the Todaro model, where potential migrants consider the probability of shifting from a low-paying informal to a formal sector job as a factor in their initial decisions to move, the study for Kenya by H. Rempel finds no mechanisms and little evidence of such shifts in practise. Once in the informal sector, a migrant is almost sure to remain there, among other non-candidates for formal sector employment. These findings are in fact in accord with the bi-modality concept earlier discussed, although in a number of studies, both theoretical and empirical, the sharp division between the formal and informal sector activities is not present. This applies to material production flows (which indicate a degree of substitution for individual products), to capital flows, and to individual employment records.[15] The sectoral and labour market structures are sometimes interpreted in terms of

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[11] R. Urzua, Population redistribution mechanisms as related to various forms of development, in: *UN – UNFPA Workshop, Population Distribution Policies in Development Planning*, New York 1981, 53–69.

[12] International Labour Organization, Population mobility and the labour process. Paper prepared for Expert Group Meeting on Population Distribution, Migration and Development, Hammamet (Tunesia), 21–25 March, 1983.

[13] C. L. Choguill, Migration and its implications for urban development, *Regional Development Dialogue*, 4, 1, 1983, 66–81.

[14] H. Rempel, *Rural-urban labor migration and urban unemployment in Kenya*, RR-81-24, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1981.

[15] L. R. Peattie, Anthropological perspectives on the concepts of dualism, the informal sector, and marginality in developing urban economies, *International Regional Science Review*, 5, 1, 1980, 1–32.

a continuum which provides for the widespread marginality phenomenon, but also for the interaction between sectors and the respective labour submarkets.

From a macroanalytical perspective, some recent studies challenge the still-popular notion of the semi-parasitic character of the primate cities in the development process.[16] The cost of infrastructural investments at alternative locations and the international competitiveness of very large cities are put, along with "normal" agglomeration economies factors, on the positive side of the cost-benefit calculation. The discussion is reminiscent of the one surrounding the concept of optimal city size, which occurred in the 1960s. That dispute, which concerned cities in the developed economies, was hampered by the lack of reliable data and by difficulties connected with monetary evaluations of public goods. The same difficulties are still present, but in a markedly more severe form, when developing economies are the object of discussion.

In a recent study, J. F. Linn found no evidence to support concerns over excessively high costs of urbanization in the developing countries, when he examined various fiscal, financial, and efficiency- and equality-related aspects. Although, in his words, "industrialization, population growth and increases in per capita income, all of which tend to be concentrated in urban areas, impose a rapidly growing fiscal burden on governments in developing countries, there is little reason to suspect that slowing-down the urbanization process *per se* would reduce this burden unless it is accompanied by reduced rates of industrialization or reduced population and income growth".[17] It may be the case that rural dwellers subsidize urbanization costs, though the basic cause is inequitable public pricing and tax policies, rather than urbanization in itself.

Limits to urban growth in the Third World may therefore be sought in the mechanics of the demographic and mobility transition. Since age-specific fertility rates in (particularly large) urban areas are considerably lower than in the rural areas, the continuous urbanization process implies a gradual decline of national population growth rates. The faster the metropolitan growth, in fact, the sooner the overall fertility may be expected to shrink.[18] However, the policy implications of such long-term projections are of little appeal, and the explanatory value of the framework is also limited.

As A. C. Kelley and J. G. Williamson argue,[19] more insight can be gained by examining various urban costs which influence migration decisions, and the competition between "unproductive" urban investment requirements and productive capital accumulation. Basically, the rise in the relative cost of living in the city may impose a limit to urban growth. Alternatively, the rise of urban unproductive investments (subsidized services, etc.) will reduce the rates of productive urban capital accumulation and provision of new urban job vacancies, and thus also hamper urban growth. In this framework, however, the national (regional) economy is looked upon as a closed system, whereas it is often observed that the expansion of many primate cities in the Third World is strongly influenced by international capital flows.

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[16] J. F. Linn, The costs of urbanization in developing countries, *Economic Development and Cultural Change*, 30, 1982, 625–648.

[17] J. F. Linn, *ibid.*, 647.

[18] See: P. Korcelli and P. Just, Metropolitan growth and population development at the national level, *Regional Development Dialogue*, 4. 1, 1983, 1–38.

[19] A. C. Kelley and J. G. Williamson, The limits of urban growth: suggestions for macro-modelling Third World economies, *Economic Development and Cultural Change*, 30, 1982, 595–623.

IMPACTS ON THE COMMUNITIES OF ORIGIN

The problem of brain drain and of migrants' remittances were included in the previous section among major policy issues concerned with population mobility, on both the interregional and the international scale. The available evaluations of such interactions are however, very incomplete, and represent a challenge which regional scientists might usefully take up. The UNCTAD study alluded to earlier was based on the human capital theory approach. This method sets the value of a migrant equal either to the education costs (his own, or these of his replacement) or to his potential income, generated by the appropriate skill level and aggregated over that portion of the life-span that is spent in the community of in-migration. The former implies that the community saves resources to produce an equivalent level of education in one of its nationals. The latter – based on the so-called present discounted value – equates the value of a migrant's worth as a productive asset to a stream of his potential income. Such calculations do not account for multiplier effects foregone, and created, at the respective ends of the migration trajectory. It seems that application of disaggregated production functions might represent a reasonable point of departure in this area. The question of migrants' remittances can be interpreted, though not in such precise analytical terms, with the help of the concept of intergenerational flow of wealth, which also stems from the human capital theory.

R. J. Pryor quotes evidence for West Africa, according to which high fertility is felt by some families to be disadvantageous. This represents to him an indication of fundamental changes in the family structure and in parental expectations with regard to wealth flows. These evolve, supposedly, from the dominance of obligations resting with children, characteristic of pre-transitional societies, to reciprocity in the transitional phase of development, and, eventually, to the predominance of parental obligations typical of post-transitional (modern) societies.

The emerging question in this context is to what extent does migration contribute to, or perhaps result from, this reversal of socioeconomic norms. Remittances, as R. J. Pryor suggests, may amount to only a fraction of the cash-goods-services which link the generations and also the origin and destination areas of migration. They may also supply "the economic mechanism and the culturally-supported framework within which parent-child expectations are modified and the rationality of fertility decisions and behaviour undergo a reappraisal".[20]

If information on remittance flows is to be used to test this concept, the data would have to be ordered by family relations. This is not the case, at least, with the available data on remittances sent across national boundaries. The relevant disaggregation would be into those proportions of the resources in question that are intended to contribute toward the support of older and younger generations, respectively, and that portion which is to be eventually used by the workers themselves, upon their return to the country (region) of origin.

Yet another issue that should be raised briefly here pertains to the interdependence between communication improvements and out-migration level. Since labour mobility cannot be viewed merely as a response to the "observed" imbalance between the supply and demand for labour (even if this includes demographic and spatial factors), and to various population redistribution policies, the question of the development of technical information channels, and how these are used by potential migrants, is of major research and policy relevance. One aspect of the availability

[20] R. J. Pryor, Population redistribution, the demographic and mobility transitions, in: J. I. Clarke and L. A. Kosiński, eds., *Redistribution of population in Africa*, Heinemann, London 1982, 25–30.

and structure of information channels is the question of to what extent better information, through physical access, actually amplifies the population flows. Traditionally, the "opening" of a remote territory through highway construction was believed to accelerate the rural out-migration. This, for example, was generally the tone of studies on the Appalachian region of the United States.[21] But opposing evidence, however, also abounds. In Poland, for example, the highest out-migration rates are observed in regions with relatively scarce infrastructure and below-average levels of public service provision.[22] In the Third World context, similar findings are reported by HABITAT:[23]

"... it is possible for the construction of a road to increase the land under cultivation, to augment farm inputs and to change cropping patterns, thus increasing productivity and inducing non-farm and wage employment in agriculture. In other words, investment in a road network, while increasing overall mobility of rural populations, may reduce seasonal and permanent out-migration pressures within the rural sector... persons from households with commuters or with employment opportunities within the rural areas have a far lower tendency to opt for seasonal or permanent migration than persons from all-agricultural households".

4. CONCLUSIONS

Policy issues in the field of labour migration in the Third World are fairly clearly identifiable, and certainly are pressing. The research response so far has been considerable, though most of it is at an early stage of conceptual development. Hopefully, the recent progress in interpretive generalizations will be followed by the formulation of rigorous analytical frameworks.

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[21] See, for example: J. Cumberland, *Regional development: experiences and prospects in the United States of America*, Mouton, The Hague 1971.

[22] K. Dziewoński and P. Korcelli, eds., *Studies on migration and settlement system of Poland*, Prace Geograficzne IGiPZ PAN, 140, 1981 (in Polish with English summary).

[23] United Nations Conference on Human Settlements, Paper prepared for Expert Group Meeting on Population Distribution, Migration and Development, Hammamet (Tunesia), 1985, 21–25 March, 23–24.

GEOGRAPHIA POLONICA 52, 1986

FOOD SYSTEMS AND SPACE

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INTRODUCING THE FOOD SYSTEM CONCEPT

If we interpreted the food system concept in semantic terms it would include the processes of food production, distribution and consumption. It would thus cut across several traditional fields of geographic research: land use studies, agricultural and rural geography, transport, population, economic and social geography. A concept covering so many varied human activities would be hardly manageable, and any classification of thus conceived food systems would encounter serious problems.

Despite the difficulties, there have been attempts in geography to tackle the problem. In 1980 a Commission of Comparative Research on Food Systems of the World was established by the International Geographical Union. Within the framework of the Commission, Christiansen (1984) suggested a tentative typology of food systems, based on the criterion of locational separation of the three functions /processes of a food system: production, storage/distribution and consumption. The author's definition of a food system, as "a structure that channels a flow of energy and matter" covers all the processes that make the food system. Their treatment, however, is more restrictive. The processes of a food system are, by and large, analyzed from one point of view: the efficiency of energy transformation at each stage of the food system.

The concept of a food system and related concepts (food chain, food cycle, food production system, food and agricultural system, food distribution system) can be found in the scientific literature of the 1970s. The concepts, however, have been often applied intuitively without definitions and lacking in rigour.

A clear interpretation of the food system as a general concept is to be found in the studies carried out under the Food Systems and Society Project initiated by the United Nations Research Institute for Social Development (UNRISD) in the late 1970s. In its draft research proposal (*Food systems*..., 1978) the Project identified a food system, or rather the core of it, as "an irregular and complex pattern of food circuits... with flows fluctuating according to seasonal changes and annual differences in food production and total food availability, as well as to changes in the levels and patterns of consumption". In the research that followed the draft proposal the scope of the food system concept has been extended to include social and economic relationships as proper elements of the system. Food circuits from the point of origin of the food (production or import) to its final destination (consumption or export) are seen as a framework for research on social groups interacting with the food circuits and, in the final analysis, with each other (Barraclough 1982, p. 125). The food system is understood as the totality of both food circuits, including related flows of inputs, technology and credit, and relevant social relationships as they affect the production of food and access to it.

The approach presented above seeks to identify all the interrelated factors that directly or indirectly determine the flows of food and related inputs. It is not clear, however, where the boundary between the system and its environment should be placed. We can always find an additional element or relationship influencing the investigated circuits. As our research for relevant factors proceeds, we can finally discover that most of the economy, society and ecology either influence or are influenced by the networks of food and related inputs. If all the influencing and explanatory factors are included into the system under study the essential components of the system — the food flows themselves — will become marginal.

The introduction of a general concept involves the question of the essence, the scope and the boundaries of this concept. In the real world there are always more or less important interdependencies among innumerable elements, and we must, in most cases, arbitrarily decide which elements and relations should be included into the system under study. The boundaries of the system, therefore, cannot and do not always need to be strictly defined. This does not apply to the essence of the system which should be explicitly stated.

This paper attempts to introduce and define the concept of a food system that could be applied in geographic research. It is apparent, even from the short preceding discussion, that the concept of a food system, if broadly conceived, can comprise an enormous number of elements and relationships of technical, physical, economic, social and political nature, covering all the stages in a food chain: from physical environment through agricultural production, post-harvest activities, storage, transport, distribution and consumption. This extensive field has been studied by many scientific disciplines, each of them concentrating on its own area of interest. It seems unlikely that the concept of a food system can comprise so many variables and still remain manageable. It is, therefore, advisable to narrow the scope of the concept and to concentrate on the essential variables of the food system. As the concept is meant to be applied mainly in geographic research, preference is given to those elements and relationships which produce spatial patterns. In the author's opinion it is the flows of food that form the backbone of a food system in space. The flows of food must be large and stable enough to form a network of food circuits. Only then is a food system established. A food system can thus be seen as a network of interrelated, overlapping circuits which channel the flows of food from places of origin to places of destination. The flows of food are not the only relations in a food system but they are of its essence.

There exist, however, other flows and relationships that influence the flows of food. These include trade or distribution of agricultural inputs and technology, flows of information, credit and capital, administrative and political decisions, power and class relations etc. All those factors and their influences on the flows of food can be analyzed in a broad framework as external determinants but not as the elements of the food system as it is conceived in this paper.

The approach applied in the paper emphasizes the spatial dimension of food systems. It is based on several spatial variables, such as the territorial coverage of food systems, distribution of surplus and deficit areas, the length and pattern of food circuits, intensity of food flows etc.

Before spatial variables can be discussed it is plausible to establish the underlying principles or mechanisms which initiate and govern the movement of food in space. Four such mechanisms can be identified:

1) self-provisioning,
2) customary reciprocal exchange,

3) market exchange,
4) command-redistribution.[1]

All those mechanisms have been present, though in varying degrees, throughout the history of mankind. Their respective roles in forming food systems in space have not been equal. The greatest system forming potential is inherent in market exchange and command-redistribution mechanisms. They have been at the root of the formation of extensive spatial networks of food circuits from the local to the international level. The corresponding roles of the two remaining mechanisms have been much smaller. Self-provisioning has been the most common principle governing food production in human history, but its organizational potential with regard to food flows has been present only at the lowest level of social structure (usually individual household). Customary reciprocal exchange was a characteristic feature of certain tribal communities. With few exceptions, the role of this form of food flows can be regarded as marginal.

LOCAL FOOD SYSTEMS

Throughout most of human history the supply of basic food has been a local concern. One cannot expect significant transfers of food in space if 90–95 per cent of population live in rural areas and derive their income from agriculture. Such a situation prevailed in Western Europe at least until the late Middle Ages (Postan 1973, p. 22), in Eastern Europe until the 18th century and in many parts of Asia and Africa well into this century. Over many centuries a sort of equilibrium existed between the number of food producers and a small minority of non-producers. Generally low agricultural yields and high costs of transport hampered long-distance movement of food and encouraged the formation of local, self-sufficient units. They could take many forms: an individual household, an extended family, a village, a large estate or a small town with its hinterland. Within the units the movement of food could be channelled along different local circuits, created by separate mechanisms regulating food flows. In proportion to the total production within the local system, the food flows were relatively small. Self-provisioning was the dominant method of food supply. It applied also to many town dwellers.[2]

The size of local systems was determined by many factors. It seems, however, that in all preindustrial societies the most important factor limiting the size of a food system was the cost of transport, particularly land transport. Even in early 19th century Germany this cost must have been still crucial, if von Thünen made it a single factor determining the cropping pattern in his isolated state.

There are many estimates of the costs of land transport in different historical periods. The evidence, however, is by no means conclusive. For the Roman Empire, Duncan-Jones (1974) and Hopkins (1982) give different estimates, though based on the same sources. It follows that the cost of transporting 1 tonne for 100 km in ox-driven cart was equivalent to 220–570 kg of wheat. As the unit costs in overland transport tended to rise with distance (poor organization, higher risk), it can be assumed that a cartload of wheat would double its price over 200–300 km.

Clark and Haswell (1967, p. 184–185) provide a table summarizing 78 independent

[1] Command-redistribution mechanism is assumed to involve an institutional and usually centralized framework (e.g., state), which administers the flows of food according to non-economic principles.

[2] Ancient towns — the Greek *polis* or the Roman *civitas* — were juridically "part and parcel of their surrounding territories" (Pounds 1974, p. 224).

estimates of the cost of traditional land transport in different countries and historical periods. For carts and wagons the median cost comes to 3.4 kg grain equivalent per tonne/km, for pack animals – 4.1 kg, and for porterage – 8.6 kg.

Apart from the costs, time distance was an important constraint on local food systems, particularly on its market circuits. To operate properly, a local market had to be within the reach of one day journey to most of rural population. If we know, for instance, that oxen move at under 3 km per hour and work usually for 5 hours a day (Hopkins 1982, p. 83), it implies that heavy goods would not be normally transported more than 10–15 km from its place of origin. This applies to everyday activities and not to emergencies or rent (tithe, tribute) payments which were governed by different principles.

The length and pattern of local food flows was also conditioned by other, area-specific factors such as: local topography, density of population, pattern of landholding, administrative structure, access to water transport etc. All those factors taken together determined actual sizes of individual local food systems.

There are several fairly accurate sources of information on actual spatial extent of local food systems. For early 20th century China, Skinner (1964) gives an estimate of only 4.5 km as an average distance to a standard market town, and 30–96 sq km as the most common range of tributary area. In areas of lower population density, e.g. 20 persons per sq km, which are more typical of other countries, the tributary area would be around 160 sq km.

In sixteenth-century Germany one town served, on the average, the area of 55 sq km in Wüttemberg and 200 sq km in Prussia and Hanover (Pounds 1979, p. 30).

In England of that time rural market areas ranged between 100 sq km in southern parts of England and over 300 sq km in the North (*The Agrarian*..., 1967, p. 497). The average distances of travel were: in the case of grain 5 miles (8 km), livestock – 12 miles (20 km) and wool – 20 miles (32 km) (Johnson 1970, p. 37).

In India (Kanpur region in the 1960s) the average distance of food transport is reported to have been twice as high as the above figures (ibid.).

P. Gould (1960) in his study of two rural markets in Ghana in the 1950s found that most of the produce (88 and 85 per cent) originated within 6.4 and 13.6 km respectively from the market. The evidence presented above seems to suggest that the average length of local food circuits is within the range of 5 to 15 km of radius.

Under the circumstances of low and spatially diffused agricultural surplus as well as high transport costs, the emergence of a large city with long-distance food supply circuits required special favourable conditions. Local systems, on the other hand, could multiply relatively easily, provided the land was available. As a result, cellular structures developed with food flows concentrated within the boundaries of an individual food system and with very little exchange, in staple foodstuffs, between the systems.[3]

This situation was caused not only by high transport costs, but also, at least in medieval and early modern Europe, by institutional measures, which were created to protect local food supplies and to confine them within the sphere of influence of an individual town. Thus, according to Kuliszer (1961, p. 266), in fourteenth-century Germany 95 per cent of towns prevented any exports of grain outside their respective hinterlands. In times of bad harvests such procedures were universal. Under such circumstances, significant differences in food availability and prices between local food systems could, and did exist.

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[3] In nineteenth century China 20 to 30 per cent of the harvest circulated within the local systems and only 5 to 7 per cent entered into the long-distance trade (Perkins 1969, p. 136). For basic foods (grains) the figures were much lower. The inter-provincial movement of grain amounted to 1 to 2 per cent of the national output (ibid., p. 150).

LARGE-SCALE FOOD SYSTEMS

Although local food systems can be regarded as basic frameworks of food supply yet already in early periods of human history some food was transferred beyond local boundaries. It can even be argued that the ability to organize an extensive network of transport and storage of food conditioned the survival of ancient civilizations.

The variety of supra-local food systems in human history is enormous. This paper does not attempt to provide an orderly description and analysis of such systems, concentrating merely on revealing spatial characteristics and criteria which could be helpful in making comparisons in time and space between different food systems. As in the preceding paragraph, prominence will be given to those characteristics which describe the extent or coverage of food systems. The extent of supra-local food systems can be measured by the length of their food circuits. These may range from below 100 km, as in the regional exchange between highlands and lowlands, wet and dry areas, or culturally different peoples, to more than 20000 km in modern world economy food flows.

Alternatively, the size of a food system can be estimated by a number of different areas, administrative units or countries that make a given system. A hierarchical classification of food systems (local, regional, national, supra-national, world) could thus be introduced. Large-scale food systems should also be evaluated by the intensity of flows or, in relative terms, by the proportion of the total food supply that is provided by a given circuit. It makes a big difference whether a given locality is in twenty or eighty per cent dependent on distant sources of food supply.

As far as the mechanisms regulating long-distance food flows are concerned. two of them play dominant roles: (1) market system based on marketable surplus and effective demand and (2) command-redistribution system, which operates through taxes, rents, quotas, tributes and various forms of food rationing. A few historical examples should make these points clearer.

HISTORICAL EVIDENCE: LONG-DISTANCE FOOD FLOWS OF THE ANCIENT MEDITERRANEAN

In ancient times the Mediterranean world saw the development of two great civilizations: Greek and Roman. Both of them created extensive food circuits, which relied principally on water transport.

In Greece practically no part of the territory is located more than 100 km from the coast. Land topography in both mainland Greece and Asia Minor is rough, making land transport difficult. It is only natural that in Ancient Greece sea transport became the principal method of transporting bulk goods, among which grain took the first place. Grain imports by individual Greek city-states (*poleis*) began to grow from the end of the seventh century B.C. This was caused initially by poor agricultural resources of some *poleis* and recurrent crop failures. These two factors were subsequently complemented by growing urbanization which surpassed the supporting capacity of many agricultural areas in individual *poleis*. By the fifth century B.C. food was commonly imported. Agricultural and trading colonies were established to relieve population pressure and facilitate food imports on a near to monopoly basis. Export controls which regard to food were being introduced.

Grain imports, which included mainly wheat,[4] came to Greece from three sources:

[4] There is no evidence of long-distance trade in barley, the chief grain for feeding slaves and livestock, implying that it was cultivated in all communities in sufficient quantities (Rathbone 1982).

the Black Sea region, Sicilly and Egypt. Practically the network of food circuits included the eastern Mediterranean and the Black Sea. The distances of food trade averaged 800–1000 km or 5–6 days of sea travel. The spatial dispersion of food imports was very convenient in view of harvest fluctuations in individual surplus areas or interruptions of supply caused by wars and piracy.

The food trade was carried out by small-scale merchants, who were often controlled by noble men or licensed by the state. Although "in the average year there was sufficient wheat on the international market to satisfy the needs of all" (Rathbone 1982, p. 47), the *poleis* were reluctant to leave food supply to chance or the free play of the market. In Athens the state often appointed official corn buyers, called *sitonai*, "who sought supplies of grain wherever they could find them, raised public subscriptions for the necessary funds, introduced price reductions and rationing" (Finlay 1973, p. 170). Other measures, both state and private, were being taken to control the international circuits of grain. As a last recourse, Athens resorted to "*katagein*, the forcible bringing into port of grain ships on the high seas" (Jameson 1982, p. 63).

The Roman Empire extended the network of food circuits over the whole of the Mediterranean region and much of the Western Europe. It was based on well organized sea and river transport and an excellent, for the period, network of roads. Most of the provinces of the Empire were relatively easily accessible.

The cost of transport varied according to the distance and the mode of transport. Land transport of staple foods (grain, wine, olive oil), even along good Roman roads, was very slow and costly. The oxen were the chief traction animals of the antiquity and the figures indicating their low efficiency have already been referred to in the previous paragraph. The cost of river transport was, on the average, 5–8 times cheaper, and by sea 30–50 times (Duncan-Jones 1974; Hopkins 1982). Even if we allow for additional costs involved in the handling of goods in water transport the difference is enormous. According to Finlay (1973, p. 126), "a shipment of grain by sea from one end of the Mediterranean to the other would cost less (ignoring the risks) than carting it seventy-five miles".

Even in emergencies, land transport was inefficient. In the famous case of the famine in Antioch of A.D. 362–363 it required the intervention of the Emperor to have grain transported overland from two grain surplus districts in northern Syria, one 80 and the other 160 km away. This example shows not only the high costs of land transport but also the importance of an organizational network, which was in that case absent. The same quantities of grain could be easily transported overland if, for instance, they were regarded as government supplies for the army.

Long-distance food flows were regulated parallelly by market forces and the state command-redistribution system. Both systems created their own circuits, with the state system dominating inter-provincial flows of grain.

The evidence on the movement of food is centred on the supply of the city of Rome. There an elaborate state-run system was created, beginning with the collection of grain levies in the supplying provinces, through sea and river transport, storage, until the final distribution of bread to those in Rome who were entitled to it (Tengstrom 1974).[5] The main sources of the grain supply to the city of Rome were Sicily, North Africa, Egypt, and Spain. The distances of regular shipments ranged from 700 km (Sicily – Rome) to 2000 km (Alexandria – Rome). The system was operated for six centuries and was still efficient in about A.D. 400, two generations before its

[5] The open market for grain operated in Rome parallelly with the state-run distribution system.

final collapse. This experience, however, cannot be generalized over the whole of the Roman Empire. Tengstrom (1974, p. 1) underlies that "the corn supply of Rome (after A.D. 332 also of Constantinople) is the only example in antiquity of a continuous transport over a long distance of cheap goods in considerable amounts".

Other long-distance food flows were far less extensive and poorly documented, e.g. the supply of the legions on the Rhine with grain coming from Britain. It is also not clear in what degree imports penetrated local food consumption in individual cities.[6]

The food circuits, which linked, though in varying different degrees, remote places of the Roman Empire, provided the rationale and the necessary coherence for the whole political system. They increased, by and large, food security of the city of Rome and certain other regions. They also enabled territorial specialization on a regional (vine growing) and local (poultry rearing) scale of those places which could safely rely on grain shipments from distant sources.

HISTORICAL EVIDENCE: LONG-DISTANCE FOOD FLOWS AND THE RISE OF THE EUROPEAN WORLD ECONOMY

On the eve of the Great Discoveries, Europe was still rural and agricultural with local food circuits dominant. Long-distance trade was largely confined to luxury products, which could bear high transport costs. There was, however, a growing urban and industrial sector which encouraged long-distance movement of foodstuffs, particularly grain.

The conditions of transporting bulk goods had not changed in any significant degree since the Roman times. The new harnessing technique (horse collar), which developed in Europe during the Middle Ages, made land transport easier, nevertheless compared to other means of transport or in proportion to the value of staple foods, the cost of overland transport was still prohibitive, except for short distances. River transport, though much cheaper, was not easy either. Many riverine cities enjoyed special privileges (*Stapelrecht*, *Umschlagsrecht*), which could virtually block the movement of merchandise along the river. The cost of river transport was augmented by frequent toll stations. On the Rhine, there were more than 30 of them, and on the Seine – 18 toll stations in 100 km of river below Paris (Pounds 1979, pp. 56–57).

Despite costs and barriers water transport provided the only solution to the food supply of a large city. According to Schmoller (quoted by Tilly 1975, p. 398) "a settlement much larger than 5000 could not exist without the importation of grain by water". In the early sixteenth century relatively few towns exceeded 5000 population, totalling no more than 5 per cent of the population of Europe. In two regions, northern Italy and the Low Countries, large cities were numerous, which placed a burden on traditional food supply.

To obtain food self-sufficiency, the Italian city-republics sought to expand their *contados* – the territories over which they exercised political control. With the exception of Milan, the efforts to secure self-sufficiency in food largely failed. The availability of more distant sources of bread grains became a condition of the continued expansion of the Italian cities. Fortunately, grain surplus areas were close enough to secure regular shipments of food. These areas were: southern Italy (Apulia, Sicily), Adriatic coast of Albania, Spain and North Africa. Compared with ancient supplies of the city of Rome, the food circuits were shorter and flows – less intensive.

[6] Athens in the fourth century A.D. is reported to have imported regularly two thirds of its wheat consumption, being selfsufficient in meat and fish (Finlay 1973, p. 133).

The cities of the Low Countries, unlike Italian, never fully established political control over the surrounding territories. Initially, for their food supply, they relied on near-by regions of Lower Rhineland, Artois and Hainault. Since the supply of grain was never abundant there was a running feud between upstream and downstream cities for control over the grain boats. In such circumstances, the Flamish and Dutch cities turned to more distant sources of supply in Poland and eastern Germany. These territories during the sixteenth century became the functional hinterland of the Low Countries. Regular supplies of grain from the Baltic provided the greater part of the consumption of urban population and made it possible for the farmers of the Low Countries to specialize in commercial crops and cattle breeding. Baltic grain was carried further to Spain, Portugal and, by the end of the sixteenth century, to the Mediterranean.[7]

Another food export from central and eastern Europe were cattle, the only bulk food product that could be profitably transported for long distances overland. In the early seventeenth century up to 100000 live animals a year were driven from Poland and Hungary to Austria and Germany, playing a dominant role in the meat supply of Vienna and south German towns (Pach 1973, p. 63). Thus, "both for bread and for meat, the East (of Europe) became an agricultural tributary of the West" (Tilly 1975, p. 422).

This pattern of long-distance trade in food played an important role in two simultaneous processes: the formation of the European world economy and the rise of national markets and distribution systems. Despite occasional setbacks, the changes in various fields of human activity became cumulative and mutually supporting.

Tilly (1975, p. 398) identified three sources of growing demand for marketed food during 1500–1800: (1) the expansion of landless labour, (2) the increase in urban population and (3) the growth of government staffs. With regard, however, to long-distance movement of food, the role of individual factors was uneven. The growth of non-agricultural labour and urban population determined the long-distance flows of food only to the extent to which the demand was concentrated in large cities. In Europe, the number of such cities (exceeding 100000 inhabitants) rose from 6 in 1500 to 23 in 1800 but the relative share only doubled during that period from 1.4 to 2.8–2.9 per cent of total population (ibid., p. 399). As far as the third factor – the growing staffs of governments – is concerned, the most conspicuous illustration of this is provided by the numbers of standing armies. In Prussia it rose from 2000 in 1640 to 200000 in 1786 and in France from 35000 in 1610 to 175000 at the Revolution (ibid., p. 410). The provision of big armies and other administrative staffs required extensive food supply systems. The states, therefore, were very active in the building of nation-wide transport network and in breaking of local impediments to free movement of grain, contributing thus to the formation of national markets and establishing parallelly their own nation-wide distribution systems. The formation of national markets was conditioned, of course, not only by the decisions of political rulers, but primarily by technical and economic processes, such as growing agricultural productivity, transport development and more efficient marketing organization.

In the later eighteenth and the nineteenth centuries, the most important role in the extension and strengthening of long distance food circuits should be attributed to the developments in transport. The building of canals, then railways and the introduction of steam shipping provided the basis for the enormous extension of the

[7] It appears that in Venice Baltic grain was competitive with Hungarian wheat, which had to be carried mainly overland (Pach 1973, p. 66).

area available for food supply. The time and cost of transport was reduced dramatically, so that bulk goods could be easily transported across and between continents.

During the nineteenth century, new territories were opened up which supplied cheap grain on the world market: southern Russia, the United States, Canada, India, Argentina and finally Australia. The average distance of food flows increased substantially. In England, in case of wheat imports, it rose from 2170 miles (3500 km) in 1856–60 to 5950 miles (9500 km) in 1909–13. The share of imports in the domestic consumption of wheat rose from 50 per cent in 1870–76 to 84 per cent in 1904–10 (Peet 1969, p. 295).

Notwithstanding later changes, it is fair to conclude that by the second decade of the twentieth century the process of the spatial extension of food circuits to the world-wide level had been basically completed.

FOOD SYSTEMS IN SPACE: EXPLANATORY FRAMEWORK

The preceding discussion, although general and fragmentary, has indicated an enormous variation, in both space and time, among food systems of the earth. Even if we consider only the spatial variables (size, length of circuits, pattern and intensity of flows etc.) the differentiation is still great, producing food systems at all levels of spatial scale.

At the top of the hierarchy, we have the world food system, which is based on a world-wide network of food flows linking effectively food surplus and deficit national systems. At the other end of the spectrum, there are local systems, which in many developing countries still provide most of the basic food supply in rural and small urban communities. Between the two extreme forms there is a variety of intermediate levels of food systems which are formed and operate in accordance with area-specific conditions. The most important of them, particularly in the twentieth century is the level of an individual nation-state. At this level, a political and economic framework is usually provided for the operation of a national food system, which – through market exchange or redistribution system – regulates most of the supra-local food flows within the national territory. In many countries food networks at other levels, both sub-national (e.g., states in India, provinces in China) and supra-national (e.g., European Economic Community) are created.

Food systems of different hierarchical levels are not mutually exclusive. Their respective food circuits and flows may partially interpenetrate and overlap, producing competing or complementary networks on the same territory.

When analysing and comparing spatial parameters of food systems in human history, explanations of their variability are naturally sought. The problem involves the identification of the conditions, processes and, generally, influencing factors which produce or determine the spatial variables of food systems. The following diagram provides a conceptual and explanatory framework, illustrating the most important points in the discussion (Fig. 1).

If we follow the earlier statement that the basis of a food system is formed by the food flows from surplus to deficit areas, we should search for those factors which determine, on the one hand, the formation of a food surplus or deficit in individual areas and, on the other, the spatial pattern of food flows. Two broad classes of factors could thus be distinguished.

The first class, exemplified by four rectangles (A, B, C, D) on the diagram, includes inherent attributes of individual places, their physical and human resource base which determines the emergence of a potential food surplus/deficit in a given area (or in a food system of a lower order). These area-specific factors include:

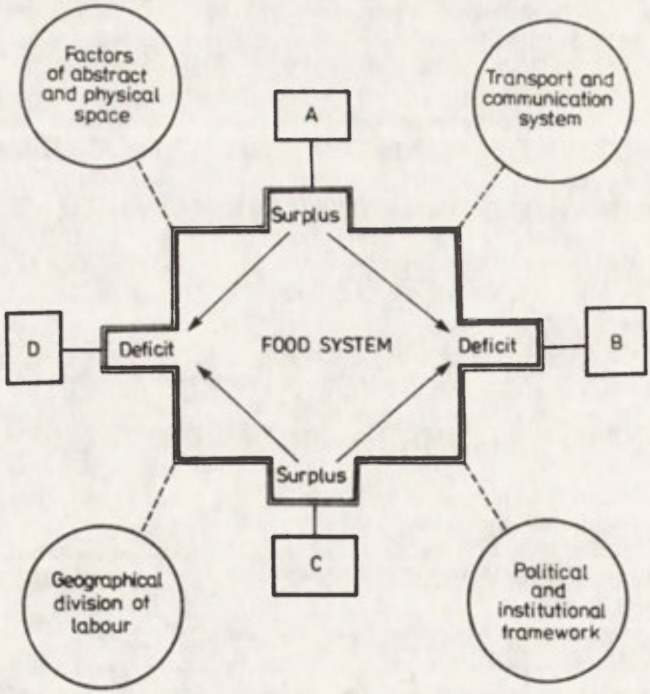

Fig. 1. A food system with its external environment: A, B, C, D, – individual surplus/deficit areas or food systems of lower order

land availability, land-man ratio, agricultural productivity and specialization, level of commercialization, yield variability, storage capacity, income per capita, income distribution, food habits, proportion of urban and non-agricultural population, food policies, etc. All those area-specific factors directly influence potential self-sufficiency of individual areas. They are not sufficient, however, to determine the actual surpluses and deficits, not to mention the pattern of food flows between the areas.

For that purpose, we must consider the second class of factors which operate above the area level, providing a general field of interaction where food systems can be located. In other words, the factors of this category determine relative locations – in various physical and functional spaces – of surplus and deficit areas (or food systems of a lower order). In this category four grups of determinants, shown by the circles in the diagram, can be distinguished:

1) Factors of abstract and physical space (inter-area pattern of distances, relative accessibility within the system, variable quality of the earth's surface, pattern of climatic variability, etc.).

2) Transport and communication system (modes and means of transport and communication, routes and networks, capacities, freight structure, etc.).

3) Political and institutional framework (pattern of socio-political relationships, international and administrative boundaries, institutional dependencies, policies affecting the interaction space, etc.).

4) Geographical division of labour (level of economic concentration and specialization, overall pattern of flows, exchange facilities and organization, etc.).

Each of the above mentioned groups of factors, independently of the others, can influence the pattern of food flows, and indirectly the distribution of surplus and deficit areas, within a given food system, as well as the relative position of the individual food system in a given territory.

SUMMARY

This article introduces the concept of a food system in a spatial context. The basis of the concept is based on the distribution of food surplus and deficit areas and the pattern of food flows among them. Certain variables of food systems have been identified to enable comparisons in space and time between the individual food systems. The discussion has been centred on the spatial extent of food systems. Local versus long-distance food flows have been contrasted and presented in historical perspective. The evidence, both historical and contemporary, has shown certain factors and causal relationships determining the length of food circuits and the intensity of flows. Finally, a tentative categorization of the conditioning factors has been introduced and presented schematically in the diagram.

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GEOGRAPHIA POLONICA 52, 1986

TRANSFORMATIONS DE L'AGRICULTURE EUROPÉENNE À LA LUMIÈRE DE LA CARTE DES TYPES AGRICOLES DE L'EUROPE

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La carte des types agricoles de l'Europe (1:2.5 millionième) qui est le résultat de la coopération de plusieurs géographes européens a été préparée selon la méthode élaborée par la Commission de Typologie Agricole de l'UGI (Kostrowicki 1979).

Plusieurs publications ont déjà expliqué la conception, la méthode et les techniques de la typologie agricole (Kostrowicki 1977, 1980a). Plusieurs autres ont montré l'application de cette méthode aux études sur l'agriculture dans divers pays du monde (Bonnamour et Gillette 1980; Dongmo 1975; Gałczyńska 1984; Gorbunova et autres 1979; Hill 1982, 1983; Panda 1979; Rikkinen et Vapaoksa 1983; Scott 1983; Sharma 1983a, b; J. Singh 1983; V. R. Singh 1979; Stola 1975; Szczęsny 1978, 1979, 1981; Szyrmer 1984; Troughton 1979; Tschudi and Johansen 1983; Tyszkiewicz 1975, 1979, 1980, 1982).

Pour ceux qui n'auraient pas eu l'occasion de prendre connaissance de la méthode voici quelques renseignements.

1. LA MÉTHODE

Au contraire de toutes les classifications de l'agriculture mondiale, la typologie agricole se base sur des fondements quantitatifs et les méthodes quantitatives sont appliquées pour grouper en types les cas individuels.

L'agriculture de chaque unité territoriale etudiée: une exploitation, une région agricole ou une unité administrative est caractérisée par 27 variables qui représentent les traits ou caractères les plus importants de l'agriculture: sociaux, opérationnels, de production et structuraux (Kostrowicki 1984). Ces variables exprimées en unités et mesures différentes sont normalisées selon l'écart mondial de chacune variable.

Ces écarts réduits aux 5 classes représentent la valeur relative de chaque variable: 1. très bas, 2. bas, 3. moyen, 4. élevé, 5. très élevé. Présentées pour chaque unité de base sous forme de codes elles peuvent être comparées entre eux selon la méthode taxonomique adoptée (Bielecka, Paprzycki 1979; Bielecka, Paprzycki, Piasecki 1979, 1980a, 1980b).

Comme toutes les méthodes mathématiques appliquées jusqu'à présent ne sont efficaces que pour un seul ensemble d'unités d'étude, et en consequence elles n'assurent pas la comparabilité des résultats ni dans le temps ni dans l'espace, on y a appliqué une méthode de déviation qui est une des méthodes avec un étalon (*with* *a frame of reference*). Dans cette méthode on compare les codes pour chaque unité d'étude avec les types-modèles établis à partir de l'étude de plus de 1000 cas couvrant l'agriculture du monde entier. Quand les distances taxonomiques entre l'unité d'étude donnée et un (ou plusieurs) code-modèle ne dépassent pas le maximum arbitrairement adopté, l'agriculture de cette unité est considérée comme appartenant au type-modèle donné. Comme le système de types-modèles est ouvert, les cas qui dévient des types-modèles au-delà du maximum adopté peuvent être utilisés pour établir de nouveaux types. En effet l'analyse et la codification ultérieures de milliers de cas enrichissait la typologie de plusieurs types-modèles supplémentaires.

Le système est aussi hiérarchique. Sur la base de plusieurs études on a déjà identifié et décrit dans le monde 6 types agricoles de 1-er ordre, 22 types de 2-ème ordre et plus d'une centaine de types de 3-ème ordre. Alors qu'il est peu probable qu'on trouve de nouveaux types de 1-er ordre, il est certain qu'on pourrait déterminer et identifier plusieurs types de 2-ème ordre et surtout de 3-ème ordre, notamment pour les pays moins bien étudiés jusqu'à présent.

2. LES TYPES D'AGRICULTURE EN EUROPE

Comme chaque type d'agriculture, de n'importe quel ordre, est décrit par 27 variables, et les types d'agriculture de l'Europe sont caractérisés par leur codes (tableau 1), ils sont caractérisés ci-dessous seulement par leurs traits les plus significatifs.

E. Agriculture traditionnelle extensive dite primaire

L'agriculture de ce type se caractérise par les systèmes fonciers traditionnels (collectifs ou communautaires, servitude, location contre prestation de travail, métayage), les petits ou moyennes dimensions des exploitations, des apports très limités de main d'oeuvre. ceux de capital inexistants ou très bas, une faible intensité de l'utilisation du sol (jachères) et de l'élevage, une basse productivité, des relations nulles ou faibles avec le marché (agriculture vivrière ou semi-vivrière). Rare en Europe, surtout sous les formes transitoires ou de vestiges.

L. Grande agriculture traditionnelle dite latifundia

Caractérisée par les systèmes fonciers traditionnels (servitude, location contre prestation de travail ou de service), grandes dimensions des exploitations, des apports de main d'oeuvre bas (animaux de trait importants), des apports de capital très bas, une utilisation extensive du sol (jachères), une productivité basse ou moyenne, une commercialisation moyenne ou élevée, une spécialisation basse ou moyenne. En Europe rare; surtout sous les formes transitoires ou de vestiges.

T. Petite agriculture traditionnelle dite paysanne

Faire valoir direct ou fermage, des apports hauts ou moyens de main d'oeuvre et des animaux de trait, faibles relations avec le marché aussi bien pour les achats de produits industriels que pour la vente. Production surtout pour l'autoconsommation. En principe on vend au marché ce qui reste après avoir réservé ce qui doit couvrir les besoins de l'agriculteur, de sa famille et de son bétail. Fréquente en Europe du Sud, de la Grèce au Portugal, ainsi qu'en Yougoslavie et en Pologne.

Au sein du Type **T** deux types de 2-ème ordre et 12 de 3-ème ordre ont été identifiés en Europe.

Ti. Petite agriculture intensive vivrière ou semi-vivrière orientée vers la production végétale

Des apports de travail très elevés et ceux des animaux de trait moyens ou

TABLEAU 1. Codes modèles

I. Types de 1-er ordre

	codes	anciens symboles
E	5321311 – 1111121 – 1221111 – 133331	(*Ts, To, Tn, Te*)
L	1551354 – 2211132 – 2334422 – 132342	(**L**) (*Tl*)
T	1241222 – 4412242 – 4422221 – 114221	(*Td, Ti, Tj, Ts, Tm*)
M	1151233 – 2154343 – 4455544 – 122331	(**M**)
S	1115555 – 3243242 – 3333433 – 124221	(**S**)
A	1133445 – 3000003 – 3045535 – 151551	(*Mu, Su*)

II. Types de 2-ème ordre

En	4211201 – 1100121 – 1221112 – 141451	(*Tn*)
Ef	5321221 – 1111111 – 1221111 – 115111	(*Ts, To*)
Et	2441211 – 2211132 – 2311211 – 132221	(*Te*)
Ll	1551354 – 2211132 – 2333323 – 124331	(*Lc, Ll*) (*Tlc, Tla*)
Lp	1351444 – 4411142 – 3323434 – 333213	(*Lp*) (*Tlp*)
Ti	1241212 – 5311452 – 5511221 – 114111	(*Td, Ti, Tj*)
Ts	2241222 – 3212231 – 2222325 – 313113	
Tm	1151222 – 4423143 – 3321321 – 124231	
Ms	1151333 – 3113341 – 4433444 – 511114	
Mi	1151212 – 5145451 – 5545555 – 215111	(*Mi, Mh, Mg*)
Mm	1151222 – 3154143 – 4444443 – 122331	
Ml	1151355 – 2154341 – 4455544 – 213223	(*M·, Mv, Mp*)
Me	1151254 – 1152132 – 1255525 – 134221	(*Mc, M·*)
Se	1115343 – 3232131 – 2222321 – 124221	
Sm	1115555 – 2143143 – 3333432 – 133331	(*Sm, So*)
Si	1115555 – 5422343 – 4522232 – 114111	
Sh	1115545 – 4155441 – 4434554 – 215111	(*Sh, Sg*)
Ss	1115555 – 2133442 – 3344535 – 411214	(*St*)
Sc	1115555 – 1142131 – 1234515 – 115111	(*Sc, Sl*)
Sg	1115554 – 4434342 – 2312423 – 141233	
Ar	1133455 – 1000001 – 1033515 – 151551	(*Mr, Sr*)
Ad	1133415 – 5000005 – 5055555 – 101551	(*Mu, Su*)

III. Types de 3-ème ordre européens

Etm	1341221 – 3311132 – 2321221 – 133221	(*Tem*)
Llm	1251354 – 2211132 – 2333424 – 143341	(*Tll*) (*Lll*)
Tir	1151211 – 4411244 – 2211211 – 114111	(*Tds*) (*Tmr*)
Tiu	1151112 – 4432454 – 3322321 – 214111	(*Tjm*) (*Tmu*)
Tmh	1251211 – 4511343 – 2311111 – 122341	(*Tdh*)
Tme	1151111 – 3423134 – 2211111 – 123331	
Tmb	1151222 – 3412133 – 3332232 – 122341	
Tmm	1151222 – 3323143 – 3323321 – 113231	
Tmo	1151111 – 3223142 – 4422133 – 113331	
Tmv	1151111 – 4434244 – 3311223 – 214222	(*Tmf*)
Tme	1241212 – 4422243 – 3423332 – 224221	

Tmg	1151121 – 3243132 – 2322432 – 322232	
Tmf	1151112 – 4254141 – 3322332 – 513112	
Tmk	1151112 – 4423144 – 4421233 – 132451	
Mso	1151122 – 2143132 – 3334534 – 411115	
Min	1151112 – 4455353 – 5533553 – 515221	
Mif	1151222 – 3154341 – 4445544 – 515111	(*Mhf*)
Miv	1151223 – 3145351 – 5534554 – 114111	(*Mhg*)
Mig	1151314 – 5155551 – 5555555 – 115111	(*Mgg*)
Mmr	1151233 – 2154142 – 3343433 – 123221	
Mmc	1151222 – 4254242 – 4434443 – 213222	
Mmf	1151112 – 3243343 – 3433433 – 324221	
Mmv	1151123 – 2255243 – 5555552 – 114121	
Mmz	1151122 – 2243342 – 2333322 – 141232	
Mmp	1151111 – 4254454 – 4422342 – 313341	
Mmt	1251122 – 3153243 – 4443341 – 313231	
Mmm	1151222 – 3255144 – 4444442 – 122331	
Mmh	1151112 – 4454254 – 5533442 – 142451	
Mmg	1151232 – 2223143 – 3433333 – 131351	(*Tml*) (*Tma*) (*Mmt*)
Mmw	1151122 – 3155145 – 3343333 – 151251	
Mma	1151233 – 2154144 – 4544444 – 141451	(*Mml*)
Mmi	1151222 – 3155355 – 5545553 – 212451	
Mlm	1151355 – 2154143 – 4455542 – 123331	(*Mxm*)
Mlc	1151254 – 2154441 – 4455543 – 113112	(*Mvm*)
Mel	1151132 – 1143132 – 2244522 – 222222	
Mem	1151254 – 1152132 – 2355533 – 133331	(*Mxc*)
Meb	1151143 – 1143142 – 2355424 – 141451	(*Mmb*)
Mea	1151142 – 1155542 – 1544514 – 151551	
Sec	1115443 – 3232231 – 2222422 – 124121	
Sep	1115343 – 2142132 – 2333422 – 222222	
Sem	1115443 – 3233133 – 2333321 – 133331	
Smw	1115555 – 2142142 – 2223422 – 114331	
Smm	1115555 – 2144143 – 3434432 – 132341	
Smg	1115453 – 1154242 – 1433412 – 152331	
Smy	1115454 – 2154141 – 1332423 – 143221	(*Smj*)
Smc	1115555 – 3233242 – 3333432 – 223221	
Smu	1115555 – 3144143 – 3344534 – 114222	
Smi	1115555 – 2154443 – 4455543 – 122222	(*Soo*)
Sma	1115555 – 2253142 – 2322424 – 143551	
Smd	1115454 – 3155144 – 4444443 – 113351	
Sgt	1115555 – 4444342 – 2312423 – 141233	
Shy	1115444 – 3144341 – 3333534 – 323111	(*Shj*)
Shv	1115555 – 4154342 – 4433545 – 115111	
Shg	1115545 – 5155551 – 5555555 – 115111	(*Shh*) (*Sgg*)
Ssf	1115555 – 3133241 – 3344535 – 515111	(*Shf*)
Ssc	1115555 – 2154442 – 3334535 – 332114	(*Stc*)
Scm	1115555 – 1141131 – 1333413 – 154441	(*Sll*)
Scc	1115555 – 1142131 – 2233525 – 115111	(*Sce*)
Arr	1151354 – 1000001 – 1022515 – 151551	(*Mrr*)
Aro	1115555 – 1000001 – 1034515 – 151551	(*Srr*)
Add	1151323 – 5050005 – 5055555 – 101551	(*Muu*)
Ado	1115555 – 5050005 – 5055555 – 101551	(*Suu*)

élevés, intensité d'utilisation du sol, irrigation, productivité de la terre très élevées, celle de travail très basse, commercialisation basse, orientation vers la production végétale, surtout alimentaire. En Europe sous formes transitoires ou de vestiges, identifiée seulement en Yougoslavie de sud-est (Macédoine) dans deux types de 3-ème ordre.

Tir. Agriculture très petite, de productivité basse, semi-vivrière.

Transitoire entre *Ti* et *Tm*, plus proche de **E**. Décrite pour l'Inde du nord; en Europe, identifiée en Macédoine.

Tiu. Agriculture très petite, irriguée, productivité de la terre moyenne, celle du travail basse, semi-commerciale, cultures perennes importantes. Transitoire entre *Ti* et *Tm*. Décrite pour l'Inde du nord. En Europe, seulement en Macédoine.

Tm. Petite agriculture mixte

Apports de main d'oeuvre et des animaux de trait élevés, apports de capital bas, productivité de la terre moyenne, celle du travail basse, semi-vivrière ou semi-commerciale. Equilibre entre production végétale et animale.

Tmh. Agriculture très petite et très intensive, semi-irriguée, productivité de la terre basse ou moyenne, celle du travail très basse, commercialisation très basse. Transitoire entre *Ti* et *Tm*, proche de **E**. Décrite pour les montagnes de l'Asie de Sud-Ouest – identifiée aussi en Macédoine.

Tme. Agriculture très petite, intensité mediocre, productivité basse et commercialisation très basse. Transitoire entre *Em* et *Tm*. Yougoslavie (Macédoine, Kosovo, Bosnie, Montenegro).

Tmb. Agriculture d'intensité mediocre et de productivité moyenne et commercialisation basse. Transitoire entre *Em* et *Tm*. Pologne du nord-est.

Tmm. Agriculture d'intensité et de productivité moyenne, semi-commerciale. Yugoslavie centrale. Pologne centrale.

Tmo. Agriculture très petite, intensité et productivité moyennes et de basse commercialisation. Caractéristique pour les paysans-ouvriers. Pologne centrale et du Sud, Yougoslavie.

Tmy. Agriculture très petite, intensive, avec une productivité moyenne et une commercialisation basse, prépondérance de la production végétale, Yougoslavie du sud.

Tmc. Agriculture intensive, avec productivité moyenne, semi-commerciale, prépondérance de la production végétale, cultures fruitières importantes. Dispersée en Europe du sud.

Tmg. Agriculture très petite, d'une intensité moyenne, productivité basse, commercialisation élevée, prépondérance de la production végétale, cultures perennes importantes. L'Europe du Sud (Grèce méridionale, Montenegro adriatique, Calabre, Espagne de sud-ouest, Portugal du Sud et de nord-est).

Tmf. Agriculture très petite, avec intensité élevée, productivité moyenne, semi--commerciale, prépondérance des cultures perennes. Italie du sud (Pouilles, Calabre du sud, Sicile méridionale).

Tmk. Agriculture très petite, intensive, avec productivité élevée de la terre, celle du travail basse, commercialisation basse, prépondérance de la production animale. Surtout dans les montagnes: polonaises, roumaines, yougoslaves et de l'Espagne de nord-ouest.

M. Agriculture de marché

Relations étroites avec le marché. Les exploitations de ce type achètent pratiquement tous les moyens de production et vendent au marché non seulement la plus grande partie de la production, mais toutes les activités des exploitations de ce type fluctuent avec les fluctuations de l'offre et de la demande, les changements de prix etc., limitées seulement en partie (subsides, tarifs etc.) par la politique gouvernementale de certains pays ou des organisations internationales (p. ex. Marché Commun). Dans cette situation la grandeur des exploitations n'influence pas tellement les autres traits d'agriculture.

L'agriculture de marché est la plus différenciée parmi tous les autres types de 1-er ordre de l'Europe. On y a distingué: les 5 types de 2-ème ordre et les 24 de 3-ème ordre suivants.

Ms. Agriculture spécialisée dans la culture des plantes perennes industrielles

Les apports de main d'oeuvre moyens, ceux de capital bas ou moyens, la productivité moyenne ou élevée, la commercialisation élevée, la spécialisation élevée dans les diverses cultures industrielles. Ce type caractéristique surtout pour les pays tropicaux a été identifié en Europe dans un seul type de 3-ème ordre.

Mso. Petite agriculture, avec des apports de main d'oeuvre bas, ceux de capital moyens ou élevées, une productivité moyenne, une commercialisation très élevée et une spécialisation élevée surtout dans la production des olives. Ce type a été décrit pour l'Europe de sud-ouest (surtout dans la province espagnole de Jaen).

Mi. Horticulture intensive

Petite agriculture avec les apports de main d'oeuvre et ceux de capital élevés ou très élevés, très productive et très commerciale, hautement spécialisée dans la production végétale.

Min. Agriculture très petite avec des apports de main d'oeuvre et ceux des animaux de trait élevés, des apports de capital très élevés, partiellement irriguée avec une productivité de la terre très élevée et celle de travail moyenne, commercialisation très élevée, spécialisation moyenne dans les différentes cultures fruitières combinées avec un peu d'élevage. Transitoire entre les types **T** et **M**, ce type a été distingué en Italie, surtout aux alentours de Naples mais aussi dans la plaine de Catane.

Mif. Agriculture spécialisée dans les cultures fruitières. Transitoire entre les types *Mi* et *Ms*; Italie (surtout Sicile), France méditerranéenne et Espagne (plaine de Valence).

Miv. Agriculture spécialisée dans les cultures maraîchères. Dispersée dans la plupart de l'Europe; ne domine pas dans les unités de recherche à cause de leur grandeur et pour cette raison, n'est pas marqué sur la carte.

Mig. Agriculture spécialisée dans la culture industrialisée des légumes ou des fleurs (serres). Dispersée dans la plupart des pays d'Europe, pour la même raison que précèdemment n'est pas marquée sur la carte.

Mn. Petite agriculture mixte

C'est une agriculture à petite ou moyenne échelle, avec des apports de travail vif moyens, et ceux de capital élevés, productivité et commercialisation élevés, spécialisation moyenne — équilibre entre production végétale et animale.

Mmr. Agriculture à l'échelle moyenne avec des apports de main d'oeuvre bas et ceux de capital élevés, productivité et commercialisation moyennes, spécialisation moyenne, prépondérance de la production végétale. La plus répandue en France centrale entre les Pyrenees, basse Loire, basse Seine et Marne et la Meuse; a été aussi identifiée en Italie du centre-ouest, en Sicile centrale et en Espagne (Aragon, Andalousie).

Mmc. Agriculture intensive et productive avec une production végétale prépondérante, cultures perennes importantes. Italie centrale et méridionale, certains endroits d'Espagne, Portugal et Autriche de l'est (Burgenland).

Mmf. Agriculture très petite avec intensité et productivité moyenne et prépondérance de production végétale, fruits importants. Transitoire entre *Mm* et *Mi* (surtout *Mif*), ce type est répandu en Europe du sud, surtout en Italie centrale et méridionale, en Corse, en France méditerranéenne, en Espagne méditerranéenne, au Portugal et en Grèce.

Mmv. Agriculture avec des apports de main d'oeuvre bas, ceux de capital très élevés, très productive, très commerciale, peu spécialisée avec une prépondérance de la production végétale. Ce type a été identifié en Lombardie et aux Pays Bas.

Mmz. Agriculture d'intensité mediocre et de productivité et de commercialisation moyennes, spécialisation basse, une proportion des herbages permanents élevée. Transitoire entre **T** et **M** ce type est le plus répandu en Grèce, surtout du nord, dans les Appenins, les Alpes italiennes et françaises, en Sardaigne et en Corse ainsi qu'en Espagne du nord.

Mmp. Agriculture très petite et très intensive avec des apports de main d'oeuvre élevés et ceux de capital élevés ou très élevés, utilisation de sol et élevage très intensifs, productivité de la terre élevée et celle du travail basse, commercialisation moyenne, spécialisation basse, production fruitière très importante. Transitoire entre **T** et **M.** Côtes atlantiques du Portugal du nord.

Mmt. Agriculture avec des apports de main d'oeuvre moyens, ceux de capital élevés, productivité élevée, commercialisation moyenne, spécialisation très basse, production fruitière importante. Italie du nord (entre la Plaine de Lombardie et le Latium), identifié également en France (Gironde), en Espagne méditerranéenne (Catalogne) et dans le Portugal du centre-ouest.

Mmm. Agriculture avec des apports de main d'oeuvre moyens, ceux de capital très élevés, élevage intensif, productivité et commercialisation élevées, spécialisation basse. En Europe: République Fédérale d'Allemagne et les territoires voisins de l'Autriche, de la Suisse, de la France, de la Belgique et des Pays Bas, aussi en Angleterre du sud-est, au Danemark, dans le sud des pays scandinaves, en Italie du nord et du nord-est, en Espagne du sud-est (Catalogne).

Mmh. Agriculture très petite avec des apports de main d'oeuvre élevés et ceux de capital élevés ou très élevés, utilisation intensive de sol, élevage intensif, productivité de la terre très élevée, celle du travail moyenne, spécialisation basse, proportion des herbages permanents élevée, prépondérance de la production animale. Transitoire entre **T** et **M.** En Espagne du nord.

Mmg. Agriculture avec des apports de main d'oeuvre bas (animaux de traits importants), ceux de capital bas ou moyens, productivité, commercialisation et spécialisation moyennes, prépondérance de la production animale. Transitoire entre **T** et **M.** Répandu dans les montagnes de l'Europe — Alpes, Pyrénées, Massif Central, Pays Scandinaves, Iles Britanniques, Irlande.

Mmw. Agriculture avec des apports de main d'oeuvre moyens, ceux de capital élevés, très haute intensité de l'élevage, productivité, commercialisation et spécialisation moyennes, proportion des herbages permanents élevée, prépondérance de la production animale.

Mma. Agriculture à l'échelle moyenne avec des apports de main d'oeuvre bas, ceux de capital élevés ou très élevés, productivité, commercialisation et spécialisation élevées, production animale prépondérante. Angleterre, Irlande, Pays Bas de l'est, Nord de la République Fédérale d'Allemagne, Normandie, Bretagne, Suisse, Autriche.

Mmi. Agriculture avec des apports de main d'oeuvre moyens et ceux de capital très élevés, très haute intensité de l'élevage, productivité et commercialisation très élevés, spécialisation moyenne, production animale prépondérante. Lombardie, Pays Bas, Flandre belge et française, Allemagne du nord-ouest, Danemark, Jersey.

Ml. Grande agriculture intensive

Apports de main d'oeuvre bas, ceux de capital (moyens de production) élevés ou très élevés, productivité de la terre et celle du travail très élevée, commercialisation très élevée, spécialisation élevée. Plus caractéristique pour l'Amérique du Nord, ce type est représenté en Europe par les 2 types de 2-ème ordre suivants.

Mlm. Agriculture mixte

Angleterre de sud-est, France de nord-est, Pays Bas.

Mlc. Agriculture spécialisée dans la production végétale. France — Bassin Parisien et quelques départements avoisinants, la Suède du sud-est.

Me. Grande agriculture extensive

Apports de main d'oeuvre très bas, mécanisation très élevée, emploi des engrais chimiques bas, intensité de l'utilisation du sol moyenne, productivité de la terre très basse ou basse, celle du travail très élevée, commercialisation et spécialisation très élevées. Plus caractéristique pour l'Amérique du nord ou l'Australie, ce type est représenté en Europe par 3 types de 3-ème ordre:

Mel. Agriculture avec des apports de main d'oeuvre très bas, ceux de capital moyens ou élevés, intensité de l'utilisation du sol mediocre (jachères), productivité de la terre basse, celle du travail élevée, commercialisation très élevée, spécialisation basse, prépondérance de la production végétale. Transitoire entre **L** et **M** — ce type est caractéristique pour les vastes territoires de l'Espagne centrale et les parties avoisinantes du Portugal.

Menı. Agriculture combinant la production végétale (surtout les céréales) et animale. Peu répandue en Europe.

Meb. Agriculture avec des apports de main d'oeuvre très bas, ceux de capital moyens ou élevés, intensité de l'élevage basse, production de la terre basse ou moyenne, celle du capital très élevée, commercialisation et spécialisation élevées, production animale dominante. Transitoire entre *Mn* et *Me*; répandu en Grande Bretagne, surtout en Ecosse, en Angleterre du nord-est, au Pays de Galles.

Mea. En vérité la combinaison de deux types différents: l'un représentant une production végétale très intensive, industrialisée (serres), l'autre — l'élevage très extensif sur les pâturages permanents. A vrai dire le premier pourrait être classifié comme *Mig*, le deuxième comme *Arr*. Faute de données on ne pouvait les séparer. Islande.

S. Agriculture socialisée

Ce type de 1-er ordre se distingue des autres types non seulement par ses traits sociaux (exploitations collectives ou d'état), mais aussi par l'échelle d'opération (très grandes exploitations), les apports de main d'oeuvre plus élevés et en conséquence une productivité du travail plus basse que dans les exploitations de même grandeur de l'Agriculture de Marché et finalement par une orientation limitée vers le marché. C'est une agriculture commerciale dans ce sens que la plupart de la production agricole est livrée en dehors des exploitations, aux agences coopératives ou d'état et vendue à un prix fixe, établi par le gouvernement. Tous les moyens de production sont aussi achetés à prix fixe auprès des agences d'état. Ce système appelé parfois — redistributif, ainsi que la planification centrale influence l'intensité et l'orientation productive de l'agriculture en question.

Au sein de ce type on a distingué en Europe 6 types de 2-ème et 20 types de 3-ème ordre.

Se. Agriculture initiale

C'est une agriculture à moyenne ou grande échelle, avec des apports de main d'oeuvre moyens (animaux de trait importants), ceux de moyens de production bas ou moyens, intensité d'utilisation du sol — mediocre, productivité basse, commercialisation moyenne, spécialisation très basse. Stage préliminaire de l'Agriculture Socialisée, ce type est représenté en Europe par 3 types de 3-ème ordre.

Sec. Agriculture d'intensité basse ou moyenne, productivité basse, commercialisation élevée, spécialisation basse, domination de la production végétale. Rare en Europe, identifié seulement en Roumanie.

Sep. Agriculture avec des apports de main d'oeuvre bas, haute mécanisation, emploi d'engrais chimiques bas, productivité basse ou moyenne, commercialisation élevée, spécialisation basse, prépondérance de la production végétale. Portugal du Sud.

Sem. Agriculture avec des apports de main d'oeuvre et des moyens techniques de production moyens. Productivité et commercialisation moyennes, spécialisation très basse. orientation mixte. Transitoire entre *Se* et *Sm* – identifié seulement en Roumanie.

Sm. Agriculture mixte

C'est une agriculture à très grande échelle avec des apports de main d'oeuvre bas, ceux des moyens de production moyens ou élevés, production moyenne, commercialisation élevée. spécialisation basse, orientation mixte. Ce type est représenté en Europe par 9 types de 3-ème ordre.

Smw. Agriculture avec des apports de main d'oeuvre bas, mécanisation élevée, emploi d'engrais chimiques bas, productivité basse, commercialisation élevée, spécialisation basse. Le centre-nord de l'URSS, de la Bielorussie à l'ouest jusqu'à l'Oural à l'est, avec le centre le long de Volga supérieure et de ses affluents.

Smm. Agriculture avec des apports de main d'oeuvre bas, ceux des moyens de production élevés, productivité moyenne, commercialisation élevée, spécialisation basse. Répandu en URSS du centre-ouest et dans tous les autres pays socialistes d'Europe.

Smy. Agriculture avec des apports de main d'oeuvre bas. ceux des moyens de production élevés ou très élevés, productivité de la terre très basse, celle de la terre cultivée moyenne, productivité de travail basse, commercialisation élevée, spécialisation moyenne, prépondérance de la production végétale, proportion des herbages permanents élevée. Les montagnes de Yougoslavie.

Smg. Agriculture avec des apports de main d'oeuvre très bas, ceux des moyens de production élevés ou très éleves, productivité de la terre très basse, celle de terre cultivée élevée, productivité du travail moyenne, commercialisation élevée, spécialisation basse, proportion des herbages permanents très élevée. Les montagnes de Yougoslavie.

Ce dernier type présente une combination yougoslave, qui résulte de la nationalisation d'anciens pâturages communaux de montagnes, utilisés seulement en partie par les exploitations socialisées et loués le plus souvent à des agriculteurs privés. Sans ces pâturages les exploitations de ce type ne différeraient pas beaucoup des autres types de l'agriculture socialisée.

Smc. Agriculture avec des apports de main d'oeuvre et des moyens de production moyens, productivité moyenne, commercialisation élevée, prépondérance de la production végétale, cultures fruitières importantes. Roumanie, Bulgarie, plus rare en URSS du Sud.

Smu. Agriculture avec des apports de main d'oeuvre moyens, ceux des moyens de production élevés, productivité de la terre moyenne, celle du travail élevée, commercialisation très élevée, spécialisation élevée, prépondérance de la production végétale, cultures industrialles importantes. Les sols riches du sud de la partie européenne de l'URSS, surtout l'Ukraine.

Smi. Agriculture irriguée avec des apports de main d'oeuvre bas, ceux des moyens de production élevés ou très élevés, productivité de la terre élevée, celle du travail très élevée, commercialisation très élevée, spécialisation moyenne, prépondérance de la production végétale. Cultures industrielles importantes. Dispersée le long de rivières du sud de l'URSS. Pour les raisons présentées ci-dessus (p. 196) n'a pas été marquée sur la carte.

Sma. Agriculture avec des apports bas de main d'oeuvre, animaux de trait importants, mécanisation très élevée, emploi des engrais chimiques moyen, productivité de la terre et du travail basse, commercialisation et spécialisation élevées, production animale dominante. Ce type couvre de vastes territoirs de la Russie du Nord.

Smd. Agriculture avec des apports de main d'oeuvre moyens, ceux des moyens de production très élevés, productivité et commercialisation élevées, spécialisation moyenne, prépondérance de la production animale. Ce type domine dans la République Democratique Allemande. Il est aussi répandu et Tchécoslovaquie, en Hongrie et en Pologne de l'ouest et du nord.

Sg. Agriculture combinant la culture très intensive avec l'élevage très extensif

Apports de main d'oeuvre, ceux des animaux de trait et des moyens techniques de production élevés, productivité de la terre basse, de la terre cultivée moyenne et celle du travail très basse, commercialisation élevée, spécialisation moyenne, orientation mixte, proportion des cultures industrielles considérable.

Sgt. Ce type représente la combinaison d'une utilisation intensive du sol des vallées, surtout pour la culture du tabac, avec une utilisation très extensive de vastes surfaces de pâturages montagnards par l'élevage, surtout des moutons. Décrit pour la Bulgarie du sud (Gałczyńska 1984), ce type a été trouvé plus tard aussi en Albanie.

Sh. Agriculture spécialisée dans la production horticole

C'est une agriculture avec des apports de main d'oeuvre élevés, ceux de moyens de production très élevés, productivité de la terre élevée, celle du travail moyenne ou élevée, commercialisation très élevée et spécialisation élevée, surtout dans la production de légumes ou de fruits. 3 types de 3-ème ordre y ont été distingués.

Shy. Agriculture avec des apports de main d'oeuvre moyens, ceux de moyens de production – élevés, souvent irriguée, productivité moyenne, commercialisation très élevée, spécialisation élevée, surtout dans la production fruitière. Yougoslavie.

Shv. Agriculture avec des apports de main d'oeuvre élevés, ceux des moyens de production élevés ou très élevés, productivité de la terre élevée, celle du travail – moyenne, commercialisation et spécialisation très élevées dans les cultures maraîchères. Dispersée dans les pays socialistes: n'est pas marquée sur la carte pour les raisons présentées ci dessus (p. 196).

Shh. Agriculture industrialisée spécialisée dans la culture des légumes ou des fleurs (serres). Dispersée dans les pays socialistes, n'est pas marquée sur la carte pour la même raison.

Ss. Agriculture spécialisée dans les cultures perennes

C'est une agriculture avec des apports de main d'oeuvre bas, ceux des moyens techniques de production moyens, une productivité de la terre moyenne, celle du travail élevée, commercialisation et spécialisation très élevées. 2 types de 3-ème ordre ont été identifiés en Europe.

Ssf. Agriculture spécialisée dans les cultures perennes fruitières. Apports de main d'oeuvre et ceux des moyens techniques de production moyens, productivité de la terre moyenne, celle de travail élevée. Commercialisation et spécialisation dans la production fruitière très élevées. Transitoire entre *Sh* et *Ss*, dispersé dans tous les pays socialistes, et donc, pour les raisons présentées ci-dessus ne pouvait être marqué sur la carte, sauf pour les républiques transcaucasiennes de l'URSS, surtout la Georgie.

Ssc. Agriculture spécialisée dans la culture des plantes perennes industrielles. C'est une agriculture irriguée avec des apports de main d'oeuvre bas, ceux des moyens de production élevés ou très élevées, productivité moyenne, commercialisation et spécialisation (en coton) très élevées. Décrite pour l'Asie centrale Soviétique, identifiée aussi dans les républiques transcaucasiennes surtout en Azerbaïdjan.

Sc. Agriculture extensive spécialisée dans la production de céréales

Des apports de main d'oeuvre très bas, mécanisation élevée, emploi d'engrais chimiques bas, intensité de l'utilisation du sol mediocre (jachères), productivité de la terre très basse ou basse, celle du travail – moyenne ou élevée, commercialisation et spécialisation très élevées. Les deux types suivants de 3-ème ordre ont été identifiés aux marges sud-est de l'Europe.

Scm. Agriculture avec des apports de main d'oeuvre très bas, mécanisation élevée, emploi d'engrais chimiques très bas, productivité de la terre très basse, celle de la terre cultivée et du travail – moyennes, commercialisation élevée, spécialisation moyenne, combinaison de la culture de céréales sur les terres arables et de pâturage d'animaux sur des herbages permanents. Transitoire entre *Sm* et *Sc* – identifiée sur les vastes territoires semiarides au sud de l'Oural.

Scc. Agriculture avec des apports de main d'oeuvre très bas, mécanisation élevée, emploi d'engrais chimiques bas, productivité de la terre basse et celle du travail moyenne, commercialisation et spécialisation dans la production de céréales (surtout blé) très élevées. Territoires semi-arides entre l'Oural et la Mer Caspienne.

A. Elevage à grande échelle commerciale hautement spécialisé

Type d'agriculture dans lequel la combinaison d'une spécialisation très élevée dans l'élevage à grande échelle avec des traits opérationnels tout particuliers prédomine sur les autres traits d'agriculture.

Ce type est subdivisé en 2 types de 2-ème ordre, différents surtout par leur intensité.

Ar. Pâturage extensif

C'est une agriculture à très grande échelle, la productivité de la terre est très basse, celle du travail moyenne. Les deux types de 3-ème ordre suivants ont été distingues qui différent surtout par leurs traits sociaux.

Arr. Pâturage extensif de marché. Agriculture à grande échelle avec une productivité de la terre très basse, celle du travail basse. Ce type caractéristique pour l'Amérique du Nord ou l'Australie est très rare en Europe. Cependant l'élevage des rennes dans le nord des pays scandinaves (surtout en Finlande et Norvège) pourrait probablement y être classifié. Un manque de données suffisantes pour établir les codes ne permet pas de savoir à quel degré l'élevage des rennes différe de Arr classique.

Aro. Pâturage extensif socialisé — à très grande échelle, productivité de la terre très basse, celle du travail élevée. Ce type caractéristique pour l'Asie centrale soviétique a été identifié aussi en Europe le long de côtes ouest et nord de la Mer Caspienne. L'élevage de rennes au nord de la Russie pourrait probablement être aussi classifié dans le même type.

Ad. L'élevage industrialisé

C'est une agriculture très intensive, très productive et très commerciale, spécialisée dans l'élevage industrialisé des animaux. Les deux types de 2-ème ordre se distinguent surtout par leur traits sociaux.

Add. L'élevage industrialisé de marché et

Ado. L'élevage industrialisé socialisé. Ces deux types dispersés presque partout en Europe ne pourraient être marqués sur la carte pour les raisons expliqués ci-dessus (p. 196).

En examinant plus attentivement la classification présentée on peut se demander pourquoi parmi les types énumérés ci-dessus, à l'exception des formes extrèmes groupées autour du type du 1-er rang **A,** on n'a pas distingué en Europe des types agricoles spécialisés dans l'élevage, alors qu'il serait facile de donner plusieurs exemples d'exploitations de l'Agriculture de Marché ou Socialisée qui se spécialisent dans l'élevage.

La première réponse à cette question (Kostrowicki 1984) était que, peut-être, la taille des unités d'études, dans lesquelles une combinaison de plusieurs types d'agriculture pourraient apparaître l'un à côté de l'autre, ne permettait pas de distinguer ces types spécialisés. Mais en résultat des études ultérieures sur ce sujet on a finalement trouvé et décrit deux types additionnels de 2-ème ordre spécialisés dans l'élevage: *Ma* pour l'Agriculture de Marché et *Sa* pour L'Agriculture Socialisée.

On pourrait regrouper autour de ces deux types un certain nombre de types de 3-ème ordre, déjà décrits auparavant, mais classés parmi certains types de 2-ème ordre (*Mm, Ml, Me, Sm*).

On pourrait noter aussi un autre manque dans la liste des traits agricoles: c'est l'absence d'une variable représentant l'orientation d'élevage, alors qu'il y a plusieurs variables qui représentent d'une manière ou d'une autre une orientation de culture (cultures pérennes, prés permanents, cultures alimentaires, cultures industrielles).

D'autre part le groupe des traits structuraux ne comptait que 6 variables, tandis que les autres groupes en avaient 7 chacun. Après plusieurs hésitations on a finalement décidé d'ajouter à ce groupe une 7-ème variable représentant l'orientation d'élevage.

Evidemment ce n'est pas facile d'exprimer ce trait par une seule variable. Après plusieurs essais on a décidé de l'exprimer comme une proportion entre le nombre des herbivores et celui des non-herbivores dans le nombre total des animaux en unités conventionnelles (UGB).

A l'échelle mondiale cette variable pourrait aider à mieux distinguer l'agriculture avec de longues jachères (fôret) de celle avec des jachères courtes (arbustes), l'agriculture traditionnelle intensive indienne de celle des Chinois etc. etc. En Europe elle pourrait aider de distinguer l'agriculture toute mixte dans laquelle l'élevage des porcins joue le rôle plus important de celle avec élevage prépondérant.

A partir des matériaux ramassés pour la Carte de Types Agricoles de l'Europe les chiffres représentant des classes mondiales de cette nouvelle variable ont été ajoutés aussi bien aux codes-modèles qu'aux codes des différentes unités d'étude.

Ainsi complété, aussi bien avec cette nouvelle variable qu'avec les codes pour les types spécialisés dans l'élevage, le matériel a été envoyé encore une fois à l'ordinateur. Les premiers résultats semblent montrer que ces modifications pourraient mieux caractériser l'agriculture européenne, en rapprochant la typologie de la réalité. Malheureusement comme la Carte était déjà sous presse, il était impossible d'y introduire tous ces changements.

3. EVOLUTION DE L'AGRICULTURE EUROPÉENNE

Quelle est donc l'évolution de l'agriculture européenne à la lumière de la typologie présentée ci-dessus et de la carte des types agricoles de l'Europe.

Naturellement on pourrait répondre à cette question de façon plus précise en comparant au moins deux cartes basées sur les typologies, séparées par des périodes de 10, 20 ou 30 ans.

Mais, bien que la carte elle-même soit statique et ne représente que l'état des choses pour la période entre les années 1975–1980, la classification dynamique de l'agriculture permet déjà de tirer certaines conclusions sur ce sujet. La carte montre par exemple la restriction de certains types les plus primaires (**E** et **L**) et la domination de types plus avancés comme **M** et **S.** Si on évoqueait la connaissance du développement de l'agriculture européenne et si on utilisait dans ce but les données déjà ramassées pour certains pays pour les périodes antérieures, on pourrait en tirer plus de conclusions.

Par exemple, l'Agriculture Traditionnelle Extensive, dite primaire (**E**), jusqu'à présent caractéristique pour plusieurs pays en voie de développement, assez répandue en Europe jusqu'au XIX^{e} siècle dans ses formes plus avancées (*Et*), survivait dans certaines régions jusqu'aux années 1950–1960; ainsi dans le nord-est de la Pologne (Biegajlo 1964a, b) où l'on pratiquait encore le système triennal avec jachères, ou en Macédoine (Biegajlo 1969; Tyszkiewicz 1969) où l'ancien système biennal méditerranéen était encore pratiqué. Avec le remembrement des terres très morcelées et le développement général de l'agriculture en 1965–1970 le type *Et* s'est transformé en type transitoire entre les types entre *Et* et *Tm* – *Tmb* ou *Tme* identifiés en 1965–1970 aussi bien en Pologne de nord-est qu'en Yougoslavie du sud.

Le type de 2-ème ordre l'Agriculture Traditionnelle Intensive (*Ti*), décrit pour des montagnes de l'Inde du nord, mais caractéristique aussi pour certaines régions du Proche et du Moyen-Orient, identifié en Macédoine en 2 types de 3-ème ordre *Tir* et *Tiu*, transitoires entre les types de 2-ème ordre *Ti* et *Tm*, pourrait être aussi traité comme un type de vestiges. D'autre part, le type plus avancé *Tmh* identifié aussi en Macédoine pourrait être traité également comme transitoire, mais entre *Ti* et *Tm*. Comme les travaux sur le terrain ont déjà confirmé, la Macédoine de 1960–1970 pourrait être traitée comme un véritable skansen des types anciens de l'agriculture européenne.

L'Agriculture Traditionnelle à grande échelle, dite latifundia constituait autrefois une forme dualiste, comme le système seigneurial en Europe caractérisé par des liens réciproques étroits entre les grandes propriétés foncières et les exploitations de leurs sujets, serfs ou métayers. Dans sa forme classique ce système est maintenant rare dans le monde, mais sous différentes formes transitoires il existe encore dans plusieurs pays en voie de développement, surtout en Amérique Latine. En Europe de l'Ouest, ce type a disparu plus ou moins tôt, du fait des réformes agraires ou de la transformation en Agriculture de Marché, surtout des sous-types *Ml* ou *Me*. En Europe de l'Est et du Sud cette agriculture a disparue plus tard, surtout du fait de réformes agraires ou de collectivisation. Dans les formes transitoires entre **L** et **M** ce type a survécu jusqu'à nos jours surtout dans la Péninsule Ibérique (type *Mel*).

A l'intérieur de la Petite Agriculture Traditionnelle, paysanne (**T**), la différenciation dépend aujourd'hui non seulement des conditions naturelles mais aussi du degré de développement agricole. On a mentionné déjà des types transitoires entre les types **E** et **T** (*Tmb*, *Tme*) ou entre *Ti* et *Tm* (*Tir*, *Tiu*, *Tmh*), ce dernier (*Tm*) dominant dans l'agriculture paysanne européenne. Avec le développement général de l'agriculture, il se transforme en type **M**, dont *Tmm* tout mixte, le plus commun en Pologne et en Yougoslavie – en *Mmm*.

Le type *Tmo* qui est un cas spécial représentant la petite agriculture de paysans-ouvriers qui, tirant leur revenus en dehors de l'agriculture, ne sont pas très interessés par la production commerciale est en plein essor surtout en Pologne, en éliminant du marché de plus en plus d'exploitations agricoles.

Les types d'agriculture traditionnelle mixte avec une prépondérance de la production végétale, comme *Tmc*, *Tmf* se transforment aussi en différents sous-types de *Mm*, le plus souvent aussi avec une prépondérance de la production végétale (*Mmc*, *Mmf*, etc.), et celui-ci à son tour en types plus spécialisés (*Min*, *Mif* etc.).

Le seul type européen d'agriculture traditionnelle mixte avec une prépondérance de la production animale (*Tmk*) caractéristique pour les montagnes européennes se transforme avec le développement général de l'agriculture en différentes formes d'agriculture de marché (**M**) qui se présente sous plusieurs types transitoires plus ou moins intensifs. Il y a une véritable chaîne de transformations de *Tmk* vers *Mmh* plus intensifs en l'Espagne du nord ou vers *Mmg* (moins intensif) qui, à son tour, avec le développement de l'agriculture, se transforme en plus intensif *Mmw* ou directement en *Mma* plus productif. Comme il était possible d'observer et de comparer ces transitions pour l'Autriche, la Belgique, la France, la Norvège, et la Finlande, pays pour lesquels on disposait de données antérieures, on peut constater que ces transformations ont été les plus rapides dans les pays scandinaves. En Norvège par exemple le type *Mmg*, dominant en 1960, fut presque entièrement remplacé par *Mmw* et *Mma* au cours des 10 années suivantes. En Autriche cette évolution était plus lente, surtout dans les terrains alpestres plus élevés.

Le cas spécial d'agriculture mixte avec une prépondérance de la production animale c'est *Mmi*, le type très intensif et très productif qui, à cause de certaines conditions naturelles et économiques, locales, s'est developpé en Lombardie du nord et aux Pays Bas.

L'agriculture de marché "toute mixte" apparait aussi sous quelques formes plus ou moins avancées et plus ou moins intensives. Le moins intensif, le moins developpé et le moins productif c'est le type *Mmz* repandu dans plusieurs pays de l'Europe méridionale (Grèce, Yougoslavie de l'Ouest, Italie, Sardaigne, Corse, Espagne du nord, Alpes italiennes et françaises), dans leurs parties les moins hospitalières. Beaucoup plus intensif et productif mais aussi assez traditionnel est le type *Mmp*, identifié surtout au Portugal et en Espagne du nord-ouest. Plus avancé est le type *Mmt* identifié d'abord en Toscane mais aussi dans les autres provinces de l'Italie du nord entre la plaine de Lombardie et le Latium, ainsi qu'en Espagne méditerranéenne, dans le centre-ouest du Portugal, en France (Gironde) ainsi que dans certaines zones suburbaines où les cultures fruitières jouent un rôle important (par ex. Vienne, Varsovie). Les deux derniers types caractérisées par l'importance de la production fruitière pourraient être considérés, comme transitoires vers le type de 2-ème ordre *Mi*. Au contraire le type *Mmm*, qui s'était développé à partir de l'Agriculture traditionnelle mixte (*Tmm*) dans les plaines de l'Europe centrale, de la Pologne de l'ouest à travers l'Allemagne, l'Alsace jusqu'en Bretagne, mais aussi en Yougoslavie du nord d'un côté et dans le sud des pays scandinaves, le Danemark et l'Angleterre de sud-est de l'autre, se transforme avec l'augmentation de grandeur des exploitations en *Mlm*, transitoire entre *Mm* et *Ml*, avec une intensification de l'agriculture en types *Mmi* ou *Mmv* ou avec une spécialisation en type *Mma*. Le cas de la Bretagne est particulièrement intéressant. En 1970 l'agriculture bretonne représentait le type *Mmm* sous une forme moins avancée avec des apports de main d'oeuvre considérables et ceux des animaux de trait encore importants etc. En dix ans elle s'est transformée en agriculture aussi bien ou plus intensive, plus productive et plus spécialisée, notamment celle des types *Mmi* et *Mma*.

Parmi les types d'agriculture mixte avec une prépondérance de la production végétale, caractéristiques surtout pour l'Europe méridionale, le type *Mmr* (le moins intensif et le moins productif) est caractéristique pour les collines de la France centrale et de sud-ouest, ainsi que pour certaines parties de l'Italie (du centre-ouest et en Sicile) et de l'Espagne (du nord-est et en Andalousie), ou les cultures perennes ne jouent pas un rôle important.

Le type *Mmc* est plus intensif et plus productif ainsi que plus méridional. Il est le plus proche du type traditionnel *Tmc* mais comme ce dernier il disparaisse. Ce type a été encore identifié dans certains endroits de l'Italie centrale et méridionale ainsi que de l'Espagne, du Portugal et de l'Autriche de l'est (Burgenland).

Le type *Mmf*, une agriculture mixte dans laquelle les cultures fruitières jouent un rôle important, est le type transitoire vers le type de 2-ème ordre *Mi* et surtout *Mif*. Le type *Mmv* beaucoup plus productif, dans lequel les cultures perennes fruitières ou autres ne jouent pas de rôle important se transforme aussi vers le type *Mi*, mais surtout vers *Miv* (spécialisé dans les cultures maraîchères).

Au sein du type *Mi* de 2-ème ordre représentant l'agriculture spécialisée dans la production végétale, on peut différencier d'abord le type *Min* — très intensif et productif, mais transitoire entre l'agriculture traditionnelle (T) et celle de marché (M) qui s'est développé probablement à partir de la petite agriculture traditionnelle très intensive orientée vers la production végétale, surtout fruitière; on n'a pas trouvé d'exemple en 1965–1970 dans une seule unité d'études mais il fut identifié pendant les travaux sur le terrain il y a 20 ans, sur la côte adriatique du Montenegro.

Le type *Min* a été distingué seulement en Italie, aux alentours de Naples et dans la plaine de Catane. D'autre part, le type *Mif* plus avancé qui occupe actuellement des territoires considérables le long de côte méditerranéenne en Italie, en France ou en Espagne subit une expansion considérable. Ce type qui en 1970 dominait en France seulement dans l'Hérault, le Var, le Vaucluse et co-dominait dans les Bouches-du-Rhône, dominait aussi en 1979 dans les départements du Gard et des Pyrénées Orientales et co-dominait dans l'Aude.

Quoique deux autres types d'agriculture spécialisée *Miv* (maraîchage) et *Mig* (cultures industrialisées sous serres) — aient aussi subi une expansion considérabe, cela n'est pas visible sur la carte à cause de leur dispersion et de la grandeur des unités de recherches.

Les deux types de 2-ème ordre suivants représentant la grande agriculture de marché intensive (*Ml*) ou extensive (*Me*), en dehors de l'Amérique du nord ou de l'Australie, se développaient en Europe du fait de l'évolution des grandes propriétés foncières (latifundia) ou de la concentration des terres et en résultat de la transformation de la petite agriculture en agriculture à échelle moyenne ou grande. Ce processus est en train de se développer dans les pays de l'Europe de l'Ouest depuis la II-ème Guerre Mondiale à l'exception de la Grande Bretagne où il est plus ancien. Au contraire la transformation des anciennes latifundia (**L**) en grande agriculture de marché (*Ml* ou *Me*) est plus récente et, dans certains pays (Espagne, Portugal), encore en cours.

L'Agriculture Socialisée, on le sait bien, s'est formée à la suite de la nationalisation des grandes propriétés foncières ou de la collectivisation de l'agriculture villageoise de types différents, cela a eu lieu en URSS entre les deux guerres et après la deuxième guerre dans les autres pays socialistes. Mais sous différentes formes transitoires ce type se développait aussi dans certains pays en voie de développement comme les ejidos collectivos au Mexique, l'agriculture autogérée en Algérie etc., ou même en Israel avec les kibboutz ou moshav. En Europe aussi l'agriculture collective établie spontanément en Portugal du sud à la suite de la révolution "de oeillets" pourrait être classifiée comme une agriculture de type **S**, à son stade initial.

Ce dernier type (*Se*) représente un stade de l'Agriculture Socialisée juste après la nationalisation ou collectivisation. Le grandeur des exploitations varie selon la grandeur des terroirs des villages collectivisés ou celle des propriétés foncières nationalisées. Ce type dominait en URSS entre les deux guerres et dans la plupart des autres pays socialistes de l'Europe après les réformes du même type des années cinquante.

Le développement de l'Agriculture Socialisée des années 60 et 70 a éliminé ce type initial d'agriculture presque entièrement; celui-ci a été remplacé surtout par l'Agriculture Socialisée mixte (*Sm*) ou des types plus spécialisés (*Sh*, *Ss*). Le premier se partage en plusieurs types différents par leur intensité, leur productivité et leur orientation productive qui signifient parfois aussi leur degré de développement: les types extensifs (*Sma*, *Smw*) caractéristiques pour la plupart de la zone non-tchernozème de la Russie, ont été remplacés par les types plus avancés *Smc* et *Smm* (plus intensifs et plus productifs) parmi lesquels le premier évolue vers le type *Smu*, le plus caractéristique pour l'Ukraine et les autres régions du sud tchernozème de l'URSS ou ailleurs. Cette évolution pourrait être aussi observée en Roumanie et Bulgarie. Le deuxième (*Smm*) évolue vers *Smd* qui domine actuellement dans la République Démocratique Allemande et se développe aussi en Tchécoslovaquie, en Hongrie et en Pologne de l'ouest et du nord.

En ce qui concerne le type de 1-er ordre **A**, le type *Ad* c'est-à-dire l'Élevage Industrialisé, s'est developpé durant les dernières décennies presque partout en Europe. Cependant, pour les raisons mentionnés ci-dessus, ce développement ne pourrait être présenté à macro-échelle de la carte des types agricoles de l'Europe.

Des observations sur l'évolution de l'agriculture européenne dans le passé pourraient mener au problème du développement futur de celle agriculture. Les études et les cartes typologiques pourraient aider à trouver la réponse à cette question à condition qu'on les refasse de temps en temps et des conclusions pourraient être tirées en ce qui concerne les tendances, les directions et le rapidité de cette évolution (Kostrowicki 1974a, 1976; Stola 1983).

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AGRICULTURAL TYPOLOGY OF THE ALPINE AREAS: AUSTRIA AND SWITZERLAND

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A series of studies on the spatial organization of agriculture both in Poland as well as in some other European countries or regions, has already been prepared within a wide programme of research on the agricultural types of Europe, undertaken by the Department of Geography of Agriculture and Rural Areas in the Institute of Geography and Spatial Organization of the Polish Academy of Sciences (Kostrowicki and a team) and carried out in accordance with the already established principles, criteria and methods (Kostrowicki 1974, 1976, 1980, 1981, 1982, 1984). The described study of Austria and Switzerland concerned with the agricultural typology of the Alpine areas is another work in this series.

The typology of agriculture, in its spatial or dynamic approach is based upon the assumption that "every agriculture as a whole is not a simple sum of activities or elements of which this notion consists, but a set of attributes interrelated one with another and with external natural and other conditions as well, in which a change of one component brings about a change in the remaining ones. The thus-understood agriculture may be recognized as a system complying with the system approach or the system theory (Kostrowicki 1976). An agricultural type (a systematic or taxonomic notion), characterizing a specific combination of social, operational, production and structural attributes of agriculture is expressed by 27 variables, transformed into codes for the sake of normalization (Kostrowicki 1982), the agricultural types are identified by means of the deviation method.

The typological study of Switzerland is carried out per cantons and of Austria per agricultural-natural production areas.

A comparison of the codes of the typological variables of agriculture, expressed separately for every basic unit, of study with models of agricultural types in Europe, reveals similarities with the following models of the 3rd order (Kostrowicki 1982):

Mmz – 1151122 – 2243342 – 2333322 – 141232 representing small-scale, medium intensive, medium-productive, semi-commercial, mixed agriculture.

Mmt – 1251122 – 3153243 – 4443341 – 313231 representing small-scale, medium intensive, productive, commercial, mixed agriculture considerable proportion of perennial crops.

Mmm – 1151222 – 3255144 – 4444442 – 122331 representing small-scale, highly capital intensive, productive, commercial, mixed agriculture.

Mmg – 1151232 – 2223143 – 3433333 – 131351 representing medium-scale, low intensive, medium productive, semi-commercial, mixed agriculture with livestock breeding prevalent.

Mmw – 1151122 – 3155145 – 3343333 – 151251 representing small-scale, highly capital intensive, medium productive semi-commercial, mixed agriculture with livestock breeding.

Mma – 1151233 – 2154144 – 4544444 – 141451 representing medium-scale, capital intensive, productive, commercial, mixed agriculture with livestock breeding highly dominant.

Mmb – 1151143 – 1143142 – 2355424 – 141451 representing large-scale, low labour intensive, capital intensive, medium productive, commercial, mixed agriculture with livestock breeding highly dominant.

The degree of similarity between agricultures in the separate basic units and seperate models of agriculture in Europe of the 3rd order varies largely. On vast areas a similarity with the model type (Mmg or Mma), is striking. However, in many cases mixed combinations occurring there resemble two or even more models. This seems to be quite a natural phenomenon, in agreement with the typological principles. This stage may be a process in time when farms of a given area are still in the period of transition from one type to another and as a result combine the attributes of two or more types, which constitute links in the given evolutionary course, e.g. Mmg-Mma. Or, they may be affected by transition in space, i.e. in the investigated unit there are two or more types which do not represent such an evolutionary course, e.g. Mmm-Mmw-Mma, or Mmm-Mma and Mmr-Mmc-Mmm-Mmt, and reflect an internal differentiation of the investigated unit.

In the Alpine areas of Austria and Switzerland the following 6 groups and 12 combinations of types have been differentiated, in 1975 (Fig. 1 and 2), namely:

I. Mmg – prevalence or domination of Type Mmg with a secondary role of other types

1) Mmg_4, 2) Mmz_1-Mmg_2-Mmw_1.

II. Mmg-Mmw – balance of Types Mmg and Mmw

3) Mmg_2-Mmw_2.

III. Mmw – prevalence or dominance of Type Mmw with a secondary role of other types.

4) Mmz_1-Mmg_1-Mmw_2, 5) Mmg_1-Mmw_2-Mmb_1, 6) Mmw_3-Mma_1.

IV. Mmm-Mmg-Mmw-Mma – balance of Types Mmm, Mmg, Mmw and Mma

7) Mmm_1-Mmg_1-Mmw_1-Mma_1, 8) Mmw_1-Mmg_1-Mmt_1-Mmm_1.

V. Mmw-Mma – balance of Types Mmw and Mma

9) Mmw_2-Mma_2.

VI. Mma – dominance or prevalence of Type Mma with a secondary role of other types

10) Mmm_1-Mmw_1-Mma_1, 11) Mmw_1-Mma_3, 12) Mma_4.

A large part of the identified combinations of agricultural types should be recognized as the types representing agriculture in the mountain areas (High Alps, foothills, Jura) and another part which represents agriculture in the units where conditions of the environment are varied, e.g. mountains and uplands, foothills and lowlands, e.g. Mmm_2-Mma_2, Mmm_2-Mmw_2 etc. A whole series of agricultural types and their combinations have been identified in Austria and Switzerland (though not described here), which occur in the areas situated at a lower level and which surround the highlands. e.g. Mmr_4 (Geneva), Mmr_1-Mmc_1-Mmm_2 (Lower Austria H), Mmz_2-Mmw_1-Mma_1 (Basle), Mmm_3-Mma_1 (Upper Austria F), Mmm_4 (Basle-city, Schaffhausen, Lower Austria D, Styria G), Mmm_2-Mmw_2 (Burgenland C), Mmm_2-Mma_2 (Aargau, Zurich), Tmf_1-Mmc_1-Mmt_2 (Vienna), Mmc_1-Mmm_1-Mmt_2 (Burgenland H).

The spatially differentiated agriculture in the highlands of Austria and Switzerland is highly correlated with the natural (relief, climate, soils) and non-natural (farming traditions, market connections, etc.) conditions; it is also a result of differences in the attributes representing agriculture itself. Spatial differences (Eastern Alps – Western Alps, High Alps-Alpine foothills, etc.) also exist in the types representing agriculture of the highlands: these differences are connected with diverse methods of farming, inputs on agriculture, as well as production effects, even if livestock breeding dominates on the whole territory. Types Mmg_4, Mmg_2-Mmw_2, Mmw_3-Mma_1, Mmw_2-Mma_2, Mmm_1-Mmw_1-Mma_2, Mmw_1-Mma_3 and Mma_4 dominate, the remaining are quite sporadic.

The spatial differentiation of the identified combinations (Fig. 1 and 2) is as follows:

Mmg_4 – occurs in Austria – the Eastern Alps – the highlands, Salzburg A and Styria A production areas as the combination e.g.

Salzburg A – 1151232 – 2253143 – 3433323 – 151351. High mountains dominate there and therefore livestock breeding, associated with summer grazing on the Alpine meadows, is the main orientation, though this form of pasturing has been facing a regress for many years and many meadows have been left unused (Zwittkovits 1974). Commercial, mixed agriculture with livestock breeding prevalent (mainly cattle), corresponding to Type Mmw or Mma, prevails in the intermontane basins and valleys. However, in general, agriculture similar to Type Mmg dominates on the scale of the whole area and its characteristics – e.g. on the area of Salzburg A – are as follows: out of the total area of 501 135 ha agricultural land accounts for 48.2%, forests for 32.0% and unproductive land (mainly high mountains) for 19.8%. Permanent grass dominates (97.9%) consisting mainly of Alpine meadows; the proportion of arable land is 2.1% only. The land-use orientation is: highly pastures, and the crop orientation fodders with a secondary role played by cereals. Large farms prevail there and the average size of the farms is 36.1 ha of agricultural land and solely 1.98 ha of arable land. Irrespective of a low density of livestock 36.2 big animal units per 100 ha of agricultural land and as many as 145.2 large animal units (LAU) per 100 ha of cultivated land, the livestock breeding orientation can be identified as: highly cattle, mixed beef-dairy, with a dominance of the Pinzgauer breed.

Effects of agricultural production are: low land productivity (16.0 conventional units – CU) but high productivity of cultivated land (74.8 CU), medium productivity of labour (204.2 CU) and low commercial per ha of agricultural land (7.9 CU). The orientations of agricultural products for the discussed area are: grass production – livestock, milk with a secondary role of beef and fodders, and commercial production – highly livestock, milk with a secondary role of beef. In sum, this area is dominated by medium-scale, semi-commercial, mixed agriculture with livestock breeding prevalent, i.e. an agriculture which is typical of highlands.

Mmg_2-Mmw_2 – occurs in many units in Austria – mountainous areas – Vorarlberg A, Tyrol A and the Alpine foothills, Lower Austria B, Upper Austria B and Styria B, and in Switzerland – the cantons of Valais and Ticino, representing combinations of two agricultural types: medium-scale, semi-commercial, mixed agriculture with livestock breeding prevalent (Mmg), and small-scale, commercial mixed agriculture with livestock breeding prevalent (Mmw). Certain differences in the size of the farms, inputs to agriculture and production effects obtained arise between individual units in Austria as well as in Switzerland;

Upper Austria B	– 1151222 – 3153144 – 4433333 – 151341,
Tyrol A	– 1151132 – 2253143 – 3443323 – 151351,
Valais	– 1151122 – 2344142 – 3533333 – 151231.

These are predominantly highlands where livestock breeding dominates and cattle grazing on the Alpine meadows associated with this activity though dwindling. In the intermontane basins and valleys the prevalent forms are: in Austria – commercial agriculture with livestock breeding prevalent, identified as Types Mmw

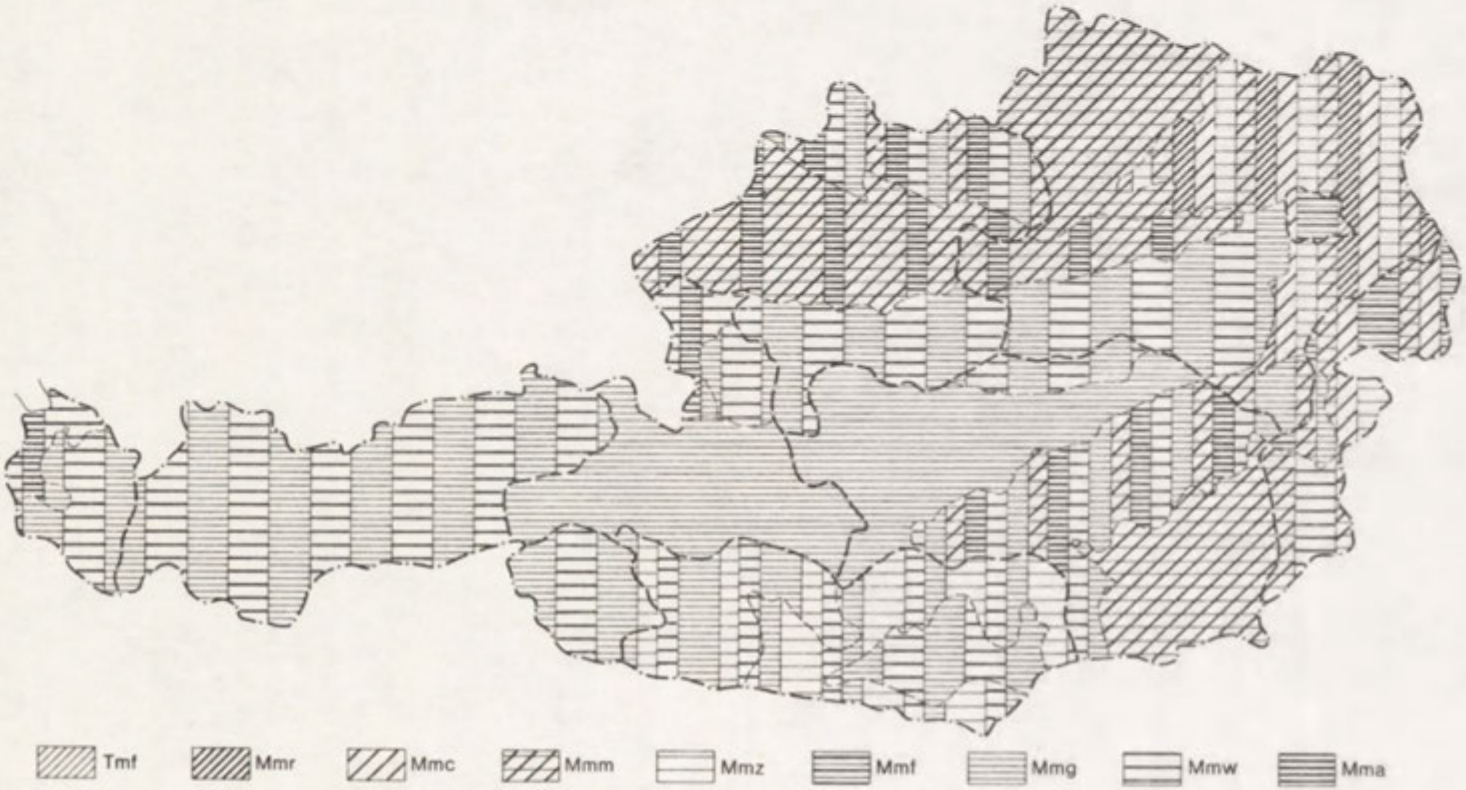

Fig. 1. Austria

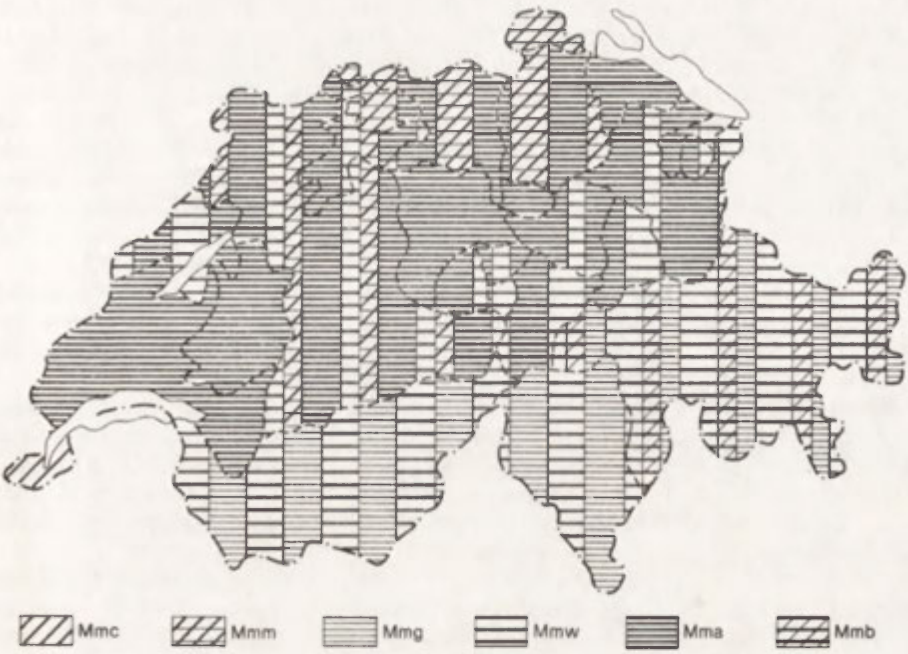

Fig. 2. Switzerland

and Mma, and in Switzerland – specialized in vegetables, fruit and vine together with livestock production, identified as Type Mif. However, on the scale of the units investigated in the study, a mixed combination dominates, with the following characteristics, e.g. for the area of Upper Austria B: High mountain areas (Dachstein) and Alpine foothills. Out of the total area of 306014 ha agricultural land accounts for 22.5%, forests for 60.3% and unproductive land (mainly high mountains) for 17.2%. Permanent grassland dominates – 87.7%, of which meadows take 70.9%; arable land accounts for 10.6%, and orchards and homeyard gardens for 1.7%. The land-use orientation is therefore: highly fodders – meadows with a secondary role of pastures, and the arable land use orientation: cereal-wheat-barley-oats with a secondary role of fodder crops (clover and grass) and potatoes. The average size of the farms is 10.8 ha of agricultural land, but solely 1.33 ha of arable land.

The density of livestock is large: 83.0 LAU per 100 ha of agricultural land and 101.8 LAU per 100 ha of cultivated land; the livestock breeding orientation can be identified as: highly cattle – milk-meat; the Simentaler breed of cattle prevails. Effects of agricultural production are: high land productivity (50.5 CU) and cultivated land productivity (67.7 CU), medium labour productivity (245.7 CU) and medium commercial production per ha of agricultural land (23.8 CU). The orientation of agricultural gross production is: fodders, milk with a secondary role of meat production, and of commercial production: livestock, milk with a secondary role of barley. In sum, this is mixed, semi-commercial and commercial agriculture with livestock breeding prevalent, typical of highlands.

Mmw_3-Mma_1 – occurs in Austria – the Alpine foothills – Vorarlberg F and Salzburg F and represents the prevalence of Type Mmw – small-scale, commercial agriculture with livestock breeding prevalent and the secondary role of Type Mma – medium-scale, more productive and more commercial agriculture with livestock breeding dominant; Vorarlberg F may serve to exemplify the case:

Vorarlberg F – 1151222 – 3254144 – 4443333 – 151351. Commercial agriculture with high inputs and a prevalence of livestock breeding dominates in this area of the Alpine foothills; it is represented by Type Mmw with a secondary role of Mma.

Out of the total area of 37513 ha agricultural land accounts for 56.3%, forests for 28.8%, and unproductive land for 14.9%. Grassland dominates in agricultural land (93.6%), predominantly meadows; arable land accounts for 4.1% and orchards for 2.3%. The land-use orientation is therefore highly fodders, meadows with a secondary role of grassland, and the agricultural land use orientation: fodders (mixed grass) with a secondary role of barley and potatoes. The average size of the farms is 14.2 ha of agricultural land and solely 0.35 ha of arable land.

The density of livestock is high 89.1 LAU per 100 ha of agricultural land and 145.2 LAU per 100 ha of arable land. The livestock breeding orientation can be identified as: highly cattle (milk-meat), with a secondary role of pigs. The Pinzgauer (Salzburg) and mountainous brown (the so-called Schwyz) cattle prevail.

Effects of agricultural production are: high land (45.8 CU) and cultivated land (91.9 CU) productivity, high labour productivity (286.0 CU) and medium commercial production per ha of agricultural land (20.4 CU). The orientation of agricultural gross production is: mixed crops-livestock, fodders-milk with a secondary role of beef, and commercial production: highly livestock, milk with a secondary role of beef and pork.

Mmw_2-Mma_2 – occurs is Swiss mountains – the cantons of Appenzell A.Rh. and Appenzell J.Rh. as well as Neuchatel (Jura), representing the balance of two types of small-scale, commercial agriculture with livestock breeding prevalent (Mmw) and medium-scale, more productive and more commercial with livestock breeding domi nant (Mma). There are certain differences both in the size of the farms, labour inputs and production effects, e.g.

Appenzell A.Rh. – 1151122 – 3444145 – 4544443 – 151451
Neuchatel – 1151122 – 2255144 – 4444443 – 151451.

Mountainous areas (Alps, Jura) predominante there where the main orientation is cattle breeding, associated with summer grazing on the Alpine meadows. Commercial agriculture with livestock breeding dominant, corresponding to Types Mmw and Mma, prevails in the intermontane basins and valleys. However, the wine orientation dominates in the southern part of the canton of Neuchatel (upland); it is represented by Type Mif. On the scale of the whole cantons it is however a mixed combination, represented by Types Mmw and Mma. Its characteristics – e.g. on the area of the canton of Neuchatel – are as follows: Out of the total area of 79663 ha agricultural land accounts for 51.7%, forests for 32.7% and unproductive land for 16.6%. Permanent grassland dominates in agricultural land (81.9%), mostly meadows, while arable land accounts for 16.7% and perennial crops (mainly vineyards) for 1.4%. The land-use orientation is fodders, meadows with a secondary role of arable land, and the crop orientation: cereals-fodders, barley-grass, with a secondary role of wheat and clover. The average size of the farms is 19.2 ha of agricultural land, of which 3.22 ha of arable land.

The number of livestock is large: 86.4 LAU per 100 ha of agricultural land, 152.8 LAU per 100 ha of cultivated land, and the livestock breeding orientation is highly cattle, meat-milk with a secondary role of pigs. The mountainous brown (Schwyz) breed prevail in Appenzell and the Bernese red in Neuchatel.

Effects of agricultural production are: high land (48.5 CU) and cultivated land (85.8 CU), high labour productivity (502.5 CU) and high commercial production per ha of agricultural land (31.2 CU). The orientation of gross agricultural production is: grass, fodders-wheat with a secondary role of milk, and of commercial production, highly livestock, milk with a secondary role of beef.

Mmm_1-Mmw_1-Mma_2 – occurs in Switzerland – the cantons of Bern and Solothurn – mountains (Alps, Jura) and uplands; it represents the combination with Type Mma prevalent and a secondary role of commercial, mixed agriculture (Mmm) and small-scale, commercial agriculture, with livestock breeding prevalent (Mmw). For instance, the Canton of Bern:

Bern – 1151222 – 3254144 – 4544443 – 151451.

This is a highly differentiated area, which contains both mountains (Alps and Jura) with their prevalence of livestock breeding oriented towards mixed milk-meat or meat-milk production and represented by Types Mma, Mmw and even Mmg, as well as uplands with their prevalence of mixed agriculture, characterized by a balance of livestock and crops productions, or even by a prevalence of crop production and represented by Type Mmm, and in some communes by Mif. On the scale of the whole canton, however, a combination of Type Mma prevalent over Types Mmw and Mmm is characteristic.

Out of the total area of the Canton of Bern, amounting to 688 687 ha agricultural land accounts for 53.1%, forests for 28.2% and remaining land (unproductive land, settlements, waters etc.) for 18.7%. Permanent grassland, with balanced shares of meadows and pastures, prevail in agricultural land. Arable land accounts for 27.6% and perennial crops for 0.3%. The land-use orientation is therefore as follows: fodders (meadow-pastures) with a secondary role of arable land, and the crop orientation: fodders, with a secondary role of wheat, barley and potatoes. The average size of the farms is 13.4 ha of agricultural land, of which 3.7 ha of arable land.

The density of livestock is high, 114.4 LAU per 100 ha of agricultural land and as many as 227.5 LAU per 100 ha cultivated land; the livestock breeding orientation is: cattle-milk-meat with a secondary role of pigs with a domination of the red Bern breed of cattle. Production effects are: high land (64.1 CU) and a very high cultivated land (131.0 CU) productivity, high labour productivity (413.3 CU) and high commercial production per ha of agricultural land (41.9 CU). The orientation of agricultural gross production is: livestock, milk with a secondary role of meat beef, fodders and potatoes, the orientation of commercial production is: livestock, milk with a secondary role of beef, pork and wheat. In sum, this is a commercial orientation with high capital inputs, highly productive and commercial agriculture with livestock production prevalent.

Mmw$_1$-Mma$_3$ – appears in Switzerland in the Cantons of Schwyz and Obwalden – highlands (Alps), representing a combination with Type Mma prevalent and Type Mmw playing a secondary role, i.e. this is commercial agriculture with livestock breeding prevalent, e.g. the Canton of Obwalden:

Obwalden – 1151122 – 2155144 – 3544432 – 151451.

The Canton is dominated by highlands where intensive livestock breeding prevails, capital inputs are very high, and at the same time a traditional form of cattle breeding, associated with summer grazing in Alpine meadows, has also survived. Out of the total area of the Canton (49069 ha) agricultural land accounts for 50.5%, forests for 32.5% and remaining land (unproductive land, settlements etc.) for 17.5%. Permanent grassland dominates (99.9%) in agricultural land, and Alpine meadows prevail (66.6%). Arable land accounts for 0.1% of agricultural land only. The orientation of land-use is therefore: highly fodders, grassland with meadows playing a secondary role, while arable land orientation is: fodders with a secondary role of vegetables.

The average size of the farms is 19.1 ha of agricultural land, of which solely 0.03 ha of arable land. The intensity of livestock breeding is high, 83.6 LAU per 100 ha of agricultural land and as many as 347.5 LAU per 100 ha of cultivated land; in the livestock breeding system cattle (milk-beef) prevail with a secondary role of pigs. The Schwyz breed dominates. Production effects are medium and high: land productivity is medium (41.1 CU) and productivity of arable land very high (170.5 CU), labour productivity high (413.6 CU) and commercial production per ha of agricultural land medium (27.4 CU). The orientations of agricultural production corroborate this that agriculture is mainly oriented towards livestock ·production, namely the orientation of gross production is livestock with a secondary role of crops, milk with a secondary role of fodders, beef and pork; the orientation of commercial production has been identified as highly livestock, milk with a secondary role of pork and beef.

Mma_4 — appears in Switzerland (the Cantons of Vaud, Fribourg, Luzern, Zug and Thurgau) — mountains (Alps) and uplands, it represents medium-scale agriculture with high capital inputs, high productivity and commercialization and dominance of livestock breeding, the its characteristic is as follows:

Luzern — 1151223 — 3254145 — 5544453 — 151451,
Vaud — 1151223 — 2254144 — 4544442 — 141341.

These areas are highly differentiated, both highland and foothills (Alps), where livestock breeding, milk-beef, represented by Type Mma, prevails as well as uplands, where livestock breeding (Type Mma) is accompanied by balanced crop-livestock production (Types Mma and Mmm).

Out of the total area of the canton (149215 ha), agricultural land accounts for 62.6%, forests for 26.3% and remaining land (unproductive land, waters, settlements, etc.) for 11.1%. Permanent grass prevails in agricultural land (79.8%), out of which meadows account for 83.7%; the area of Alpine meadows is slight (16.3%). The proportion of arable land is 19.9% and of perennial crops 0.3%. The land-use orientation can therefore be identified as grassland with a secondary role of pastures and arable land. The crop orientation is barley-clover with a secondary role of wheat and mixed grass.

The average size of the farma is 10.8 ha, of which 2.21 ha is arable land. In the size structure of the farms, holdings up to 5 ha take almost one fourth of the total number, their owners are mostly part-time farmers. The number of livestock is very high, 227.4 LAU per 100 ha agricultural land and as many as 300.0 LAU per 100 ha of cultivated land owing to intensive pig breeding in many farms of industrial character, based on purchased industrial fodders. The livestock breeding system is therefore: cattle-pigs, milk-meat. The *Schwyz* breed dominates among cattle.

Productive effects are as follows: very high land productivity (117.4 CU) and cultivated land productivity (155.1 CU), high labour productivity (560.0 CU) and high commercial production per ha of agricultural land (88.6 CU) and the orientation of gross agricultural production is livestock, milk-pork with a secondary role of fodders, and of commercial agricultural production: highly livestock, milk with a secondary role of pork and beef.

In sum, this is a commercial agriculture, with high capital inputs, high prevalence of livestock breeding, the most productive and most commercial in the Swiss highlands.

The remaining combinations representing the agriculture of the Alpine areas occur sporadically, for instance:

Mmz_1-Mmg_2-Mmw_1 — appears in Austria — the South-Eastern Alps — mountainous areas — Carinthia A, characterized by the following combination of the attributes:

Carinthia A — 1151122 — 2253143 — 3433323 — 141351

representing a combination with medium-scale, semi-commercial agriculture, with livestock breeding prevalent (Mmg) with a co-occurrence of Types Mmz and Mmw.

Mmz_1-Mmg_1-Mmw_2 — appears in Austria — the South-Eastern Alps — the Alpine foothills — Carinthia C, characterized by the following combination of the attributes:

Carinthia C – 1151122 – 3253143 – 3433322 – 141351
representing a combination with small-scale, commercial agriculture, with livestock breeding prevalent (Mmw) with a co-occurrence of Types Mmz and Mmg.

Mmg$_1$-Mmw$_2$-Mmb$_1$ – appears in Switzerland – the Alps – mountainous areas – the Canton of Graubünden, characterized by the following combination of the attributes:

Graubünden – 1151132 – 2244142 – 2543323 – 151351
representing small and medium-scale, commercial agriculture, with livestock breeding prevalent (Type Mmw) and a co-occurrence of Types Mmg and Mmb.

Mmm$_1$-Mmg$_1$-Mmt$_1$-Mmw$_1$ – appears in Austria – the South-Eastern Alps – the Alpine foothills – Burgenland C, characterized by the following combination of the attributes:

Burgenland C – 1151122 – 3154143 – 4433332 – 132241
representing highly differentiated agriculture, combination of Types Mmm, Mmg, Mmt and Mmw.

Mmm$_1$-Mmg$_1$-Mmw$_1$-Mma$_1$ – appears in Austria – the South-Eastern Alps (foothills) – Styria C and the Bohemian-Moravian Upland (Mühlviertel) – Upper Austria D, characterized by the following combination of the attributes:

Styria C – 1151222 – 3254144 – 4433333 – 141351
representing highly differentiated agriculture with livestock breeding prevalent, combination of Types Mmm, Mmg, Mmw and Mma.

The identified agricultural types of the Alpine areas for 1975 are spatially highly differentiated. Differences are marked both between the Eastern (Austria) and the Western (Switzerland) Alps as well as between the high mountain areas and the Alpine foothills. These differences are associated with diverse farming systems, unequal labour and capital inputs to agriculture and various production effects, even if livestock breeding dominates, in the whole area of the Alps.

To sum up current situation it may be said that the Eastern Alps (Austria) are dominated by Type Mmg or the combination Mmg$_2$-Mmw$_2$, while the combination Mmw$_2$-Mma$_2$, or even more mixed, e.g. Mmw$_3$-Mma$_1$, Mmg$_1$-Mmz$_2$-Mmw$_1$ or Mmm$_1$-Mmg$_1$-Mmt$_1$-Mma$_1$ occur in the Alpine foothills.

However, in the area of the Western Alps and Jura (Switzerland) Type Mma prevailed then, though the combination similar to that occurring in the area of the Eastern Alps – Mmg$_2$-Mmw$_2$ (Tyrol A, Vorarlberg A, etc.) as well as more mixed combinations, such as: Mmm$_1$-Mmw$_1$-Mma$_2$ or Mmw$_1$-Mma$_3$ have also been identified in certain cantons (Valais and Ticino). The present spatial differentiation in the Alpine area is also a result of transformation that have taken place in the spatial structure of agriculture lately. Its trend is the transition from semi-commercial to commercial agriculture, from Type Mmg through Type Mmw to Type Mma.

In 1960 it was Type Mmg$_4$, representing medium-scale, semi-commercial agriculture with livestock breeding prevalent which dominated the area of the Eastern Alps (Austria) and its agricultural areas – Tyrol A, Salzburg A, Vorarlberg A, Carinthia A, Styria A (high mountains) and Salzburg B, Styria C and Lower Austria C (Alpine foothills). Following changes which occurred in the spatial structure of agriculture in 1960–1975 (Szczęsny 1979), in particular in inputs to agriculture and production effects, other types have been identified which signalize transition from Type Mmg to Type Mmw. Type Mmg$_4$ has survived only in the area of the High Alps – Salzburg A and Styria A, though even here the agricultural spatial structure have been affected by some minor or major changes, e.g. Salzburg A:

1960 – 1151232 – 2343143 – 2322223 – 151351
1975 – 1151232 – 2253143 – 2423323 – 151351
namely: a decrease in the number of horses (from 11.7 to 7.3), increased mechanization (from 71.6 to 242.1 HP), increased productivity of arable land (from 36.3 to 74.8 CU),

increased commercial production per ha employed (from 40.4 to 101.0 CU) and increased degree of commercialisation (from 32.2 to 40.4%). Some new combinations have been discovered also, e.g. in Vorarlberg A, Tyrol A (mountainous areas) and Salzburg B and Styria B (Alpine foothills), such as a balanced combination of Mmg and Mmw (Mmg_2-Mmw_2), a transition from Mmg to Mmw, i.e. from semi-commercial agriculture to mixed, semi-commercial and commercial, e.g. Tyrol A

1960 – 1151222 – 2253143 – 2432223 – 151351
1975 – 1151122 – 2253143 – 3443323 – 151351

i.e. a decrease in the number of persons employed per farm (from 2.7 to 1.6), an increase in the size of the farms (from 19.5 to 20.5 ha of agricultural land), and predominantly increased land productivity (from 14.9 to 28.8 CU) and labour productivity (from 108.2 to 259.4 CU), as well as increased commercial production per person employed (from 32.5 to 114.4 CU) and the degree of commercialization (from 30.1 to 44.0%).

However, in the area of Styria C (Alpine foothills) Type Mmg has been replaced by the combination Mmm_1-Mmg_1-Mmw_1-Mma_1, which reveals transition from semi-commercial to commercial agriculture (from Mmg to Mmw and Mma) e.g.

1960 – 1151222 – 3243143 – 3332223 – 141351
1975 – 1151222 – 3254144 – 4433333 – 141351

i.e. increased mechanization (from 62.6 to 244.0 HP), increased chemical fertilization (from 70.5 to 83.7 kg NPK), increased number of livestock in LAU per 100 ha of agricultural land (from 68.7 to 80.4), increased land productivity (from 26.5 to 46.8 CU), increased cultivated land productivity (from 39.1 to 66.4 CU), increased commercial production per person employed in agriculture (from 36.8 to 103.0 CU) and increased degree of commercialization in agriculture (from 35.8 to 40.2%) as well as of the level of commercialization (from 9.5 to 22.3 CU).

In Carinthia A (mountainous areas) changes are slightly different, Type Mmg (Mmg_4) was replaced in 1975 by the combination Mmg_2-Mmz_1-Mmw_1 – prevalence of Type Mmg and co-occurrence of Types Mmz and Mmw, transition from Type Mmg to Mmz and Mmw, following changes in the spatial structure of agriculture:

1960 – 1151232 – 2343143 – 2322223 – 141351
1975 – 1151122 – 2253143 – 3433323 – 141351

a lower average size of the farms (from 22.8 to 17.2 ha of agricultural land), lower number of horses (from 14.0 to 5.6) and increased mechanization (from 68.7 to 210.3 HP), as well as increased land productivity (from 10.2 to 21.1 CU), increased arable land productivity (from 37.5 to 69.1 CU), increased labour productivity (from 88.8 to 193.1 CU), increased commercial production per person employed (from 27.1 to 84.5 CU) as well as a higher degree of commercialization in agriculture (from 30.0 to 43.7%).

The combination Tmb_2-Mmg_1-Mmw_1 representing the prevalence of semi-commercial agriculture, identified in Carinthia C, and Carinthia E in 1960, has been replaced by new combination, i.e. in Carinthia C – Mmg_2-Mmz_1-Mmw_1., and in Carinthia E – Mmg_2-Mmw_2, transition from semi-commercial to commercial agriculture, e.g. Carinthia E:

1960 – 1151222 – 3344144 – 3332232 – 131341
1975 – 1151122 – 3154144 – 4443332 – 131341

i.e. the number of people per farm is lower (from 2.5 to 1.9), the number of horses is also lower (from 10.4 to 1.8), while increase is noted in mechanization (from 81.0 to 253.7 HP), land productivity (as many as from 32.9 to 65.8 CU), arable productivity (from 43.4 to 87.8 CU), labour productivity (from 115.2 to 325.4 CU), commercial production per person employed (from 42.5 to 148.6 CU) and the degree of commercialization (from 36.2 to 45.6%).

The combination Mmg_2-Mmw_2 which appeared in Upper Austria B and Lower Austria B in 1960, was also identified in 1975 with certain changes in the structure of agriculture, e.g. Upper Austria B:

1960 – 1151222 – 3253143 – 3332223 – 141351
1975 – 1151222 – 3153144 – 4433333 – 151341

i.e. lower number of horses (from 5.1 to 1.7) and increased mechanization of agriculture (from 91.2 to 254.4 HP), increased land productivity (from 25.6 to 50.5 CU) and arable land productivity (from 33.9 to 67.7 CU), increased labour productivity (from 106.5 to 245.0 CU), increased commercial production per person employed (from 41.8 to 115.4 CU) and the degree of commercialization (from 39.1 to 47.0%) as well as a lesser role of livestock production in commercial production (from 87.9 to 75.0%).

The observed tendencies of changes reveal that a gradual transition from the combination Mmg_2-Mmw_2 to Mmg_1-Mmw_2-Mma_1 is taking place, e.g. Salzburg F and Vorarlberg F, where Mmg_2-Mmw_2 is replaced by Mmw_3-Mma_1 with the following characteristic, e.g. Salzburg F:

1960 – 1151222 – 3245144 – 3432333 – 141351
1975 – 1151222 – 3155145 – 4443333 – 141351.

The remaining Alpine territories, the foothills in particular, were also affected by minor or major changes in 1960–1975, the transition to commercial agriculture can be exemplified by Lower Austria F where Mmm_3-Mmg_1 is replaced by Mmm_3-Mma_1, or Upper Austria D (uplands) where Tmb_1-Mmm_1-Mmg_1-Mmw_1 is replaced by Mmm_1-Mmg_1-Mmw_1-Mma_1 etc.

The same is true of the remaining territories in Austria, surrounding the highlands, e.g. Lower Austria D, a transition from Mmm_2-Mmg_2 to Mmm_4, Lower Austria H from Mmc_2-Mmm_2 to Mmr_1-Mmc_1-Mmm_1-Mmt_1, or Vienna H from Tmf_4 to Tmf_1-Mmc_2-Mmt_2.

Transformations in the spatial structure of agriculture and agricultural types in Austria's areas have been occurring in various ways, as is corroborated by the differentiated picture of the spatial differentiation of that country's agricultural types in 1975. It is quite likely that changes which are noted in the territories of the Western Alps (Switzerland) though much earlier and more rapid occurred in a similar way.

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GEOGRAPHIA POLONICA 52, 1986

AGRARIAN STRUCTURE IN POLAND, 1950–1983

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Changes of two kinds have influenced the evolution of Poland's agrarian structure: the first associated with transfer of land from one social form of agriculture to another and the second connected with the size of farms. The spatial differentiation of the agrarian structure and agriculture in Poland is largely a result of the historical past and different political and economic systems operating in the country's separate parts in the period from 1772 to 1945.

After World War II the agrarian structure developed basically under the influence of the Agrarian Reform of 1944, the settling of the Recovered Territories, industrialization processes and agrarian policies pursued by the State. At the beginning the subdivision of land of the former landed estates among peasants augmented in various degree the number, the proportion and the size of most of the small-scale individual farms.

Combined effects of historical past and the Agrarian Reform were both highly differentiated size-structure of individual farms and varying proportion of socialized i.e. state farms. The largest individual farms (average 8.7 ha) continued to be characteristic of Greater Poland and Eastern Pomerania before World War I under Prussia, medium-sized farms in the Polish conditions (average 7.3 ha) of northern and western territories incorporated to Poland and settled by new agriculturalists after World War II, while in central and eastern Poland (formerly under Russia) small farms (average 4.9 ha) were the most common and in the southern Poland (former Austrian Galicia) very small farms (average 3.2 ha) prevailed.

Moreover the Agrarian Reform called into being the state farms based on the former large landed estates, particularly in those territories where there had been no agrarian overpopulation like in Greater Poland and on the Recovered Territories.

Few years later the process of collectivization was started that reached 11.2% of agricultural land in 1955. The failure of collectivization resulted in decreasing their importance to merely 1.2% of agricultural land in 1960.

The subsequent years (1960–1980) were characterized by a slow increase of the area of the socialized farms at the cost of individual ones: the intensity of that processes in various years varied (Table 1).

Nevertheless the dominance of individual farming is still a typical feature of Poland's agrarian structure. Its spatial pattern is characterized by noticeable differences in the proportion of individual farming between central, southern and eastern Poland, where the area of agricultural land owned by individual farmers is much larger (over 90%) and that of northern and western Poland, where it is smaller (on large portions of northern Poland even under 60% – Fig. 1a). In 1983 the proportion of agricultural land cultivated by various social sectors was as follows: individual farms 76.2%, state farms 18.8%, collective farms 3.8% and farms managed

TABLE 1. Changes in the structure of agricultural land ownership

Specification	1950	1960	1970	1978	1979	1980	1981	1982	1983
	in percentages								
Individual farms	89.6	86.9	81.8	75.8	75.0	74.5	74.9	75.8	76.2
State farms	9.6	11.9	14.8	18.5	19.1	19.5	19.4	19.0	18.8
Collective farms	0.8	1.2	1.3	2.9	3.4	4.0	4.1	3.9	3.8
Agricultural circles	–	–	0.5	2.2	1.9	1.5	0.9	0.6	0.5
Agricultural land outside farms	–	–	1.6	0.6	0.6	0.5	0.7	0.7	0.7
Land sold by the State Land Fund to individual farmers in thousand hectares	–	59.6	46.1	94.4	113.2	128.0	165.0	240.0	101.0
Land leased by the State Land Fund to individual farmers in thousand hectares	–	524.0	611.0	542.1	471.6	491.0	577.0	476.0	441.0

Source: Data compiled by the Central Statistical Office.

Fig. 1.a) Individual farming as a percentage of all agricultural land, 1983; b) State farming as a percentage of all agricultural land, 1983; c) Collective farming as a percentage of all agricultural land, 1983

by agricultural circles (a new type of socialized agriculture introduced in the seventies) – 0.5%.

Changes affecting individual farming in the past decades consisted of gradual transfer of their lands to other social forms of agriculture and changing shares of the size classes of individual farms.

In 1950–1960 the following processes were noted in the socio-economic structure of individual farms: the subdivision of certain farms to form new, smaller holdings (sometimes fictitious subdivision trying to avoid higher taxation of larger farms), rarely to amalgamate them into larger units; the transformation of certain small farms into those owned by peasant-workers, as well as transfer of certain individual farms to the socialized sector. Bi-occupational farms were a consequence of increased industrialization of adjacent areas; when such areas were not available, migration of man-power from agricultural to more distant urban centres largely increased.

The emergence of the bi-professional population affected decisively the socio-economic structure of the rural areas. Profits gained by peasant-workers from outside largely increased; however their interest in agricultural production, especially commercial production, began to wane.

In result in the decade of 1950–1960 the number of individual holdings went up, especially of those under 2 ha; while that of larger farms went down. Consequently, the average size of farms decreased from 5.5 ha to 5.1 ha.

The transformations in the agrarian structure were an effect of a new agrarian policy realized by the State in 1956–1970. Changes initiated by the 1963 Act on the curtailment of the subdivision of farms following testamentary dispositions, the inheritance procedures as well as of the sale of agricultural property, as well as new proceedings regarding transfers of farms for retirement pensions were accompanied by a certain increase of outlays on agriculture, which was particularly significant for the new trend in the transformations of the structure of individual farms. In 1960–1970 the number of farms ceased to increase, that of small and medium farms was slightly decreased, and that of larger farms increased. Consequently, the average farm size went up from 5.1 ha to 5.4 ha.

The most evident process of transformations in the agrarian structure of individual farms was in 1970–1980 a decrease in their total number amounting to 109.7 thousand holdings, i.e. to over 3% (Table 2), was also resulting from growing outmigration of rural population to the industrial and urban centres.

TABLE 2. Changes in the number and size structure of individual farms, 1970–1982

Year	Number of farms in thousand	Size groups of farms in ha					
		0.5–2	2–5	5–7	7–10	10–15	above 15
1970	3006.8	24.7	32.7	14.7	14.8	9.8	3.8
1980	2897.1	30.0	29.5	12.8	13.0	9.7	5.0
1982	2842.0	29.8	28.9	12.6	12.9	10.1	5.7

Source: Data compiled by the Central Statistical Office

The liquidated farms were mostly those for which there was no successor, and which were economically weak, or some professional farms, the owners of which had abandoned them altogether. Some of them were neglected farms and as such taken over by the authorities. The process accelerated in the second half of that decade as a consequence of the introduction of new, more liberal regulations concerning retirement pensions (the size limit of a farm was lowered from 5 ha down to 2 ha). In 1976 the group of farms without successors amounted to 14% of the national total of the individual farms (430 thousand farms according to the Central Statistical Office). It appears on the basis of research carried out by the Institute of Agricultural Economics that every fifth holding was without a successor; a much lesser number of such holdings was among the bi-professional farms, or in those where some family members earned their livelihood elsewhere.

In 1979 over 80% of the farmers who liquidated their farms transferred their land to the State Land Fund. This institution is an agency, which not only takes over agricultural land but also transfers it to other branches of the national economy. Out of the total area taken over by the State Land Fund over 70% went to socialized farming. The largest percentage fell on the state farms, which thus increased the area by 26%, the second place was taken by the collective farms, which had thus obtained 35% of the land and in this way enlarged their surface by 200% (Table 1).

A higher percentage of the land taken over by the State Land Fund together with the elimination of former restrictions made it possible for many farmers to enlarge their farms. At the same time prices of land from the State Land Fund were lowered below those demanded by the private sellers.

In 1970–1982 the share of individual farms which had enlarged their land was about 3–4% each year, whereas that of decreasing holdings was under 1%. Both these processes, i.e. the decrease of the total number of farms and their increasing sizes, did not follow the same course in Poland as a whole. In the west and north they were much more rapid and consequently the structural transformations were greatly accelerated and included larger areas. In central Poland the agrarian transformations were slower and the slowest in the country's eastern and south-eastern parts. These spatial differences played a very important role. Where the range of the agrarian transformations was limited, the farms were the smallest and it was necessary to introduce changes.

The decrease of the number of farms in 1970–1980, with the only exception of the group of over 10 ha, was quite even in the separate size groups (Table 2). The groups chiefly affected by the decrease were: 2–5 ha (by 2.2%), 5–7 ha and 7–10 ha (by 3.7%), and the least affected 10–15 ha (by 0.1%). On the other hand, the number of the farms in the 0.5–2 ha group increased by 5.3% and that in the over 15 ha group by 1.2%. It is an interesting fact that in 1980–1982 the number of farms in the 0.5–2 ha group went down by 0.2%, similarly as in the groups of 2–5, 5–7 and 7–10 ha, whereas that in the group of over 10 ha went up by 1.1%.

Consequently, in spite of the decreased number of farms, the structure of individual farms changed but a little. Nevertheless, the average size of the farms increased, namely: of the farms of over 0.5 ha from 5.4 ha in 1970 to 6.2 ha in 1981 (the total area of the farm) and in terms of agricultural land from 4.7 ha to 5.4 ha. The spatial picture of these downward tendencies was uneven. In the country's north and south-west as well as in the most intensively industrialized southern region the number of farms went down at a twice as rapid rate (23–26%) as in central, central-eastern and south-eastern Poland (10–13%). The national average (13%) characterized also the west-central and north-eastern parts. Bigger spatial differences took place in the structure of liquidated holdings. In south-eastern and southern Poland farms of over 5 ha accounted for 20–24% of the total. In central Poland the proportion was 38–45% and in the remaining areas up to 70%.

In central and north-eastern Poland the number of farms of over 10 ha went down by 8% and in the southern, south-western and northern parts the decrease was higher (12–17%). A highest increase of the proportion of the farms of over 10 ha was noted in the west-central, south-western, northern and north-eastern territories (by 3–4%). East-central, south-eastern and southern Poland was characterized by only a slight increase in the proportion of larger farms (by 1–3%).

In 1970–1980 the number of people employed in agriculture went down by 1893 thousand, i.e. by ca 33%. An important decrease in the total number of people employed in individual farming brought about the decrease of employment per 100 ha of agricultural land. In 1970 the average density of employed in individual farming was 40.2 people and in 1980 – 29.6 people. This is the level of employment expressed in physical units; their labour efficiency depends on age, sex and involvement in work. If employment is however expressed not in physical units but in terms of full-time working people the average was 23 persons per 100 ha. The index decreased very seriously in the group of the largest farms, in which it was slightly over that characteristic of the state farms, while the structure of the labour force was much worse and the level of mechanization much lower.

In 1980 the number of people employed in individual farming was 3857 thousand. The basic factor contributing to the decrease was outmigration of a part of the labour force to non-agricultural occupations, with or without the change of the residence place. The phenomenon of mixed incomes in families utilizing land was more and more common and it took place not only in small but also in medium large farms.

To improve the agrarian structure it would be advisable when a farm is liquidated to make it possible to enlarge other farms, especially those which may be further developed. However, the agrarian policy in this respect was not always pursued as it should have been. Some significant moves to increase the size of the farms began only after 1977. In the 1970s the improvement of the agrarian structure was limited in principle to the increase of the proportion and less often of the number of farms of over 10 ha. This was quite evident where the number of those farms was already high, where it was small, no changes were noticeable.

Differences in the structure of the farm size were still considerable in Poland. The distribution of individual farms according to their size groups in 1983 presented itself as follows. Very small farms (0.5–2 ha) were typical of southern Poland, where they accounted for 10% and even 20% of the total farm area; in western Poland this proportion was 6–20%. The lowest (under 2%) percentage of up to 2 ha farms in the total area of individual farms characterized north-eastern Poland (Fig. 2). Small farms (2–5 ha) were numerous particularly in south-eastern Poland, where they accounted in many places for over 30% of the total area of individual farms. Their proportion in central and south-western Poland oscillated between 10% and 20%, in the country's north it was usually 10%, while in the north-eastern part even under 5% (Fig. 3). Medium farms (5–7 ha) were most numerous in south-eastern Poland, where their share exceeded 15% and even 20% in the total area of individual farms. The least number (under 10% and 5%) was found in western and northern Poland (Fig. 4). The farms in the 7–10 ha group were characteristic of central Poland (over 20% and 25%), their least number (under 15% and 10%) was Greater Poland, Mazuria and the country's south (Fig. 5). The percentage of farms in the group of 10–15 ha was the least (under 10% and 5%) in south-eastern Poland; elsewhere in the country it oscillated between 15% and 30% (Fig. 6). Farms of over 15 ha were predominantly found in northern, central and south-western Poland, where they accounted for over 40% and even 50% of the total area of individual farms. In the south-eastern part they never exceeded 10% (Fig. 7).

The distribution of the area structure of individual farming according to their size is presented on a synthetic map (Fig. 8), showing the leading categories of the sizes of individual farms.

The leading size categories are worked out by the method of successive quotients (Tyszkiewicz 1978, 1981). The map shows that the prevailing proportion of large farms (over 10 ha) with a marked proportion of medium farms (5–10 ha) are found in northern Poland and Greater Poland. Most of the areas characterized by a balance between large and medium farms usually lie in central-western, central and central-eastern Poland. In central Poland structures with a prevalence of medium farms and a marked proportion of both very small farms (0.5–2 ha) and large farms were the most common. Medium farms, with a significant proportion of small and still

Fig. 2–4 Individual holdings as a percentage of total acreage of individual farming, 1981

a marked proportion of large farms are most common in south-central Poland. A balance, or a slight prevalence, of medium over small farms occurs in the south-eastern belt. In the subcarpathian areas there is prevalence of small farms and a significant percentage of medium and very small farms. In the Upper Silesian Basin very small farms with a higher or lower percentage of small farms prevail. A comparison of the spatial systems of the leading structures in 1970–1980 corroborates the conclusion that the highest increase of the share of the farms of over 10 ha took place in the northern, north-eastern and west-central as well as south-western part and makes it evident that the share of farms in the 2–5 ha and 5–10 ha groups declined.

Land held in common consisting mainly of village pastures is the remanent of the

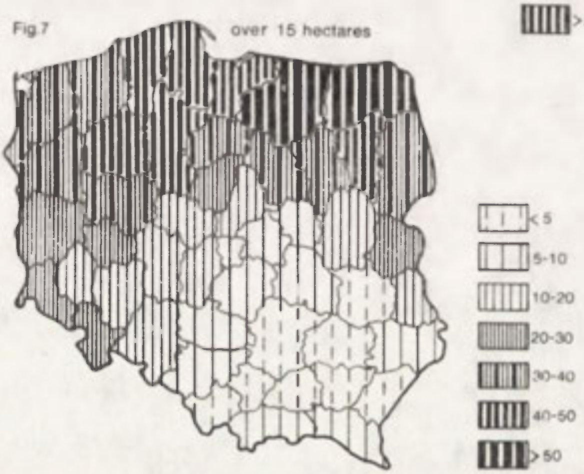

Fig. 5–7 Individual holdings as a percentage of total acreage of individual farming, 1981

old epoch. They survived mainly on the south-eastern and eastern parts of the country (Fig. 9).

An analysis of changes in the spatial pattern of the agrarian structure will not be complete if the state farms were not considered. Their share in the country's agricultural land in 1951–1980 went up from 9.6% to 19.5% (Table 1).

The state farms play various role in the different parts of Poland. Two specific areas can be differentiated there, namely: the north-western part where the proportion of the state farms exceeded 20%, and sometimes 40% and 50% of agricultural land, and the south-eastern part, where the state farms rarely occupy more than 5% or over 10% of agricultural land (Fig. 1b). In comparison with the socialized farms in other socialist countries the Polish state farms are not large. In 1982 their average size was 3452 ha.

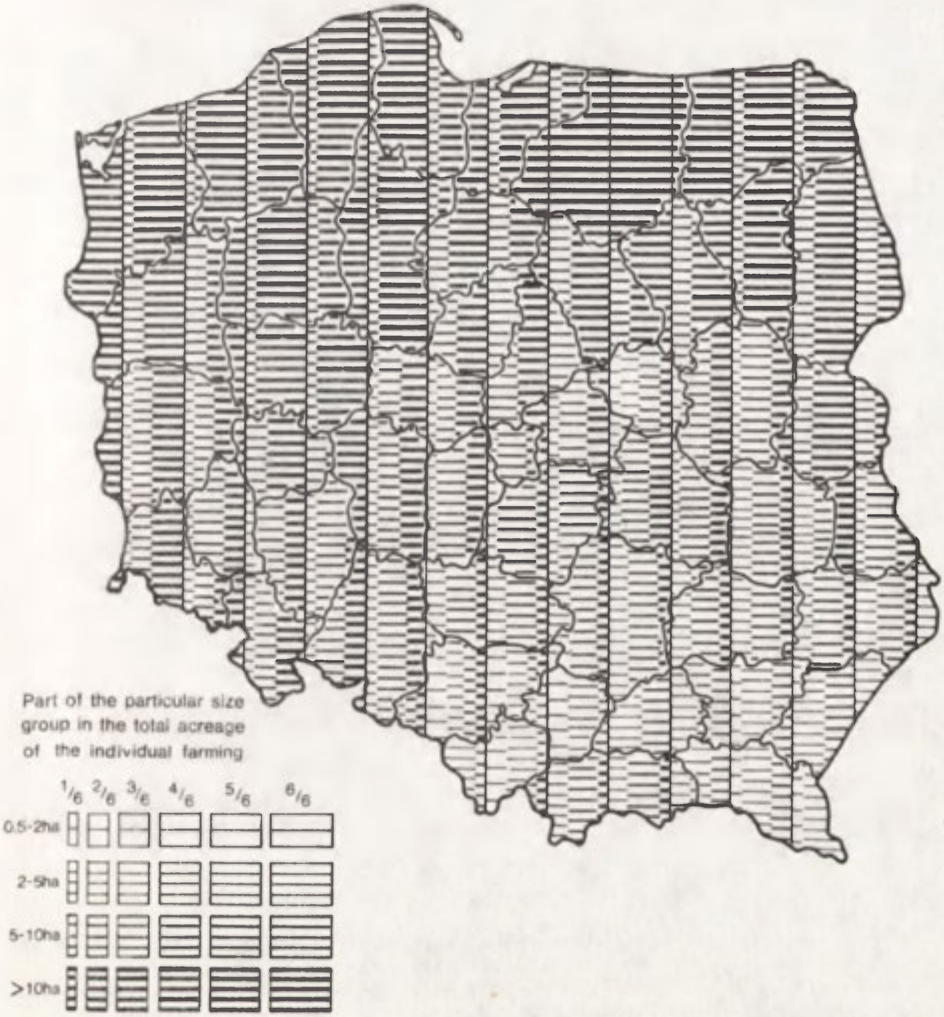

Fig. 8. Leading size structures of individual holdings, 1980

The collective farms have played an insignificant role (Table 1). Their share in the country's total agricultural land in 1950–1980 went up from 0.8% to 4.1% mainly thanks to the transfer of land from the State Land Fund; but that land was not only of worse quality but also was sharply fragmented (Table 3). According to the Institute of Agricultural Economics certain collective farms consisted of up to 55 plots of agricultural land and that half of their number did not exceed 5 ha. About one-third ol lanu utilized by collective farms was situated very inconveniently in relation to the farm main buildings. The collective farms are usually small. In 1970–1981 their average area went up from 242 ha to 359 ha. They are unevenly distributed, being mainly concentrated in Greater Poland (over 5% of agricultural land) and subsequently in other territories of the country's western part; their lowest proportion is in central Poland (Fig. 1c).

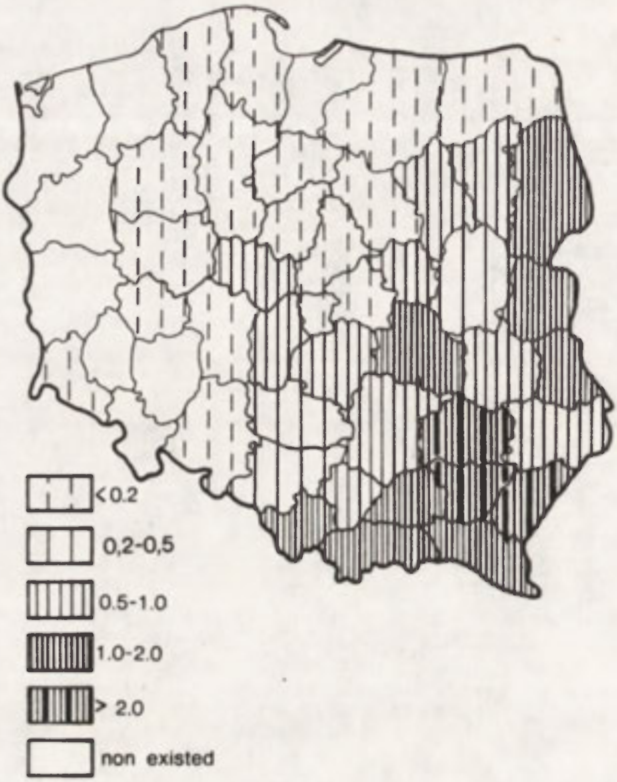

Fig. 9. Land held in common as a percentage of the total agricultural land, 198]

TABLE 3. Origin of agricultural land held by the collective farms in 1970–1979 (in per cent)

Year	State Land Fund	Members' contributies	Purchase, lease and other sources
1970	63.6	33.9	2.6
1979	65.1	20.1	14.8

Source: Data compiled by the Central Statistical Office

First farms run by agricultural circles were called into being in 1972, mostly on the basis of land acquired from the State Land Fund: these circles combined services rendered to farmers with production.

Those farms usually cultivate land taken over from the State Land Fund where there are neither state nor collective farms. The cultivation of that land, often dispersed in all directions, was not profitable and moreover draw attention away from the circles' main concern, i.e. the rendering of services to individual farmers. Since the running of such farms has been greatly criticized as uneconomic, their activity has been recently curbed (Table 1).

Recently a phenomenon which for quite a long time has been almost not existent has become more widely applied, namely the land lease. However with the growing outflow of the rural population from villages and the ageing of the remaining part, the tendency has developed to take land over on lease. The statistics indicate that this form is becoming more and more popular. The total area of leased land increased from 5.8% in 1970 to 6.1% in 1980. Such contracts can be made with either some State agencies – like the State Land Fund – or with private owners (the latter are usually elderly people or the owners of abandoned farms who have

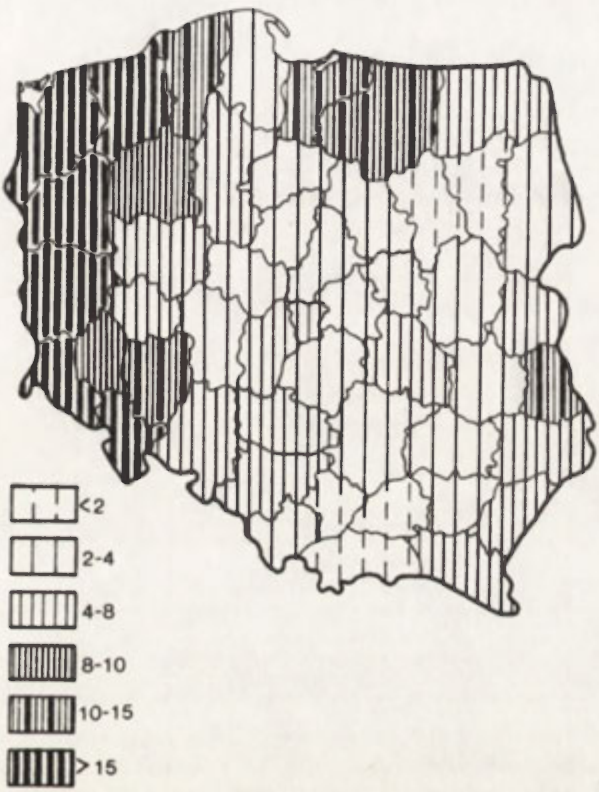

Fig. 10. Land leased as a percentage of total acreage of individual holdings, 1983

settled in towns). In 1983 the leased land amounted to 820 thousand ha on the national scale. Figure 10 presents the spatial distribution of the land held on lease by individual farmers. It appears that land lease is most common in the western and northern voivodships (over 15% of land utilized by individual farmers), then in the central part: it is the least developed in southern and eastern Poland. On average every tenth Polish farmer held land on lease. New regulations laid down in 1981 made the lease a more stabile form (ten-year contracts) and the tenant and his interests are better protected than before (when the short-term contracts often led to the wasteful use of land).

Changes in the agrarian structure in agriculture are influenced by the country's economic situation and the State agrarian policies.

In 1980–1983 there were some changes in the tendencies observed in land transfers between the separate forms of tenure in Poland (Table 1). The land cultivated by socialized agriculture decreased by 1.7% to the benefit of individual farming because of the transfer of land owned by agricultural circles. Altogether, their share in the total agricultural land decreased from 2.2% in 1978 to 0.5% in 1983.

The area of the state farms went also down when the restrictions regarding transfer of land to individual farms were abolished. Particularly land acquired from the State Land Fund often consisting of small, scattered plots, inconveniently situated was given back then almost entirely sold or leased to individual farms. This was due to the new regulations that base the functioning of state farms on self-rule and economic foundations.

Since individual farmers were eager to acquire land from the State Land Fund, demand for land substantially increased (Table 4). In 1982 the total transfer of land from the State Land Fund to individual farms amounted to 240 thousand ha (in 1978 it was 91 thousand ha), of which 85% were acquired to enlarge existing farms and 15% served to establish new farms (the total number of new farms established on the grounds acquired from the State Land Fund was 6722).

TABLE 4. Changes in takings and disposal of land by the State Land Fund

Specification	1979	1980	1981	1982
1. Taken over in thousand hectares	242	196	308	145
– from socialized agriculture (in per cent)	16	21	86	49
– from individual agriculture (in per cent)	84	79	14	31
2. Disposed in thousand hectares	289	242	204	285
– to socialized agriculture (in per cent)	52	35	12	9
– to individual agriculture (in per cent)	39	53	81	84
– to non-agricultural land use (in per cent)	9	12	7	7

Source: Data compiled by the Central Statistical Office.

In the last years private turnover of land have become more popular. On the country's scale this form has played an important role and largely contributed to the enlargement of the size of the farms. Prices of land in private transactions have gone up; this form of land turnover spread also over the areas where it had never been practised before. Quite often the transactions were connected with inheritance procedures and a change of generations when older people transferred their grounds to the younger members of their families, less or more closely related, who may have had their own small farms. Such situations in particular in the central, eastern and south-eastern parts of Poland, brought about both a decrease in the number of farms and an increase of the size of farms.

In the 1980s private transactions have predominatly been influenced by the crisis and inflation, affecting Poland, the phenomena usually associated with an increased demand for land.

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CLASSIFICATION FONCTIONNELLE DES ESPACES RURAUX SUR LES TERRITOIRES MONTAGNEUX EN POLOGNE

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La Pologne est un pays de plaines. Seuls 8,7% de sa superficie se situent à plus de 300 m d'altitude, dont 3,1% à plus de 500 m. Ce sont, sur la frontière sud du pays, les Carpates, montagnes jeunes, alpines à l'est, et les Sudètes, monts hercyniens, à l'ouest. Elles s'étendent sur 5 voïvodies. Ce sont sur les espaces carpatiques, commençant à l'est par les Bieszczady, les voïvodies de Krosno, de Nowy Sącz et de Bielsko-Biała, et sur les espaces sudétiens, les voïvodies de Wałbrzych et de Jelenia Góra. Elles comprennent également une partie des Précarpates et des Sub-Sudètes. Au total, ces voïvodies occupent 7,5% de la superficie du pays et sont habitées par 8,7% de la population, dont pour les voïvodies des Sudètes respectivement 2,7% et 3,4%, et relativement plus grande est la part de la population rurale du pays (10%) laquelle se concentre surtout sur les espaces carpatiques (7,8%).

Ces territoires se caractérisent par une grande différenciation de l'utilité des conditions naturelles pour le développement de différents domaines de l'économie. Outre les parties les plus élevées des Beskides (altitude max. 1725 m), des Tatras (alt. max. 2495 m) et des Sudètes (alt. max. 1602 m), inutiles du point de vue de l'activité productrice de l'homme, mais attrayantes pour le tourisme et la récréation, peuvent se développer ici, auprès de différentes orientations de la production agricole et sylvicole, des fonctions industrielles, de sanatorium et de récréation.

Ces fonctions sont d'ailleurs favorisées par l'existence, notamment dans les Sudètes, de différentes matières premières, surtout énergétiques, chimiques et rocheuses, et également dans les Carpates, de sources d'eaux minérales, de valeur salubre.

A côté de la différenciation spatiale de conditions naturelles, l'aménagement par l'homme avait une grande, ou même décisive, influence sur la structure fonctionnelle actuelle des espaces ruraux en territoires montagneux. Les Sudètes, et notamment leur partie occidentale, appartiennent, à la différence des Carpates, aux territoires le plus tôt habités et le plus transformés par l'activité économique. L'industrie de ces territoires est l'une des plus anciennes en Europe. Le pilier de base de l'actuelle structure spatiale de l'industrie y date du XIXe siècle. De la même époque date le développement des fonctions de sanatoriums et touristiques, liées avec les sources d'eaux minérales, quoique par exemple Lądek-Zdrój et Cieplice étaient connus comme stations balnéaires au XVe siècle (Jankowski, Bohdanowicz 1975). D'autres fonctions se développent parallèlement sur ces territoires, par exemple l'agriculture, la sylviculture, tandis qu'à la même époque dans les Carpates se distinguaient avant tout l'agriculture et la sylviculture. Cela s'explique par le fait que dans le passé, les territoires des

Carpates et ceux des Sudètes avaient appartenu à des Etats différents du point de vue du développement socio-économique. Les territoires des Carpates, faisant partie de la Galicie, ont été à l'époque des partages de la Pologne (1772–1918) incorporés à l'Autriche-Hongrie. Les Sudètes, jusqu'en 1944, faisaient partie de l'Allemagne. Après la seconde guerre mondiale, la partie sud-est de la Pologne était un territoire à très forte densité de la population, de structure agraire très morcellée, à grand surpeuplement agraire et très faible développement de l'industrie et d'autres fonctions non-agricoles. Les Sudètes avec leur Bassin Industriel Sub-Sudétien par contre appartenaient aux territoires le plus développés, et occupaient une place importante dans la vie économique du pays.

Les différences dans la structure spatiale des espaces ruraux des Carpates et des Sudètes ont été accrues par les disparités dans leur développement socio-économique au cours des quarante dernières années. En ce temps, les processus d'industrialisation et d'urbanisation ainsi que la réforme agraire ont eu la plus grande influence sur les changements de la structure de la majorité des territoires ruraux en Pologne, y compris les Carpates. Sur les territoires restitués – dont les Sudètes, la plus grande influence a été exercée par le peuplement, à la place de la population d'origine allemande, par des populations venues des anciens territoires orientaux de la Pologne, des régions surpeuplées du centre et du sud-est, et aussi, par la réforme agraire et la création d'un fort secteur socialiste dans l'agriculture.

L'Institut de Géographie et de l'Aménagement du Territoire de l'Académie Polonaise des Sciences poursuit, entre autres recherches, des études sur la structure spatiale et sur la classification fonctionnelle des territoires ruraux, compris en tant que territoires multifonctionnels (Kostrowicki 1976). Ces études se posent pour objectif de résoudre une série de questions d'ordre méthodique, portant sur la classification d'objects multitraits en employant des critères et des méthodes garantissant la comparabilité des résultats obtenus dans l'espace et dans le temps, et, par la suite, une meilleure connaissance de la structure fonctionnelle des territoires ruraux en Pologne.

Les études ont d'abord été effectuées pour l'ensemble de la Pologne à l'échelle macro d'après les territoires ruraux de 49 voïvodies (Stola 1978, 1980), et ensuite, profitant des résultats obtenus, l'on a procédé au choix des territoires pour les études détaillées à l'échelle des communes, y compris les territoires montagneux des voïvodies de Nowy Sącz et de Wałbrzych, afin de vérifier à une autre échelle la justesse des critères et méthodes utilisées et de connaître en détail la structure fonctionnelle des territoires ruraux à différentes fonctions de base.

L'élaboration de la classification fonctionnelle a été précédée à chaque fois par une analyse des traits représentant la structure spatiale des fonctions réparties en trois groupes. C'étaient, au niveau des études à macro-échelle: I. Fonctions internes, à caractère biogénétique (agriculture, sylviculture, pêche, récréation), II. Fonctions externes, à caractère technogénétique (industrie, construction) et III. Fonctions de services. Par la suite, cette répartition a été modifiée, et au niveau des études détaillées, nous avons: I. Fonctions productives à caractère biogénétique (agriculture, sylviculture, pêche), appelées ensuite bioproductives (dénomination de J. Kostrowicki 1982), II. Fonctions productives à caractère technogénétique ou technoproductives (industrie, construction) et III. Fonctions de services ou non-productives (récréation, y compris tourisme, transports, résidence etc.). Le choix des traits diagnostiques les représentants a été précédé à chaque fois par l'étude d'un grand nombre d'indices caractérisant la structure de l'emploi et des sources de revenus de la population, les migrations pendulaires, la structure de l'utilisation du sol, les questions de la productivité et du degré de commercialisation de l'agriculture etc. On a choisi parmi ces traits seulement ceux qui paraissaient alors représenter relativement bien les différenciations fonctionnelles des espaces ruraux, en posant pour principe l'utilisation d'un nombre réduit de traits, la proportion gardée entre le nombre d'indices représentant des différentes fonctions et possibles à élaborer sur la base des données statistiques accessibles.

Par la suite, modifiant les méthodes utilisées dans la typologie de l'agriculture (Kostrowicki 1980; Kostrowicki, Szczęsny 1972; Stola 1983a), on a procédé à la normalisation des indices (variables) adoptés et à leur groupement[1]. Chacune des études antérieures y apportait des expériences méthodiques utiles aux élaborations ultérieures. En fin de compte, les essais méthodiques réalisés ont permis de préciser les fonctions de base des territoires ruraux en Pologne et d'élaborer les méthodes de leur classification (Stola 1984c) et ont apporté des résultats à caractère cognitif, qui forment également la base de ce rapport.

La classification fonctionnelle des territoires ruraux à l'échelle macro et des voïvodies choisies à l'échelle des communes a démontré que les espaces ruraux en montagne sont beaucoup plus différenciés que dans les autres parties du pays (Stola 1983b). En témoigne le fait que sur huit catégories fonctionnelles des espaces ruraux en Pologne distinguées à l'échelle macro (Stola 1984, fig. 1), seuls les territoires sudétiens, les voïvodies de Jelenia Góra et de Wałbrzych, ont été classées parmi les catégories distinguées, et d'ailleurs chacune d'elles dans une catégorie différente, par contre les territoires carpatiques et donc les voïvodies de Bielsko-Biała et de Nowy Sącz, ont été considérées en tant que catégories à part, ne ressemblant à aucune des huit catégories distinguées, et la voïvodie de Krosno, en tant que catégorie transitoire, ressemblant aux deux catégories.

Les territoires ruraux des Sudètes occidentales (voïvodie de Jelenia Góra) ont été classés dans la catégorie à prépondérance des fonctions non-agricoles, notamment industrielles et de récréation avec la participation de l'agriculture. Les grandeurs des indices des traits acceptés pour la classification (tab. 1) adoptent, après la normalisation, pour ces territoires, la forme du code suivant: 2, 1, 2, 4, 5, 4. Elles se distinguent par une faible densité de la population (moins de 50 habitants au km^2) et une faible part de la SAU (moins de 50%), constituant en assez grande partie la propriété des exploitations socialisées, principalement d'État (tab. 2). Près de 60% de la SAU appartient aux exploitations individuelles de 5 ha en moyenne. Elles se distinguent par un emploi assez faible (22 personnes/100 ha SAU), une productivité et un degré de commercialisation moyens (fig. 1–3). En général, seul le quart de la population rurale vit de l'agriculture (tab. 3). L'autre partie de la population tient ses revenus du travail dans l'industrie d'extraction et de transformation, dans différentes fonctions de services dont la récréation relativement bien développée (en moyenne 6–10 lits au km^2).

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[1] La normalisation des indices des traits a été effectuée en divisant leur valeur en 5 classes, auxquelles ont été attribués les rangs de 1 à 5 qui représentaient les valeurs des plus petites aux plus grandes à l'échelle du pays. Pour chaque unité examinée (p.ex. commune), la valeur de chaque variable a été exprimée par un chiffre (rang) adéquat, représentant la classe du trait donné. Les critères ainsi exprimés ont servi de base à la classification des unités examinées. Cette classification a été effectuée à l'aide de la méthode de déviation, souvent employée dans les études typologiques de l'agriculture. Les structures de variables identiques ou différent par la somme de déviations n'excédant pas 15–20% du nombre théoriquement possible de déviations (nombre de variables multipliée par 4) ont été admis comme appartenant à la même catégorie fonctionnelle d'espaces ruraux. Les structures qui diffèrent par un nombre supérieur de déviations étaient considérées comme des catégories différentes ou des structures intermédiaires.

TABLEAU 1. Indices des traits utilisés pour la classification des territoires ruraux à l'échelle des voïvodies et des communes

Pologne N°	Voïvodies de Wałbrzych et de Nowy Sącz N°	Indices	Classes 1 tres basse	2 basse	3 moyenne	4 élevée	5 tres élevée
1		Habitants au km²	0–30	30–50	50–70	70–100	> 100
2		% de la SAU dans la surface totale	0–50	50–60	60–70	70–75	75–100
	1		0–20	20–40	40–60	60–80	80–100
	2	% de la SAU socialisée dans la SAU totale	0–20	20–40	40–60	60–80	80–100
3		Nombre d'employés dans l'agriculture sur 100 ha de la SAU	0–25	25–30	30–40	40–60	> 60
	3	% de la production commerciale dans la production globale de l'agriculture	0–40	40–50	50–60	60–70	70–100
4		Nombre de lits dans les maisons de tourisme et de repos au km²	0–1	1–2	2–6	6–10	> 10
	4		0–2	2–4	4–6	6–10	> 10
5		% de la population non agricole	0–30	30–40	40–50	50–60	60–100
	5		0–20	20–40	40–60	60–80	80–100
	6	% des employés dans l'industrie et la construction dans le total des personnes actives professionnellement	0–10	10–20	20–40	40–60	60–100
6		Nombre de personnes se déplaçant vers le lieu de travail pour 1000 habitants en âge d'activité	0–200	200–300	300–400	400–800	> 800
	7	Nombre d'employés dans les services pour 1000 habitants	0–5	5–10	10–15	15–20	> 20

TABLEAU 2. Structure foncière de la SAU et structure de la taille des exploitations individuelles en 1982

Voïvodie	% de la SAU			% des exploitations de surface totale en ha						Moyenne des ha pour 1 exploitation individuelle	Emploi dans l'agriculture individuelle pour 100 ha de la SAU
	exploitations individuelle	exploitations de l'Etat	exploitations de coopératives	0,5–1	2–5	5–7	7–10	10–15	> 15		
Bielsko-Biała	90,4	3,1	4,8	56,6	34,0	5,6	2,5	0,9	0,4	1,9	52,1
Krosno	80,4	14,5	2,3	43,8	41,6	7,8	4,1	1,8	0,9	2,6	50,2
Nowy Sącz	94,7	1,8	0,8	29,9	41,7	13,5	9,1	4,3	1,5	3,0	51,5
Jelenia Góra	57,9	33,2	5,7	43,6	24,3	8,3	10,3	8,0	5,5	4,5	22,0
Wałbrzych	59,1	29,9	8,7	45,5	19,3	7,3	11,8	9,9	6,2	4,8	24,2

D'après *Rocznik Statystyczny GUS*, 1983 (l'Annuaire Statistique de l'Office Central des Statistiques, 1983).

TABLEAU 3. La population

Voïvodie	Population totale en milliers en 1982	% de la population rurale en 1982	Population rurale sur 1 km² en 1978	Accroissement naturel de la population rurale en 1982	% de la population non agricole dans la population rurale en 1978	% de la population rurale employée en dehors de l'agriculture en 1978
Bielsko-Biała	845	51,3	137	10,7	79,2	70,4
Krosno	456	68,2	56	12,0	62,8	52,0
Nowy Sącz	638	64,4	81	14,0	55,0	43,6
Jelenia Góra	496	35,8	48	11,2	74,2	69,7
Wałbrzych	719	27,2	58	10,5	67,1	60,9

D'après *Rocznik Statystyczny GUS*, 1983 (l'Annuaire Statistique de l'Office Central des Statistiques 1983): *Narodowy Spis Powszechny z dnia 7 XII 1978*, GUS, 1980 (Recensement National Général du 7 XII 1978, Office Central des Statistiques 1980).

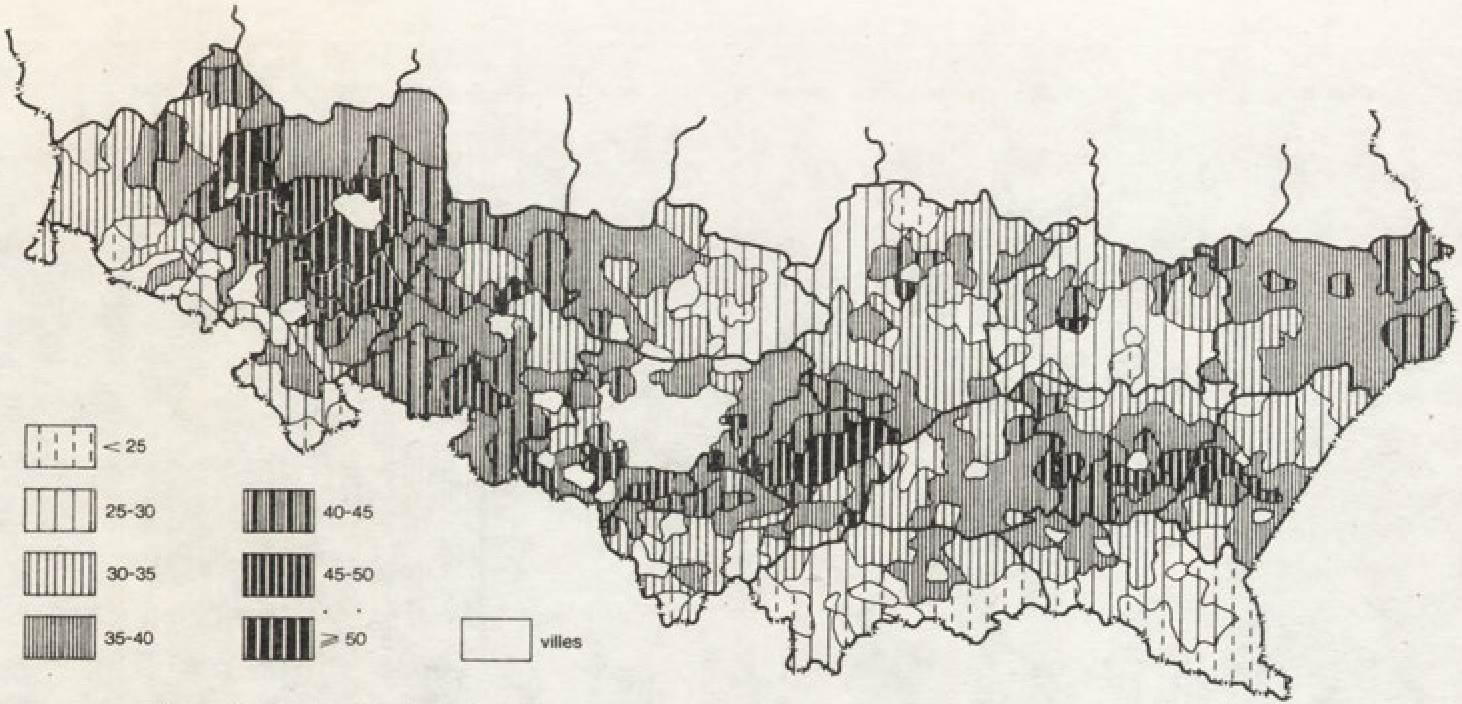

Fig. 1. Production globale de l'agriculture individuelle en millier de zlotys/1 ha SAU (d'aprés R. Kulikowski)

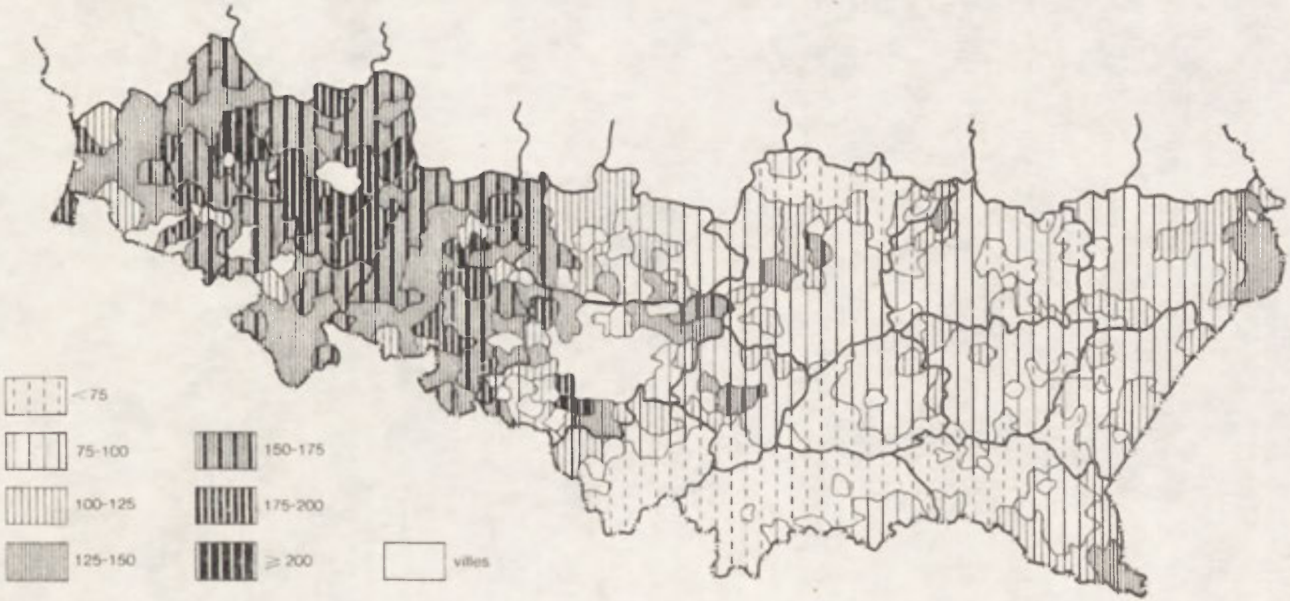

Fig. 2. Production globale de l'agriculture individuelle en millier de zlotys/1 travailleur dans l'agriculture (d'après R. Kulikowski)

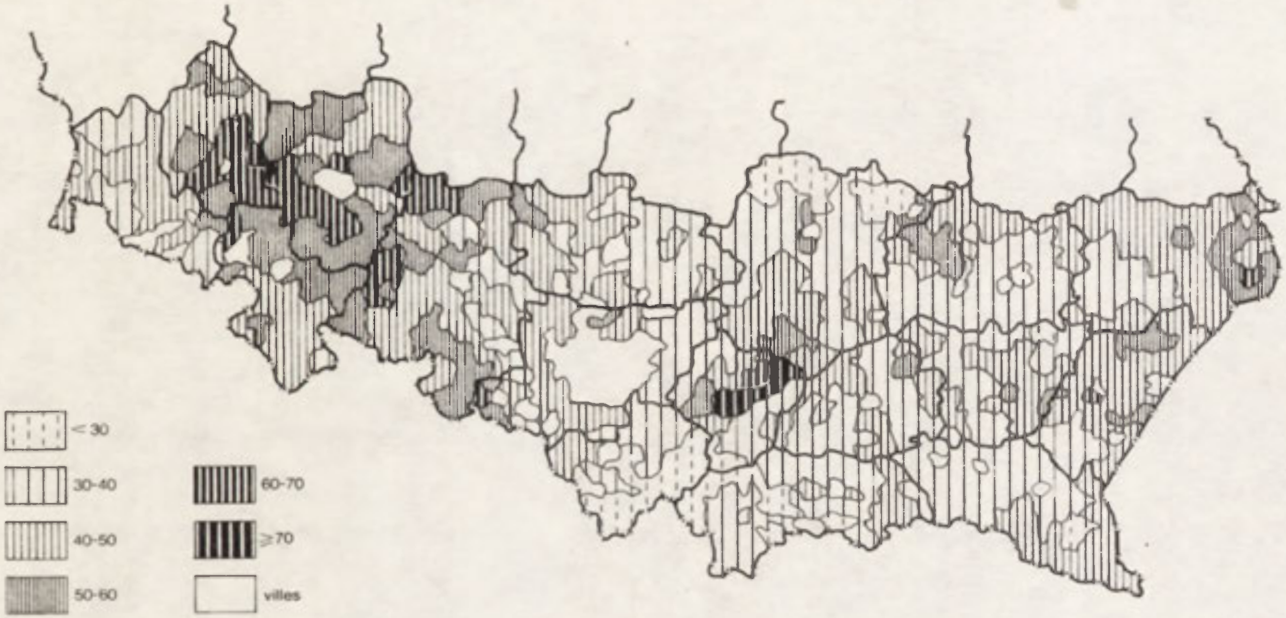

Fig. 3. Part (%) de la production commerciale dans la production globale de l'agriculture individuelle (d'aprés R. Kulikowski)

Par contre les territoires ruraux des Sudètes orientales, appartenant à la voïvodie de Wałbrzych, l'une des plus urbanisées en Pologne (la population urbaine était de 72,8% en 1982) ont été rangés dans la catégorie à prépondérance de fonctions technoproductives, et notamment industrielles avec la participation de l'agriculture (3, 3, 2, 3, 5, 4). En comparaison avec la catégorie précédente, celle-ci se caractérise par une plus forte densité de la population (58 hab./km²) et une plus grande participation de la SAU (60%) constituant à 40% des exploitations socialisées, et par une structure similaire d'exploitations individuelles mais qui obtiennent, grâce à un apport de capitaux relativement important, une productivité et une grandeur de production commerciale assez élevées. Une grande partie de la population rurale (67%) tire ses revenus du travail en-dehors de l'agriculture, et surtout dans l'industrie (environ 35% du total des personnes actives profesionnellement) et dans les fonctions de services.

Les études détaillées et la classification fonctionnelle à l'échelle des communes ont démontré une grande différenciation interne de la voïvodie de Wałbrzych. Sur 30 communes, dont 17 urbo-rurales où l'on a étudié séparément les territoires ruraux et les villes-chefs-lieux de communes, on a distingué six catégories fonctionnelles de territoires. Avant tout, un fait attire l'attention (fig. 4, cat. V, 3–4, 3, 2–4, 0–1,

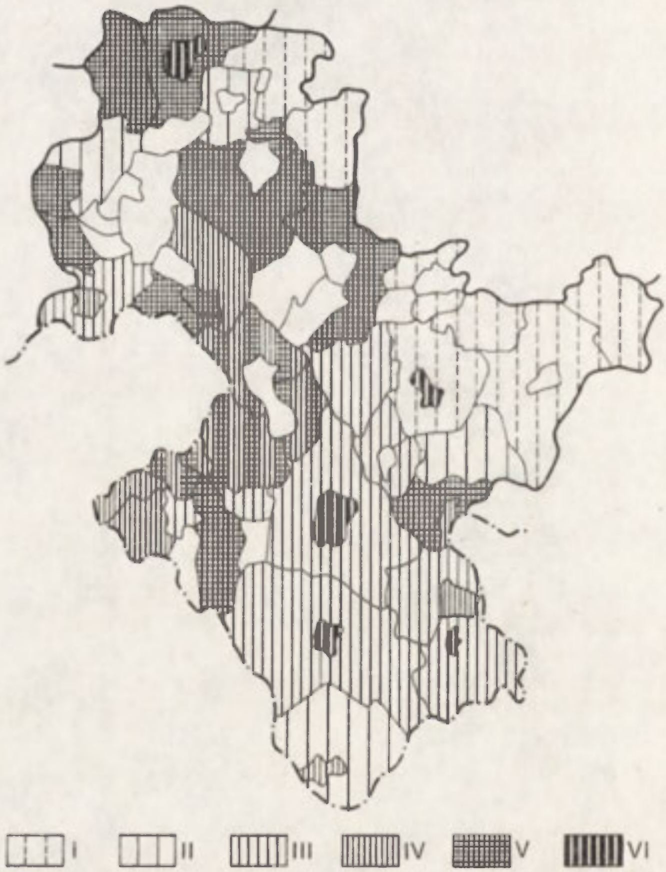

Fig. 4. Catégories (types) fonctionnelles des espaces ruraux de la voïvodie de Wałbrzych (I–VI)

4, 5, 1–3), à savoir que la catégorie à fonctions industrielles avec la participation de l'agriculture n'est présente que dans la partie nord-ouest, avoisinant l'agglomération de Wałbrzych, où la participation des employés en dehors de l'agriculture est de plus de 70–80% (dont 40–70% en moyenne dans l'industrie) du total des personnes actives professionnellement, tandis que dans les communes du nord-est avec prépondérance de fonctions agricoles (fig. 4, cat. I, 4–5, 2–3, 3, 0–1, 2–3, 2–3, 1–2), seulement 10–20%.

Sur les territoires occidentaux, à part l'industrie (cat. IV), ainsi que dans le Bassin de Kłodzko, entouré de montagnes boisées (le plus dans la commune de Stronie Śląskie – 75%) et riches en sources minérales, on trouve des fonctions de sanatorium et de tourisme à divers niveaux de développement (de 2 à plus de 10 lits au km^2) ainsi que l'agriculture ou la sylviculture (cat. III, 2–3, 2, 2, 2–3, 3–5, 2–3, 1–2, ainsi que cat. IV, 2–3. 1–2, 2–3, 5, 5, 3–5, 3–4). Il faut ajouter que sur les territoires frontaliers des Sudètes, y compris ceux entourant le Bassin de Kłodzko, on observe depuis quelques années le phénomène de disparition de l'habitat rural et de la régression du tourisme. Vers la fin des années 1940, les Sudètes possédaient environ 50% des investissements de tourisme et balnéaires du pays. Depuis ce temps, notamment dans les années 1970, entre autres à cause d'un développement plus rapide des investissements pour le tourisme et les vacances dans d'autres régions du pays (Carpates, Littoral, Grands Lacs de Mazurie etc.), on note une baisse relative de l'importance touristique des Sudètes. A l'heure actuelle, les territoires montagneux et prémontagneux assemblent en Pologne environ 40% de tout le mouvement touristique, et la participation des Sudètes n'est que de 10%. Cela reste certainement en relation avec les processus de l'exode rural des villages sudétiens situés en montagne vers les villes accentué notamment dans les années 1970, ce qui a fait qu'en ce temps (Stasiak 1983) l'exode rural surpassait ici nettement l'accroissement naturel. En fonction de quoi, ces territoires ont connu un processus inverse par rapport aux autres régions du pays, de même que dans les Carpates; à savoir, la migration pendulaire – de la ville vers le travail sur les territoires ruraux.

Les territoires ruraux des Carpates ont été considérés en tant que catégories à part ou transitoires, d'après la classification à l'échelle macro. Ainsi, les territoires de la voïvodie de Bielsko-Biała faisant partie ou voisinant l'influence de l'agglomération urbo-industrielle de Bielsko-Biała et, la plus grande en Pologne, celle de Haute Silésie, ont été inclus dans une catégorie à fonctions industrielles avec la participation de fonctions de tourisme et vacances, de fonction dortoir et d'agriculture (5, 2, 5, 5, 5, 4). Elle se caractérise, après la voïvodie de Katowice, par la plus grande, à l'échelle du pays, participation de la population non-agricole (plus de 80%), vivant du travail notamment dans l'industrie, dans la construction, dans la sylviculture locales etc., ou qui se déplace vers les centres urbo-industriels avoisinants, et encore dans les fonctions de récréation très développées (en moyenne au-dessus de 10 lits/km^2) dans le Beskide Silésien et de Beskide de Żywiec. La part relativement faible de la SAU (50%) appartient en général (tab. 2) à des exploitations individuelles très morcelées, en grande partie bi-professionnelles[2], demandant un grand apport de travail humain, comptant plus de 50 habitants/100 ha de la SAU, dont presque le quart a dépassé l'âge de 60 ans (18% en moyenne en Pologne). Cette agriculture, de productivité de la terre relativement basse et de très faible productivité du

[2] Le surpeuplement agricole de la campagne et le développement des processus d'industrialisation, notamment dans les villes, lié au développement relativement plus faible des processus d'urbanisation (surtout de la construction de logements dans les villes) ont créé un phénomène de migration pendulaire particulièrement développé dans les territoires des Carpates, concernant une population en majorité bi-professionnelle de paysans-ouvriers, et de semi-urbanisation, trouvant son expression également dans le caractère de l'habitat rural.

travail, est nettement une agriculture de subsistence et donc d'un faible degré de commercialisation.

Du point de vue de la part de la SAU dans la surface totale (50%), de la structure foncière et dimensionnelle des exploitations, du niveau élevé de l'emploi dans l'agriculture pour 100 ha de la SAU, de la productivité et du degré de commercialisation de l'agriculture (34%), les territoires de la voïvodie de Nowy Sącz ressemblent à ceux de la voïvodie de Bielsko-Biala. Ils se caractérisent également par des fonctions de récréation hautement développées. Ils diffèrent par contre par une plus faible densité de la population, une part nettement inférieure de la population non-agricole (53%) et un indice inférieur de la migration pendulaire. A l'échelle macro, elles ont été classées commes catégories à prépondérance de fonctions de récréation et agricoles (4, 2, 5, 5, 3, 2) avec la participation de la sylviculture.

La classification fonctionnelle de la voïvodie de Nowy Sącz, élaborée à l'échelle des communes à l'aide des mêmes indices et normalisés de façon identique (tab. 1) comme dans la classification de la voïvodie de Walbrzych, a démontré de très grandes disparités dans la structure et le développement fonctionnel entre les territoires ruraux de ces voïvodies, et donc entre les Sudètes occidentales et les Carpates centrales (cf. fig. 4 et 5), ainsi qu'une différenciation des territoires à l'intérieur de la voïvodie de Nowy Sącz.

Fig. 5. Catégories (types) fonctionnelles des espaces ruraux de la voïvodie de Nowy Sącz (I–VII)

Au total, sur 54 unités comportant 28 communes rurales et 13 communes urbo-rurales étudiées séparément, on a distingué quatre catégories présentes notamment sur les territoires ruraux, et deux dans les villes-chefs-lieux de communes, et une commune a été considérée en tant que catégorie à part.

La catégorie II (fig. 5) est représentée le plus souvent, surtout dans les territoires septentrionnaux, à la limite des Beskides et des Pré-Carpates; elle comporte des fonctions agricoles à participation relativement importante de fonctions techno-productives (3–4, 1, 1, 1–2, 3–4, 3, 1–2). Elle se caractérise par une agriculture en grande partie individuelle, très morcelée, en général à petit degré de commercialisation (1). La part moyenne ou élevée de la population non-agricole (3–4), co-habitant souvent avec l'utilisateur de l'exploitation agricole et vivant en plus du travail dans l'agriculture, trouve la source de ses principaux revenus le plus souvent dans le travail dans l'industrie et dans la construction (3) dans le lieu d'habitation ou se déplace vers le lieu de travail dans les centres urbo-industriels.

A côté de cette catégorie on trouve pour la plupart des territoires (I cat., 3–4. 1, 1–2, 1–3, 2, 1–2, 1–2) à fonctions agricoles, peu commerciales, ou, dans la région arboricole des Carpates, moyennement commerciales (3) avec un faible développement d'autres fonctions. Ou encore, sporadiquement, les territoires (cat. III, 2. 1–2, 1, 2–4. 3, 2, 1) à prépondérance de sylviculture avec participation de la récréation ou de l'industrie. Par contre dans les parties méridionales des Beskides, dans la région de Podhale, domine la catégorie V (2–4. 1, 1, 5, 3–4, 2–3, 1–3) à fonctions de récréation (5) avec la participation de l'agriculture ou de la sylviculture et avec une aussi importante part de la population non-agricole, tenant ses revenus davantage du travail dans les fonctions de services, dont certaines liées au tourisme. Sur ces territoires, on rencontre assez souvent le tourisme "rural", à savoir, la population locale joint au travail agricole la location de chambres et les services touristiques (p.ex. le village de Bukowina). A part cela, sur les territoires carpatiques peu éloignés du point de vue des transports des centres urbo-industriels s'est développée, notamment dans les années 1970, la construction de résidences secondaires.

Les villes-chefs-lieux de cinq communes se caractérisent par un développement prononcé de fonctions de sanatorium et de vacances (fig. 5, cat. VI) ainsi que de services (1–3, 0–2, 1, 5, 5, 2, 5). Les sièges des autres communes ruro-urbaines, sauf deux, ont été classés dans la catégorie V (3, 1, 1–2, 5, 5, 4, 4) à fonctions industrielles, de sanatorium et de services avec la participation de l'agriculture.

Les territoires du Bas-Beskide situés dans la partie sud-est de la voïvodie de Nowy Sącz différent du point de vue (cat. VII) fonctionnel des catégories sus-mentionnées. Elles ressemblent probablement aux territoires voisins de ce Beskide, appartenant à la voïvodie de Krosno.

Les espaces ruraux de la voïvodie de Krosno, situés dans le sud-est de la Pologne possèdent, à l'échelle macro (3, 1, 4, 3, 4, 3), beaucoup plus de similitudes sous certains aspects, p.ex. densité de la population, développement de l'agriculture (structure agraire, productivité et commercialisation), avec la voïvodie de Przemyśl, voisinant du côté nord, ou encore, p.ex. sous l'aspect de la structure de l'emploi de la population, des migrations pendulaires – plus à la voïvodie de Rzeszów qu'à celle de Nowy Sącz. De façon générale, les territoires montagneux de cette voïvodie, notamment les Bieszczady, différent des autres territoires carpatiques avant tout par une densité de la population nettement plus faible, 25 habitants/km^2 (tandis que sur les territoires occidentaux des Carpates elle arrive à 100–150 habitants/km^2), par une participation relativement plus importante de la population non-agricole, une participation nettement inférieure, au profit des forêts, de la SAU, appartenant en assez grande partie aux exploitation d'État (tab. 2). L'agriculture individuelle se caractérise, comme dans les autres territoires des Carpates, par une faible productivité de la terre mais une productivité du travail et un degré de commercialisation un peu plus élevés (cf. fig. 1–3). Quoique ces territoires se caractérisent par de grandes valeurs touristiques les fonctions de récréation sont relativement peu développées. Ceci est sans aucun doute la conséquence d'un faible peuplement des territoires périphériques par une population immigrante, à la place des *Lemkowie* qui vivaient là auparavant, d'un faible développement de l'infrastructure technique et nottament de l'accès aux transports. La population non-agricole tient ses revenus du travail dans les entreprises locales, à l'abattage des forêts et au traitement du bois, ou bien se déplace pour travailler en ville.

Sans doute, l'élaboration de la classification fonctionnelle à l'échelle des communes pour tous les territoires montagneux, en employant une liste uniforme et élargie des indices de traits (Stola 1983c) et de méthodes identiques, aurait permi d'obtenir une image plus complète de la différenciation fonctionnelle des espaces examinés.

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GEOGRAPHIA POLONICA 52. 1986

TRENDS IN CHANGES OF LIVING STANDARDS IN POLAND, 1960–1981. AN ATTEMPT AT DEFINING REGIONAL DISPARITIES*

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1. PRELIMINARY REMARKS

Under the term of living standards we understand a vast complex of problems, such as determinants of living conditions, favoured models of consumption, style or way of life, to begin with. Living standards have their global dimension on the scale of a continent, given civilization or state and, at the same time, an individual and physical dimension related to a man, a family, a household, a social-professional group, regional or local community, as well as to social strata and classes. They are a resultant of the effects of many different factors and undergo constant changes. This variability comes as a result of historical processes, economic-political situation of the country, and *curriculum vitae* of individuals (Ciechocińska 1981, 1983).

In classical anthropological approaches the stress is laid on the influence of geographical environment upon living standards and dependencies are pointed out between properties of physical and socio-economic spaces. Disregarding the difficulties when it comes to operationalization, there are many adherents of integrated approach which combine working, recreation and housing conditions. It should be stressed, however, that such approaches incur demographic-social limitations as not all members of the population are – for instance – professionally active.

Living standards are a product of definite social relations formed under a given political-economic system which, in general, determines the existence of permissible disparities, as well as the terms of access to socially valued goods. In the present study the problems of living standards have been confined exclusively to regional disparities resulting from differences in the levels of socio-economic development. The existing disparities have been produced by a centuries long historical process and by spatial inequality of economic development. These phenomena are well known and broadely described in literature. Now they are put to an empirical test under conditions of socialist industrialization doctrine carried into effect, and of a changed dynamics of economic growth in a socialized and centrally planned economy.

* The author wishes to thank Dr Zenon Piasecki for consultation in selecting quantitative methods and provided computations.

2. APPLIED INDICATORS

Four indicators. the usefulness of which had been earlier tested experimentally (Ciechocińska 1975, 1984), were adopted as a basis for evaluating trends in changes of living standards. The obtained results encouraged the continuation of the studies even though certain symptoms indicated that the adopted indicators were getting out of date. However, among other things, the fact that they allow extension of the time series thus expanding interpretative and cognitive possibilities, convinced the author to use the same indicators again (Bielecka, Paprzycki and Piasecki 1979).

This is a vital argument, since a new administrative division of the country was introduced in 1975, largely limiting the possibilities of carrying out retrospective regional studies. Moreover, economic situation of the country has changed, bearing evident traits of profound economic collapse. The use of the same indicators give a possibility to observe how living standards and regional structures were getting differentiated, depending on changes in the economic situation of the country.

The indicators used here illustrate the level of the population's income estimated on the basis of the volume of retail sales in socialized trade per one inhabitant; cultural consumption and the standard of well-being was estimated on the basis of the number of TV subscribers per 1000 inhabitants; the standard of health service – on the basis of the number of physicians per 10000 inhabitants; and housing conditions – on the basis of the average number of persons per one room.

The first three of the mentioned indicators (Table 1) showed a regular growth.

TABLE 1. National average of indicators applied to investigate trends in changes of regional living standards in Poland, 1960–1981

Year	National average			
	volume of retail sales in socialized trade per capita (in zlotys)	physicians per 10000 population	TV subscribers per 1000 population	average number of persons per room
1960	6964	2.6	14	1.66
1970	12685	15.1	129	1.37
1975	23700	15.9	189	1.21
1980	36900	17.8	223	1.11
1981	41400	18.0	227	1.10

Source: Statistical Yearbooks, GUS, Warszawa.

A decrease of the fourth indicator also proved an improvement of living standards. The latter did not mean, however, that the housing problem had been solved or painful shortage of flats liquidated in Poland. The average number of persons per one room give an indirect information on how many people live in a flat, while many families – especially young ones – do not have an independent flat yet. In many regions of the country people registered on the lists of future flat-holders have to wait no less than 15 years to get one (Kulesza 1982).

The applied indicators were characterized by a differentiated dynamics of growth which, as it can be seen on Table 1, reached the highest level in the 1960–1970 decade. It was then that a record increase was noted in the number of TV subscribers, connected with the construction of a network of TV stations in the country. At the end of the next decade the demand for TV sets was virtualy satisfied and the indicator relating solely to black-and-white TV sets was no longer a differentiating factor. Only colour TV sets became such a factor.

Enormous increments in the value of retail sales in socialized trade, counted in zlotys per one inhabitant, give information that cannot be interpreted explicitly, however. This is so because they occurred over relatively very short periods of time when constant prices were strictly observed, followed as a rule by periods accelerated price rises when a ban on price increases was lifted and new prices were introduced officially. On the other hand, it was a classical inflation process. Therefore, although sales indicator could show upward tendencies it was accompanied by physical shortage of goods on the market and unsatisfied consumers' demand.

Such were macro-economic and multi-dimensional problems of inflation, depreciation of the money and devaluation of the zloty, while increasing well-being or pauperization of the population were appearing alternatively. It is worth adding that in periods of total market breakdown, for instance in 1981, direct exchange transactions of goods for goods became widespread and the role of non-market supplies for the population was visibly growing. In such conditions certain social groups and regions were in a privileged situation.

The indicator of the number of physicians per 10000 inhabitants showed a relatively slow increase. But this is not the best illustration to show whether free medical care was generally available in the regions. For instance, in 1973 six million people who earned their living on private farms, were covered by free medical services under an administrative decision and health care over them was entrusted to state medical centres without expanding them accordingly.

So, in Polish conditions provision of adequate equipments to such medical centres as dispensaries, hospitals, clinics etc., are more important for evaluation of regional disparities in the standards of health service than any other criteria. Unfortunately, there are no indicators that would show the level of investments on medical equipments and delays in that sphere are considerable in comparison with other East European countries.

3. CONNECTIONS BETWEEN DYNAMICS OF ECONOMIC GROWTH AND REGIONAL DISPARITIES IN LIVING STANDARDS IN 1960–1970

Economic growth is identified with the average annual increase of the national income. In the light of the applied indicators the decade of the 1960s, was marked by a general spread of TV, relatively quickest improvement of the housing situation and a development of the health service. Only the indicator of retail sales in socialized trade showed lower dynamics that could be regarded as non-inflation in comparison with the next decade. But in spite of that, evaluation of living standards was negative in people's view. Workers' protests that erupted in the December of 1970 was an expression of disapproval of too low and slow improvement of living standards which were considered as unsatisfactory, all the more so as an evident regress was noted in certain domains.

In the 1960–1970 decade the annual growth rate of the produced national income stood at 6.1%, while of the distributed at 5.8%, and the average annual growth rate of consumption amounted to 5.3%. An increase of labour productivity was not accompanied by higher earnings. Economic growth was favoured for doctrinal reasons while the role and importance of social development elements was neglected in practice. Under conditions of social ownership of production means, economic activity was identified with the implementation of the objectives of socialism defined as the highest possible satisfaction of constantly growing material and cultural needs of the people.

Both, socialist doctrine of industrialization and regional policy were to serve those objectives. Seeing in industrial development an instrument that would help to make up for neglects in regional development, they tended to expand the industry locating new industrial plants with a view of balancing the existing regional disparities also in the sphere of living standards.

The studies were carried out for the set of 323 spatial units (poviats) in 1960 and 1970. The values of indicators for individual spatial units were compared with the national average and five living standards were distinguished on that basis for each time section.

Meridional distribution of economically highly developed and underdeveloped regions, confirmed by the studies under discussion, is a characteristic feature of spatial structures in Poland. This arrangement is presented on Fig. 1. We can see there that areas of the highest living standards are situated mostly in the west and are less frequent in the north of the country. The roots of those divisions lie in political decisions that were taken late in the 18th century. Intensive economic development in the 1960–1970 decade caused a shift, seen on Fig. 2, of the units marked by the highest living standards from the northern and western parts to a part of central and eastern Poland.

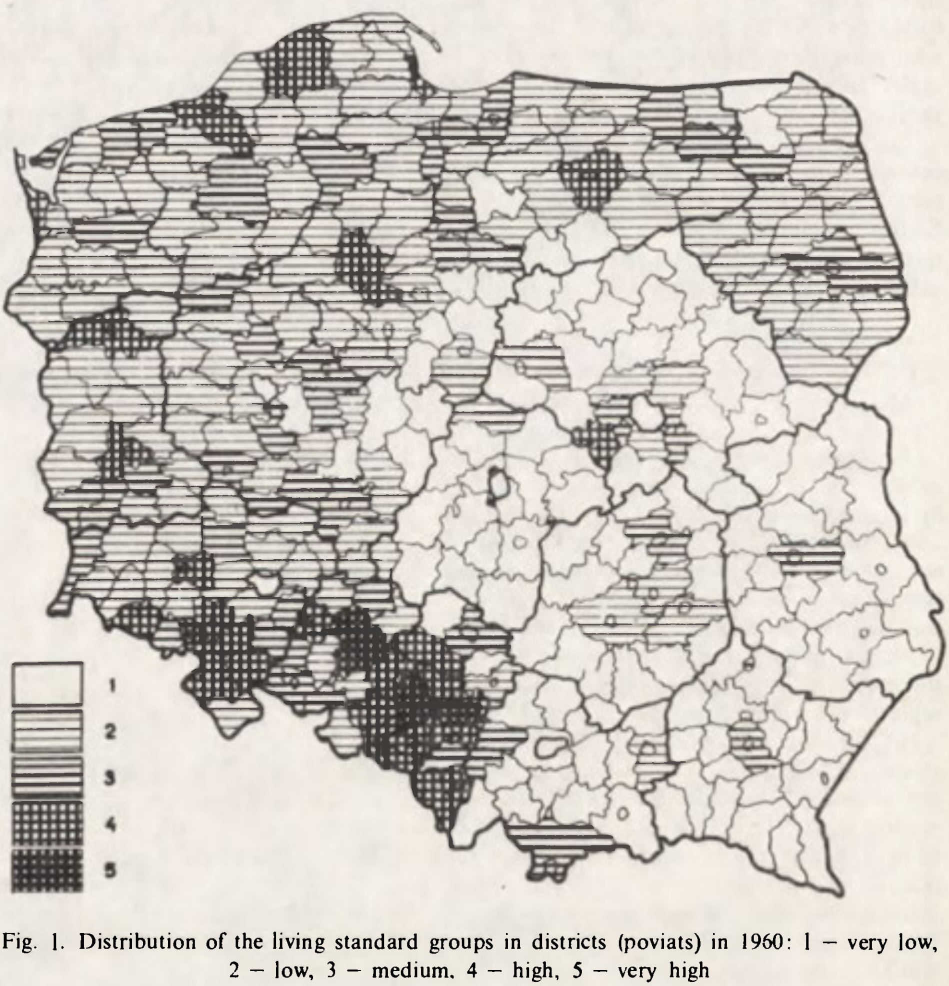

Fig. 1. Distribution of the living standard groups in districts (poviats) in 1960: 1 – very low, 2 – low, 3 – medium, 4 – high, 5 – very high

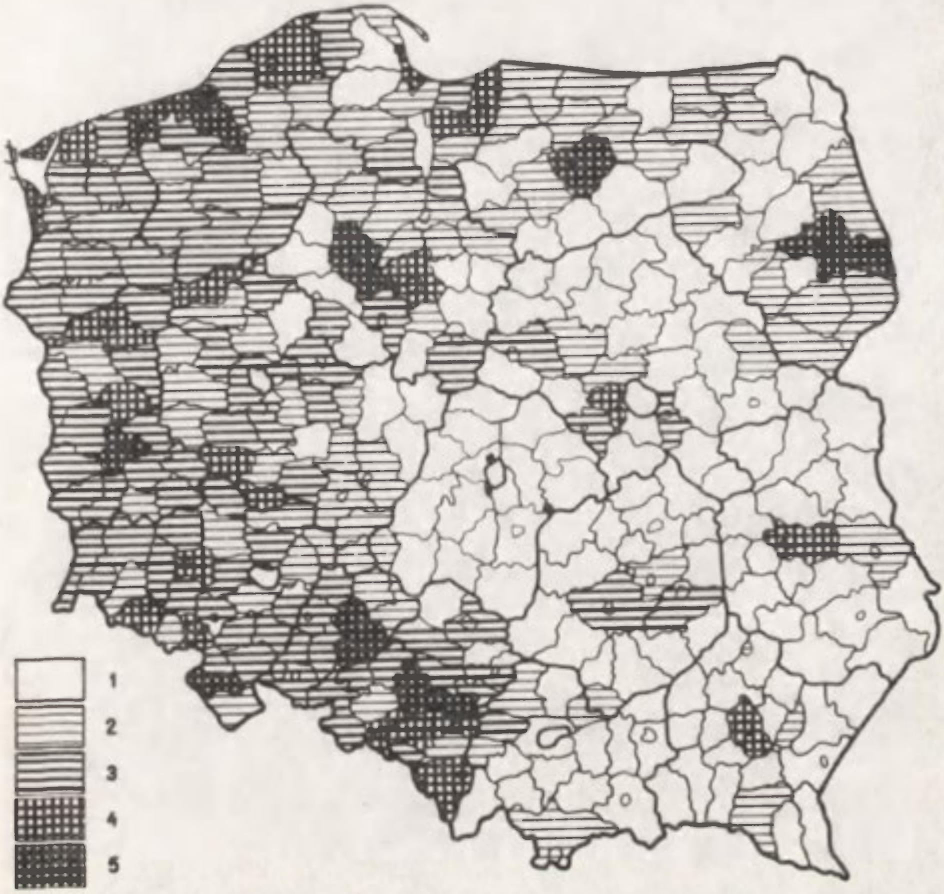

Fig. 2. Distribution of the living standard groups in districts (poviats) in 1970: 1–5 – cf Fig. 1

This shift must not be interpreted, however, as promotion of one and degradation of other units since in each case indicators related to other national averages. A general increase of discussed indicators occurred in all units with a reservation, however, that it was not equal on different areas. Figure 3 presents an analysis of the noted shifts and at the same time points out those units which kept unchanged living standards. We can also see how numerous were those units in which living standards either rose by one or two groups or fell down. This was a decade marked by high polarization of regional development as proved by the data in Table 2.

In 1970 an increase could be noted in the number of standard-I and -V groups on the extremities of the distribution of spatial units. It was accompanied by a heavy drop in the number of standard-IV groups as compared with the 1960 figure. The 1960–1970 decade saw a rapid polarization of the units belonging to standard IV in 1960. A majority of them advanced to higher standards and only some of them moved down to the group with the lowest living standards on the national scale. Thus, on the basis of the data in Table 2 we may speak of a relative growth of groups with the highest living standards as the number of units rated among the standards from I to III totalled 127 in 1970 against 95 only in 1960.

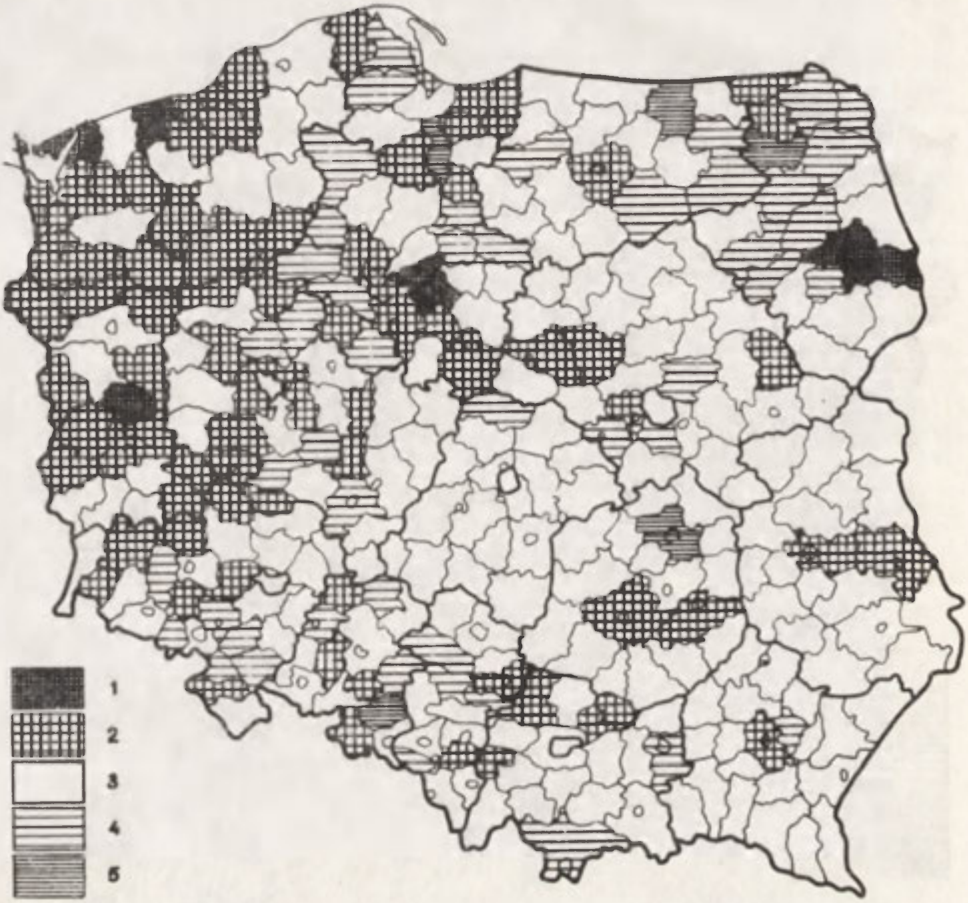

Fig. 3. Dynamics of the living standard groups in districts (poviats) in 1960–1970: 1 — shift to higher living standard by one group; 2 — shift to higher living standard by two groups; 3 — no change; 4 — shift to lower living standard by one group; 5 — shift to lower living standard by two groups

TABLE 2. Spatial units (poviats) according to living standards, 1960–1970

Year	Total	Living standard				
		very low I	low II	medium III	high IV	very high V
1960	323	108	120	50	34	11
1970	323	119	77	81	26	20

Source: M. Ciechocińska (1975), p. 200.

Accordingly, the number of units belonging to the standards IV and V dropped from 228 in 1960 down to 196 in 1970.

In a word, they were a symptom of a general trend towards improvement of living standards. This conclusion cannot overshadow the fact that a visible growth of the number of units with the lowest living standards on the national scale took place at the same time, as can be seen on Table 2.

The trend towards improvement of living standards was not equal, however, in all the regions. No changes took place in 187 units, that is in more than a half (58.0%) of the total number. This means that they preserved an unchanged standard and the reached improvement corresponded to the national average. A visible improvement of living standards which went up above the average level, was noted in 83 units, that is 25.0% of the total, which moved up to higher groups. A reverse situaton took place in 55 units making up 17.0% of the total.

A generally known pattern of regional development could be stated in those years, namely, regions representing higher living standard in the initial year were developing faster than backward regions. To make it short, the 1960s saw a continuation or an increase of the existing disparities, instead of a process of equalizing living standards in a period of economic growth, and this reverse process came as a result of polarization both in western and in eastern parts of Poland.

4. ECONOMIC GROWTH IN THE YEARS 1971–1981

The upward trend of economic growth in Poland totally collapsed in 1979, as it can be seen on Fig. 4 showing how the produced national income dropped at that time. But it was not earlier than in the summer of 1980 that the crisis became the subject of outspoken discussions, although its symptoms could be seen much earlier in different sectors of the economy. A drop in agricultural production took place in 1973, affecting in the initial phase mainly the non-socialized sector. Socialized agriculture enjoying privileges in the state policy of means distribution noted a smaller drop. In 1976 socialized building industry broke down, although the crisis did not affect yet the non-socialized sector of the industry, etc.

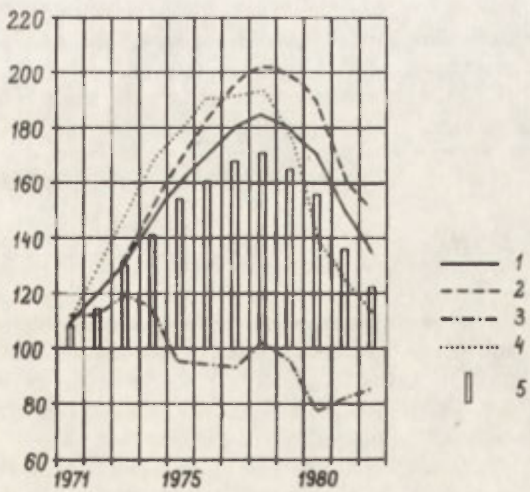

Fig. 4. National income produced in 1970–1982 (constant prices), 1970 = 100: 1 – total, 2 – industry, 3 – agriculture, 4 – construction, 5 – total per capita

There can be different opinions on what was the succession of the national economy sectors hit by the crisis. The image may slightly differ, depending on the used method in calculating the national income, whether chain indices are applied with the previous year being the basis for comparisons, or a constant basis is taken e.g. 1960 = 100 or 1970 = 100, whether constant or current prices are taken into consideration.

But, considering the range and depth of the Polish crisis, those questions are of minor importance in analyzing the lowering living standards in the regions. The very fact that the produced national income fell down forecasts dangerous consequences. In the early 1970s Poland's economic development was largely financed by foreign sources mostly through credits raised abroad. Over a very short period large amounts of new technologies, machines and installations flew into Poland exceeding her absorptive possibilities and causing overheating of the economy.

The chances of living on credit are always limited and the continuation *a la long* of the existing standards is usually effected at the cost of future generations doomed to lower ones in consequence. Relations between the amounts of the produced and distributed national income are fundamental in economics. We do not mention here analyzes of the factors determining a growth of the produced national income, that is of the share in that income of invested capital and of working force outlays. It is worth noting that although the growing trend in the distributed national income broke down already in 1977, in the light of the data released by the Central Statistical Office downward tendencies caused by the crisis in the sphere of social consumption (consumption of material goods by the population, paid from personal incomes) appeared only in 1981.

So, we encounter here a phenomenon of at least three year delay in the decline of consumption as compared to economic factors which determine it. This was so because the state made attempts to protect the interests of the population at the cost of the interests of the economy. Observations made here seem to prove that at the turn of the 1970s and 1980s welfare functions of the state dominated over organizational-production functions. This can be also interpreted as domination of short-term solutions over long-term structural solutions while the need for the latter appeared together with the first symptoms of the crisis. These statements are vital in an analysis of the drop of living standards on regional scale as the latter should not be overlooked when obtained results of the studies are interpreted.

The question remains open how long the people and the economy may be treated separately, considering the fact that the interest of the economy is also the interest of the people with the only reservation, namely the latter is more noticeable in relation to future generations. Contrary to running opinions the future is neither as distant or indefinite as we use to think. We must simply view it in terms of a postponement of the necessary decisions whose delay can mean nothing else but higher costs.

It is interesting to watch how general relations between accumulation and consumption were disposed in the national income for distribution, especially so as a big investment programme was being put into operation in the 1970s with the Katowice steelworks as its leading target. As it follows from Fig. 5, beginning with 1978 net investment outlays on fixed assets, spent within the accumulation framework, were marked by a rapid downward trend the first symptoms of which were noted already in 1977, if we do not take into account the decline that took place in 1975. When we put aside share downfalls we can see that the curve illustrating the increase in material circulating assets and in stocks had a very similar line.

Summing it up, the facts discussed here entitle us to divide the 1971–1981 decade into two parts, the first of which 1971–1975 was characterized by the relatively highest economic growth, see Table 3. As for regional disparities in living

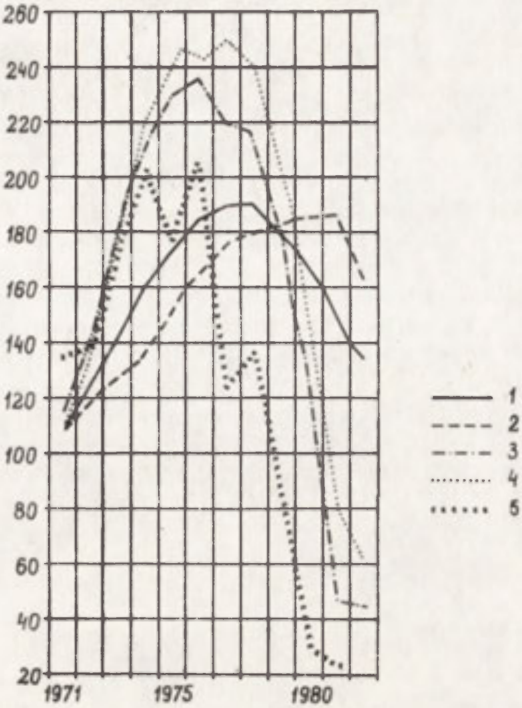

Fig. 5. National income distributed in 1970–1982 (constant prices), 1970 = 100: 1 – total, 2 – consumption, 3 – capital formation, 4 – net investment outlays on fixed assets, 5 – increase in material circulating assets and in stocks

TABLE 3. Rates of growth of the national income in 1961–1982 (constant prices)

Specification	Average annual growth rates (percent)			
	1961–1970	1971–1975	1976–1980	1981–1982
National income produced	6.1	9.8	1.2	−8.8
socialized economy	7.6	11.6	1.6	−11.1
non-socialized economy	1.3	1.3	−0.8	3.2
per capita	5.1	8.8	0.3	−9.6
National income distributed	5.8	12.0	−0.2	−10.5
consumption per capita	3.8	7.5	3.4	−10.3

Source: *Rocznik Statystyczny 1979*, 1983, GUS, Warszawa.

standards it meant continuation of the trends in the 1960s; and the second half was marked by numerous signs of economic breakdown which augured heavy crisis of the 1981–1982 years (Table 3). An analysis of the 1975–1981 regional disparities in living standards was carried out in this context.

5. CHANGES OF REGIONAL DISPARITIES IN LIVING STANDARDS IN 1975–1981

The analysis of the changes of regional disparities in living standards was carried out for 49 so-called small voivodships which replaced 17 big voivodships when a new territorial division of the country was put into effect in 1975 after district-level units had been liquidated. To limit subjective evaluations taxonomic method was used, the so-called Wroclaw taxonomy (Perkal 1953).

The tables were drawn up of mutual taxonomic distances for the set of 49 voivodships in four-dimension space of diagnostic variables (adopted indicators defining their mutual positions). The tables were used in dendrite grouping of the analyzed set to investigate the disparities between regions. The research problem amounts to finding an answer to the question whether the existing disparities diminished or increased in the years 1975–1981.

Dendrite grouping was made on the basis of the criterion of the closest similarity defined by using taxonomic distances (Vielrose 1967) for the 1975 and 1981 time sections. As Fig. 6 and 7 show, in both cases dendrite linkages of the first degree were composed of 13 sub-sets. Essential differences appeared, however, in internal structures of the analysed sets of units.

The set of first-degree dendrites in 1975 was marked by a greater differentiation of the number of individual sub-sets. This is proved by the existence of one dendrite linking as many as 12 units, and of five dendrites linking only two voivodships each. As it is seen on Fig. 6 three dendrites linking 5 and more units grouped nearly

Fig. 6. First degree dendritic linkages in the set of regions in 1975: 1 – number of voivodship, 2 – taxonomic distance between a and b voivodships, 3 – number of dendrite

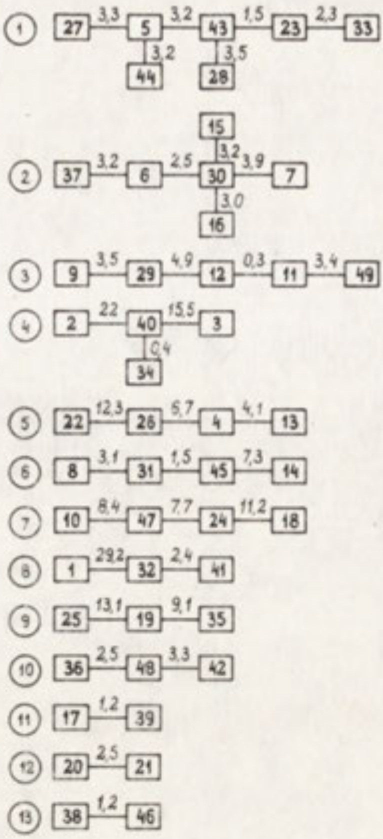

Fig. 7. First degree dendritic linkages in the set of regions in 1981

one half of all voivodships situated mainly in eastern and central parts of Poland. They were relatively weak regions (Kukliński 1983, 365).

In 1981 essential changes took place in the disparities between regions, measured on the basis of a similarity of the investigated units. In the first place, the number of individual dendrites was more equally spread. Less numerous were the units belonging to the biggest and the smallest dendrites. At the same time, more numerous were dendrites linking as similar voivodships situated in the east and west of the country, see dendrites 1 and 5 on Fig. 7. The year 1981 indicates great changes; this is proved, among other things, by great variability of the compositions of individual dendrites in the two compared time sections. The same units which in 1975 appeared also jointly in dendrites 1, 5, and 13, in 1981 could be found only in a few dendrites such as 4, 7, and 6. In general, this is a proof that a trend appeared to equalize the disparities.

A relatively big number of the first-degree dendrites (13) and considerable shifts in configurations of similarities, illustrated by assembled dendrites, makes it practically impossible to use them in quantitative comparisons of the observed changes. Cognitive value of the composed dendrites depends on the disclosure of the variety of occurring changes.

Individualization of the investigated units, based on the properties of their similarities, brings in new elements which usually get lost in aggregate approaches.

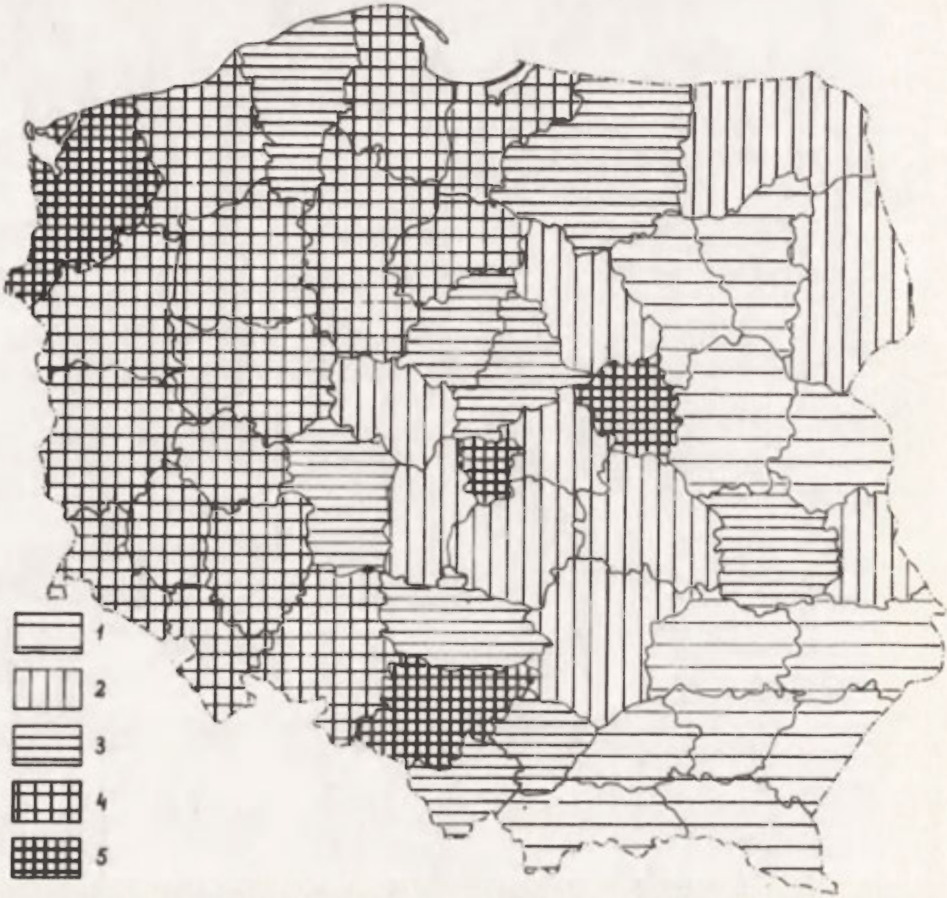

Fig. 8. Distribution of the living standard groups in voivodships in 1975: 1–5 – cf Fig. 1

This hampers to formulate valuation judgements. Nonetheless, a detailed analysis of the shifts between dendrites was abandoned and an attempt was made to define in quantitive terms the changes of inter-regional disparities in living standards. Taxonomic distances between individual voivodships were adopted as a basis for this analysis while the Warsaw voivodship served as a point of reference. The indices applied for the Warsaw voivodship possessed on the whole the most favourable values.

The appearing taxonomic distances were arbitrarily divided into five equal groups supposedly representing living standards:

– group I – voivodships of relatively lowest living standards (taxonomic distances 150–120.1),

– group II – voivodships of relatively low standards (taxonomic distances 120–90.1),

– group III – voivodships of average standard (taxonomic distances 90–60.1),

– group IV – voivodships of relatively high standard (taxonomic distances 60–30.1),

– group I – voivodships of relatively lowest living standards (taxonomic distances 0–30).

The distinguished standards provided the basis for making cartograms (Figs 8, 9, 10)

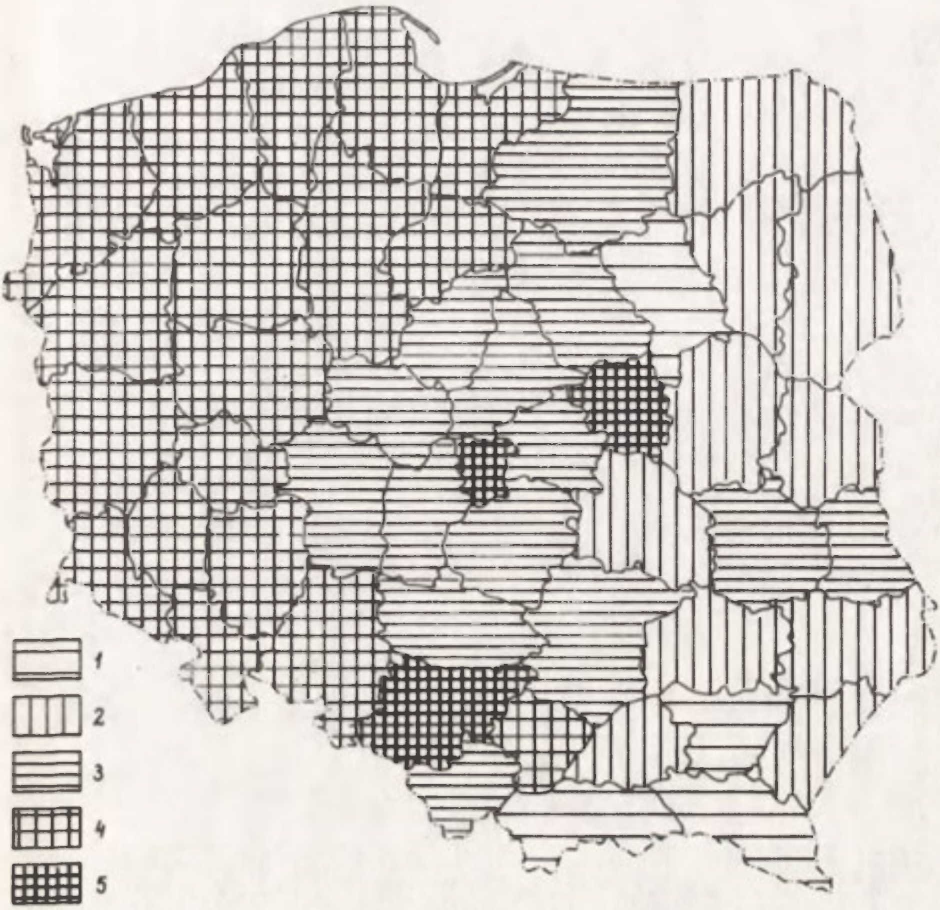

Fig. 9. Distribution of the living standard groups in voivodships in 1980: 1–5 – cf Fig. 1

corresponding to the 1975, 1980 and 1981 time sections. The situation in 1975 (Fig. 8) corresponds on the whole to the general situation in 1970 (Fig. 2). Meridional distribution is well visible. It divides Poland into the East where the lowest and most differentiated standards are predominant, and the West characterized by an equal spread of high living standards, with two exceptions – an average standard in Slupsk voivodship and the highest one in Szczecin voivodship.

Thus, the analysis of taxonomic distances in 1980 (Fig. 9) in the western part of the country indicates that the whole area, the two mentioned voivodships put aside, is homogenous from the point of view of its living standards. On the other hand, in the eastern part where in 1980 (Fig. 9), as compared with 1975 (Fig. 8), many regions shifted to the group of higher living standards closer to those in the Warsaw voivodship taken as a sample, a great dynamics was noted in the analysed changes. As economic crisis was increasing this trend was visibly gathering momentum; this is proved by comparing the situation in 1981 (Fig. 10) and that in 1980 (Fig. 9). This is an illustration of the flattening of disparities in living standards and we may guess that the same applies to other aspects of regional development in the situation of an economic breakdown.

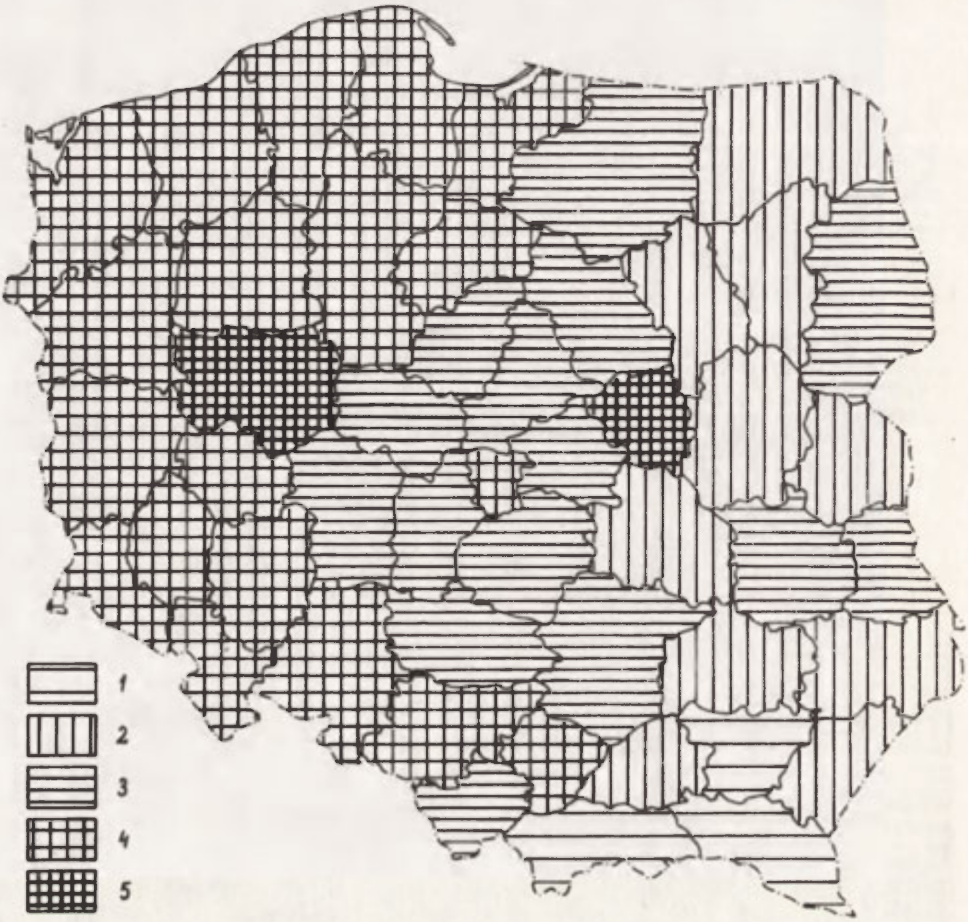

Fig. 10. Distribution of the living standard groups in voivodships in 1981: 1–5 – cf Fig. 1

The crisis affected more heavily the regions with higher industrialization and urbanization level. Their development in the period under discussion was relatively slower than in many other regions having until then lower living standards. As a result of this process, voivodships considered to be strong (Kukliński 1980; Najgrakowski 1981) maintained their former small taxonomic distances in relation to the Warsaw voivodship, while a number of economically less developed voivodships noted a higher rate in the improvement of living standards and consequently moved up to higher-standard groups.

Shifts of the examined spatial units from one group to another are treated as essential changes of regional disparities in living standards. Table 4 presents the number of voivodships falling within the distinguished standards in the analysed time sections. While Fig. 11 gives a synthetic picture of the shifts that took place in the entire 1975–1981 period and shows the spatial location in Poland of those voivodships in which living standards either relatively deteriorated or relatively improved. As it was pointed out earlier, "deterioration" concerned in general a few units with the highest standard, while "improvement" covered on the largest scale units marked by the lowest standard.

TABLE 4. Voivodships according to living standards

Year	Total	Living standard				
		very low I	low II	medium III	high IV	very high V
1975	49	11	10	9	15	4
1980	49	4	10	14	18	3
1981	49	3	10	15	19	2

The shifts in the living standards of individual voivodships, presented on Table 4, were a result of transfers by no more than one group up. It is worth noting that in the 1960–1970 decade there were transfers by two groups (see Fig. 3). Although, as we mentioned earlier, the results of the studies carried out in 1960–1970 and in 1975–1981 cannot be considered fully comparable, they allow nonetheless to observe the basic trends of changes in disparities between regions.

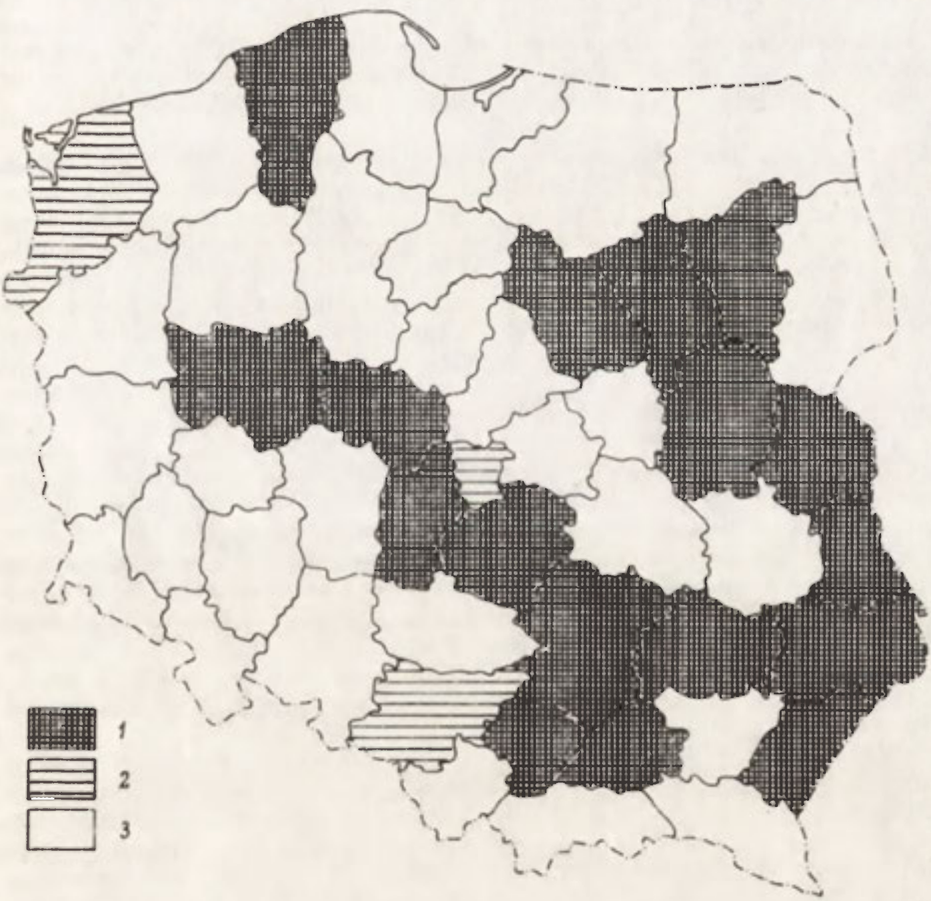

Fig. 11. Changes of living standard groups in voivodships in 1975–1981: 1 – shift to higher living standard by one group, 2 – shift to lower living standard by one group, 3 – no change

Table 4 and Fig. 11 indicate that the number of units rated to the standards IV and III has increased at the cost of the extreme groups I and V. This is an evidence that living standards were getting more equal. A reduction by one half of the number of units (Table 4) belonging to the standard V proves a considerable decrease of the rate of "improvement" in those regions. It is significant that in 1981 only the Warsaw and Poznań voivodships could be found in the standard-V group while between 1975 and 1981 Szczecin, Katowice and Łódź voivodships shifted to the standard-IV group (Fig. 11).

It must be stressed that the changes occurring in the mentioned voivodships were not caused by a drop in living standards since the values of the examined indicators went up in that period (see Table 1). However, in the mentioned voivodships changes were relatively smaller in comparison with the dynamics noted in many other units. Table 4 shows that no shifts took place in nearly 60% of the analysed voivodships. Most of them (21) belonged to the swelling groups of the III and IV standards. This is a proof that those standards were predominant in the analysed period.

6. FINAL REMARKS

The analysis of changing disparities in living standards in Poland disclosed that polarization of regional development took place in the period of accelerated economic growth. During the crisis the disparities tended to diminish. This was a result of a variety of processes.

Effects of the crisis hit most badly the regions with the highest level of urbanization and industrialization or those which developed big investment projects the implementation of which was temporarily put off. Changes of regional disparities in living standards were linked with a decline in the production and investment growth. Cancellation of the privileges enjoyed by the best developed (strong) regions, following a popular demand for equality, was an additional factor that caused a deterioration of their situation. People demanded then an equal treatment of all regions, regardless of their importance for the economy of the country.

Among analysed indicators the volume of retail sales in the socialized trade was one of the most important to determine changes in regional disparities, while other indicators had a weaker impact on their scale. In the initial phase the crisis was surfaced as food shortage in the regions with the highest urbanization and industrialization level, creating thus a more favourable situation in agricultural regions. Supplies of industrial goods dropped at the same time and their shortage was all the more painful as symptoms of inflation induced people to buy out goods no matter whether they were needed or not at the time. Moreover, priorities in the supplies for socialized trade in industrial or industrialized regions were withdrawn. The socialized trade began to distribute the supplied goods in proportion to the number of inhabitants. As a result of those decisions regions which so far were not privileged on the distribution list, began to receive larger supplies of goods. Hence the shift in regional disparities in favour of eastern voivodships.

Supplies of goods to the regions underdeveloped so far increased both in absolute and relative quantities. It must be added that a specific feature of the Polish crisis was a shortage not a surplus of goods on the market. That is why every increase in supplies meant a simultaneous increase in sales. The symptoms discussed here explain why the value of retail sales indicator in socialized economy went up per 1 inhabitant in zlotys. This is a good example of how changes in political-economic situation of a country may obscure information obtained from the applied indicators. Because during the crisis other forms of obtaining goods were developed (control of supplies, various ways of supplying goods directly to work establishments, ommitting the network of socialized trade, widely spread exchange of goods, non-socialized trade, etc.) which are not taken into account in the applied indicators.

The discussed symptoms were most painful in the initial phase of the crisis as they were accompanied by a sharp decline of production. Not without importance were also temporary perturbations involved in the introduction of more decentralized forms of management, which affected most badly the regions with highest concentrations of the population and production and most strongly centralized management. Therefore susceptibility to changes was different in different regions. In the light of those observations a division into strong and weak regions (Kukliński 1983, 365) became controversial since strong regions were no longer strong for a transitional period.

Temporary shrinking of regional disparities in living standards in the discussed phase of the crisis cannot be treated as a regularity concerning the entire period of recession. Observations of crisis symptoms in other countries belie that (Carney, Hudson and Lewis 1980).

Investigations of the changes in living standards should be continued also in the phase of recovery. Only combined results, including a post-crisis improvement of economic conditions, will allow to formulate generalized opinions. But in that case another set of indicators would be needed, more adequate to the changed situation.

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GEOGRAPHIA POLONICA 52, 1986

SOCIAL PROBLEMS OF THE DEVELOPMENT OF THE UPPER SILESIAN INDUSTRIAL DISTRICT

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CONCEPTUAL AND HISTORICAL BACKGROUND

The socio-economic territorial system in mid-southern Poland can be seen from two different perspectives, i.e. that of settlement systems and that of industrial systems. In terms of the latter, it used to be viewed as the Upper Silesian Industrial District. While there is a general agreement on the identification of the Upper Silesian Industrial District (USID), a variety of opinions exist on its definition and delimitation. As a planning unit, the USID was officially defined in 1953 as an entity embracing two zones, i.e. Zone A, to which a conurbation of 13 county boroughs (according to post-1959 administrative status) were included, and Zone B, to which 4 surrounding poviats (county units) and one county borough were included. A common interurban transportation system and telephone tariff were applied to the defined USID (Barteczek 1977).

For scientific purposes, the USID was defined as a system of industrialized basic territorial units interrelated by commuting to work. While delimitation of the industrial district was based on functional patterns, the criteria of the very identification of industrial districts in mid-southern Poland were basically historical; in consequence, the USID was identified as an entity surrounded by five others, i.e. Rybnik, Bielsko, the West Cracovian or Jaworzno/Chrzanów, Częstochowa, and Opole industrial districts (Misztal 1973/78). The six (including the USID), accompanied by the Cracow Industrial District, were argued to form an agglomeration of industrial districts (Fierla 1969).

The common image of the USID seems to be rather indistinct and to apply to an entity comprising core and periphery, which together could be identified with the agglomeration of industrial districts, excepting perhaps the Cracow Industrial District. On the contrary, in every-day economic activities, the USID tends to be identified with the respective provincial level, i.e. the voivodship of Katowice, which has been especially the case since the administrative reform of 1975. In consequence, at least five ways of the identification of the USID may be found, i.e. (1) Zone A or the conurbation, (2) Zone B or the urban agglomeration,[1] (3) the industrial district

[1] The identification and delimitation of Polish urban agglomerations and conurbations were extensively discussed in the literature; the identification of the Katowice conurbation with the Zone A of the USID, and of the Katowice agglomeration with the Zone B, follows arguments provided elsewhere (Rykiel 1985a).

according with the historically biased scientific definition, (4) the voivodship of Katowice, and (5) the agglomeration of industrial districts (Fig. 1).

To complicate the picture, the system, however defined, was divided by international boundaries, which throughout the 19th century with its industrial revolution and capitalist development, were stable spatial barriers. The development of the system can therefore be viewed in terms of integration of its parts or erosion of the boundary effect. Although it is called Upper Silesian, the industrial district has from the historical point of view been composed of 3 sub-areas, i.e. the post-Prussian Upper

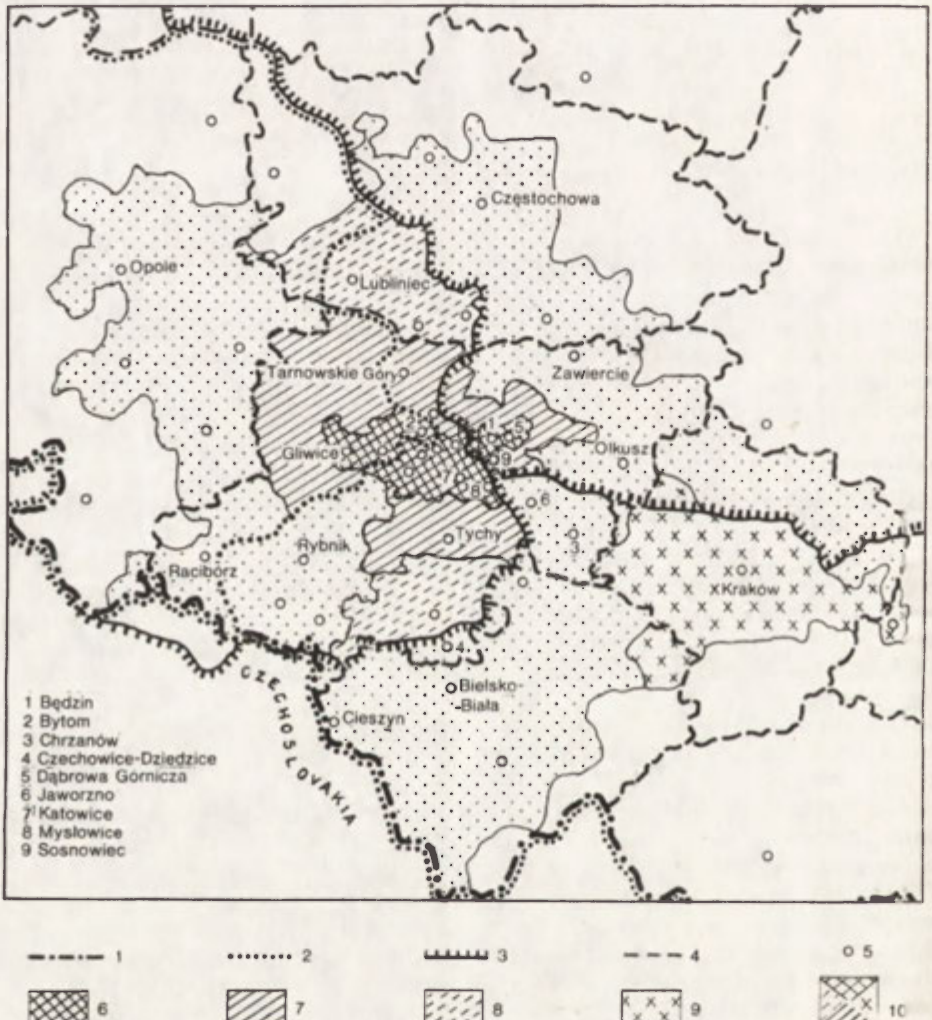

Fig. 1. The Upper Silesian Industrial District: 1 – post-1945 international boundaries, 2 – international boundaries, 1922–1938, 3 – pre-1914 international boundaries, 4 – post-1975 voivodship boundaries, 5 – major towns, 6 – USID Zone A, 1953, 7 – USID Zone B, 1953, 8 – USID after Misztal (1973/78), 9 – Cracow Industrial District after Misztal (1973/78), 10 – the agglomeration of industrial districts, after Fierla (1969)

Silesia, the post-Russian Dąbrowa Basin, and the post-Austrian West Cracovian District.

Since the decline of feudalism, metallurgy has been a basic element in the regional economic base. The industrial revolution, as evidenced by the common application of steam power in metallurgy and mining, development of coking in iron metallurgy and new technologies in the production of zinc, involved changes in the location of industry in favour of Upper Silesia. Extensive and easily accessible deposits of hard coal underlay the most rapid economic development of the region within Central Europe. In Upper Silesia coal was included in royalties while in the Dąbrowa Basin it was subjected to the ground access rule. As a result, state capital in Upper Silesia contrasted with the rather limited capital of individual landlords in the Dąbrowa Basin, involving the economic dominance of the former. This led to immigration across the border to Upper Silesia, and from the latter to Western Germany. Being poor, the immigrants to Upper Silesia provided severe competition to the local populace in the regional labour market. The application of tariff protectionism by Russia (1877) and Austria (1878) involved the expansion of the boundary control system and thus concentration of international exchange on main railway passes, which limited local interconnections. Protectionism compelled Silesian entrepreneurs to found branches of their enterprises on the other side of the border to avoid tariffs. This involved a confrontation of German entrepreneurs and supervisors in their branches outside Silesia with Polish workers on social-class, national and political grounds.

After the First World War, the Upper Silesian Industrial District was divided by a new Polish-German boundary which involved technological inter-plant operations across the border (Pounds 1959). Polish Upper Silesia attracted extra-regional migrants, yet during the 1930s recession they competed with the local people on the labour market. Upper Silesians were regionally – rather than nationally – minded, which in the 19th century Europe was a norm rather than an exception. Yet the 20th century, especially the Second World War, involved a necessity of national options. Those who chose Germanhood were used in the Dąbrowa Basin and the West Cracovian District during the Nazi occupation of Poland. After the war, on the contrary, the new political system was represented in Upper Silesia by people who mostly came from the Dąbrowa Basin. This development underlay stereotypes according to which the whole regional groups were perceived as supporters of certain political orientations. This even strengthened the already existent psychical barrier along the 19th century boundary.

THE IMPACT OF THE POST-WAR ECONOMIC MODEL ON THE SOCIAL DEVELOPMENT

What is referred to here as the post-war economic model was one which had predominated in most of East European countries from 1949 onwards. In Poland, it explicitly dominated from then till 1980, and it is only now (formally since 1982) that it may be succeeded by the new economic system.

The post-war economic model stressed industrialization, especially heavy industry. The expansion of heavy industry in the USID, accompanied by the collapse of the traditional mechanism of the reproduction of the socio-economic group of miners by biological succession, resulted from the changed political, economic and social system and diversified economic infrastructure. It created labour shortages which underlay immigration. The newcomers were mostly rural and thus hardly industry-skilled, and it was that which implied their low work-ethic. The massive immigration made the housing question urgent, the more so that a considerable part of the regional housing pool comprised neglected, run-down and substandard structures. To attract immigrants, the latter were generally preferred on the regional housing market (Frąckiewicz 1982). This, together with the newcomers' low work-ethic, produced the local population's aversion to them and contributed to social disintegration. Furthermore, the newcomers did not know the regional history in detail, including the peculiarities of, and antipathies between, individual sub-areas of the region; they even did not care about them, but rather perceived the region as a whole and, in the long run, this considerably contributed to regional integration.

The emphasis placed on industrialization in the post-war economic model produced a strong industrial lobby. This was because one reason of industrialization in East European countries was to change social structure on both national and regional scales. Therefore, industry must have achieved a political role. The industry managing groups must therefore have gained politically important or even decisive positions. The competence of industrial departments and large industrial enterprises considerably exceeded that which resulted from sole production; they were also responsible for the reproduction of manpower, i.e. housing construction, health care service, recreation, food supply, cultural institutions, partly education, etc (Jałowiecki 1984a).

The economic model was highly centralized by design. However, the national economy is so highly a complex mechanism that, even in cases of the most centralized systems of power, it is impossible to make each decision on the central level. Out of the unavoidable decentralization of decision-making, the sectoral decentralization is more acceptable for centralistic systems than the regional decentralization, since the very nature of the former makes it rather difficult to be changed in an autonomy, as contrasted to the politically more dangerous regional decentralization, i.e. autonomy (Szul 1984).

Even though the swing to industry was a national phenomenon, the industrial lobby, because of the agglomeration economies, was most closely related to certain regions only, i.e. those which may be referred to as strong regions (Kukliński 1976). The USID was a typical strong region in which the industrial lobby represented a regional lobby and, because of the economic potential of the region, also political power. Although from the long-run and/or macro-economic perspective an endeavour was desirable to shift the centre of gravity of national industry northward, the regional/industrial lobby forced accumulation of industry in the USID, for it implied an accumulation of power. This development was most explicitly observed in the 1970s when the USID originated politicians took nationally important positions. The investment boom of the 1970s occurred to a considerable extent in the USID. Not only location-tied investment projects were developed in the region (e.g. coal mines) but also a considerable part of large and prestigeous projects which could be located in a footloose manner (e.g. the motor-car factory, the largest steelworks in Europe, etc.); according to an anecdote, the USID was the first choice even for the new merchant seaport.

The economic model was highly centralized. Individual enterprises and investment projects were assessed by their formal or political rather than economic efficacy. In doing this, only those inputs gained official recognition which were expected to give results in goods produced while infrastructure, both economic and social, was viewed as non-productive costs, which should be neglected when possible or else minimized. This approach, in the case of the USID at least, must have led to the atrophy of the transportation system and an ecological catastrophe, both of which exercised influences upon the quality of life.

The high centralization of economic decision-making involved the atrophy of the market. The price system formed external parameters for the market, i.e. prices were dependent on the central decision-maker rather than either the supplier or the purchaser, which made the price system inflexible. Because of the inertia of the central decision-maker, prices used to be fixed below the equilibrium level, which involved the surplus of demand over supply, i.e. deficiency of the supplied goods. This produced a general disequilibrium (Szul 1983). In spatial terms it meant a relative increase in both the hierarchical ranks of the given goods and their threshold ranges, as compared with those under equilibrium. Therefore, purchasers must have travelled longer distances to buy the given goods because of the uncertainty of finding them in their local supermarkets. The growth of spatial mobility was even more explicit, for under disequilibrium both the supply and the price system was considered in political rather than purely economic terms (Szul 1983). As a consequence, the supply system under disequilibrium was submitted to pressures of regional politicians. This development naturally favoured strong regions at the expense of weak regions.

In this way the USID appeared to be an explicitly strong region, vis-a-vis other Polish regions during the increasing crisis at the turn of the 1970s and the 1980s. Purchasers from an extensive supra-regional zone in southern Poland travelled for shopping to the Katowice conurbation rather than to their respective regional centres so as to diminish the uncertainty of the purchase. Given the tightness of the market, this must have involved conflicts between residents and the visitors, particularly as some of the latter were intent on making shopping for personal gain on the speculative market. Attempts were made to tackle the shortages in the markets in both weaker and stronger regions by administrative rather than economic means, i.e. by supplying basic retail items to large industrial enterprises rather than to supermarkets. This implied an endeavour to solve the economic problems explicitly within the industry-oriented system rather than by a change in the system. As a result, social disintegration occurred, yet hardly stopped the growing crisis. Finally, the application of the rationalization of purchases turned out to be unavoidable. Originally, however, the system was highly disaggregated spatially, i.e. not only regionally but even locally. In the USID, individual towns applied their own rules of rationalization. Individuals were allotted to their towns on the basis of their places of residence. However, within the conurbation, it happened that people working together were subordinated to several local rationalization systems. As a consequence, it must have produced an extensive informal market.

After the application of the national coupon system the situation changed in the sense that individual purchasers were *de facto* attached to a certain supermarket. Before the system was relaxed, human spatial mobility had dramatically decreased both regarding journeys for shopping and for tourist purposes because coupons were valid only within a specified region.[2]

Apparently, the post-war economic development in the USID was similar to the 19th century capitalist development, in the sense that both were industry-oriented. The main difference, however, was that the capitalist economic model was basically profit-orientated which, in the region composed of the peripheral areas of the three empires, led to the industrial monofunctionalism. It was, on the contrary, only under the post-war economic model, notwithstanding its industrial orientation, that the considerable development of the tertiary sector took place. The development of the tertiary sector produced, under the conditions of full employment, women's job vacancies. This particularly applied to Silesian cities within the region, and especially to Katowice as the regional centre. However in Upper Silesia, women's economic activity was traditionally limited. This tradition, based on the monofunctional regional labour market throughout the 19th century, was internalized as a social value, although in the much poorer Dąbrowa Basin this was not the case as employment there of

[2] Now (January 1986), the coupons are essentially nationally valid, yet those for meat products must be pre-registered monthly at a chosen butcher's.

women was an economic necessity for the family. Although the development of the tertiary sector in Upper Silesian cities involved a certain change in the conservative attitude of Silesian families, it attracted even more obviously the Dąbrowa Basin women to commute to Upper Silesia. The intensive commuting across the former spatial barrier involved intensification of social contacts, which considerably contributed to the integration of the respective communities.

Urban renewal also influenced integration. Until the 1950s, the Dąbrowa Basin towns had much poorer water-supply, sewerage and electricity systems, lacked a gas-supply system and, spatially, were highly disordered. The urban renewal, which accompanied the restructuring and renovation of Dąbrowa Basin industry, led to the erosion of the urban landscape differentiation along the pre-1914 boundary, resulting indeed in providing much better infrastructure and better spatial order to the Dąbrowa Basin towns than to their Upper Silesian counterparts. During the renewal, little attention was, however, paid to the formation of city centres. Moreover, the unique city centre of Sosnowiec (the largest centre of the Dąbrowa Basin) was destroyed in the renewal. As a result, the *de facto* city centre for both Sosnowiec and other Dąbrowa Basin towns is that of Katowice (Pietraszewski 1982). This development intensified integration by daily or weakly commuting to Katowice.

THE POLITICAL DEVELOPMENT IN THE STRONG REGION

After 1970, the national role of the USID politicians considerably increased. Generally, the economic model was not changed; rather, it was made more explicitly industry-oriented by further developing the investment boom based on the 1960s financial reserves and foreign credit. Since those in power were explicitly regionally rooted, the USID was recognized to be a prestigeous model region. The investment boom was projected to be aimed at the restructuring of regional industry. Most large investment projects were located on the outskirts of the old industrial core (e.g. coal mines in the Rybnik area, the motor-car factory at Tychy, the large steelworks by Dąbrowa Górnicza, the zinc/lead works by Tarnowskie Góry, etc.). The next step, i.e. modernization and liquidation of the old enterprises in the conurbation, has had to be delayed because of the crisis.

The 1970s prominent political figures, because of their own regional background, must have been conscious that the pre-1914 spatial barrier did not disappear in human minds and was still considerably marked in attitudes, dislikes and spatial behaviour. The mental unification was therefore recognized as an important political task. This was, however, approached by an extensive and simplified propaganda which stressed that the respective working classes on either side of the barrier had never minded each other. What the propaganda proposed was a socio-political national homogeneity which was to be achieved rather mechanistically. The propaganda could, however, be hardly successful since it ignored reality. A survey made at Mysłowice (a Silesian town located next to the spatial barrier) indicated that, when asked to name towns where they would not like to live, the respondents pointed, first of all, to those located just on the other side of the spatial barrier: Sosnowiec, Jaworzno, and Będzin, while the motives behind the dislike were extremely emotional (Rykiel 1985b). The point, therefore, is that people on either side of the barrier, including the working classes, have minded and do mind their counterparts. This is, of course, underlain by the historical process, especially the development of the capitalist labour market, whereas those from either side of the barrier formed severe competition for those from the other side on the relatively tight labour market, and it was in this way that they formed a thrust for the very social existence of their counterparts.

Another socio-political phenomenon was that of changing the names of local geographical objects after the socio-economic system had been altered in the late 1940s. What is worth more extensive discussion is the relation between social revolutions all over the world and the involved changes of the respective geographical names (i.e. those of towns, districts, streets, etc.). This discussion is not developed here, but the matter is raised to point to some aspects of the problem which apply to the USID. As in most parts of Europe, changes to the names of towns, and particularly of large cities, could be hardly found in the Polish tradition. From this point of view, it is interesting to note that it was Katowice that was re-named *Stalinogród* in 1953–1956. Within the region, it was the Dąbrowa Basin that was felt to be the origin of the new political system. What was therefore felt desirable by the new system in the region was to fix their own tradition in the local geographical names. This was fairly easy to achieve by giving names of local politicians to new streets in the expanded Dąbrowa Basin towns. The point, however, was that the new streets were located in new, i.e. peripheral districts while it was felt more desirable to introduce the new terminology to city centres. In the latter, however, streets were already named, which implied a necessity to change the names. Yet the 'old' names were in most cases given only after the restitution of the Polish statehood in 1918 to replace the disliked czarist names; hence, they explicitly referred to the Polish patriotic feelings. A second change in local toponomastics, aimed at the propagation of the local revolutionary tradition, would therefore have come into conflict with patriotic/historical traditions.

What was characteristic of USID industry was relatively low efficiency. The industrial district absorbed 24% of the national consumption of electricity while having 18% of the respective gross value of fixed assets, only 15% of employment, and giving only 12% of gross production. The neighbouring Rybnik Industrial District indicated even more disadvantageous proportions, viz. 6, 3, 2, and 1 per cent, respectively (Misztal 1973/78). The proportions may certainly be related to the sectoral structure of the respective industry. Quite opposite proportions were characteristic of Gdańsk and Warsaw Industrial Districts in which machinery and electronics played a much more important part, as opposed to coal mining and metallurgy in the USID. The low efficiency of USID industry, especially coal mining, was basically a structural feature, i.e. one which resulted from the atrophy of any aspect of the market mechanisms in the economic system, which implied considerable price distortions. On the other hand, low efficiency was rather unacceptable in the most prestigeous region. The ways by which higher efficiency would be achieved were, however, sought not in systemic changes but in the increased exploitation of manpower, e.g. by the new organization of work in mining, which was referred to as the four-brigade system. This system was based on mining operations round the clock. It was rather inflexible, i.e. any absence at work disorganized the operations. Rather rigorous financial penalties were thus imposed on miners to discourage absenteeism. It was much more advantageous for miners to arrive at work being ill than to stay at home and being payed from the National Health Insurance. This development must have resulted in an increase in the accident rate; a rate which was even higher because of the exploitation-orientated system under which on Sundays mining operations rather than conservation and repair work were carried on. Moreover, under the new system, the day free of work might occur for individual miners at any time, not necessarily on Sunday. This considerably disorganized family life and participation at Mass, the latter being especially felt by the original Silesians, being traditionalistically Catholic.

The special role of the USID as the prestigeous model region became particularly clear during the 1975 administrative reform. In the reform, poviats (the county units) and county boroughs were abolished, and the three-tier system transformed into the two-tier system. This resulted in an increase in the number of provincial units, i.e. from 17 to 49 voivodships. The average area of one voivodship decreased in the reform from 5.9% to 2.0% of the national territory, i.e. 3.9%. However the area of the voivodship of Katowice decreased from 3.1% to 2.1% of the national territory, i.e. by only 1.0%. This implied a relative growth of the regional territory; whereas before the reform it covered 2.8% of the national territory *less* than the average voivodship. after the reform it covers 0.1% *more* than the average. In terms of economic potential the proportions are even more striking. What the voivodship lost were relatively less industrialized areas in the north (Częstochowa, Kłobuck, Lubliniec, Myszków) and south (Bielsko-Biała, Cieszyn); what it gained were industrial areas of Jaworzno/Chrzanów, Olkusz, and Racibórz. Moreover, the new regional boundaries were delineated from the point of view of industrial links rather than any social and central-place relationships. All the regional coal mines were included to the voivodship, even those located in satellite towns of other regional centres (e.g. Czechowice-Dziedzice being but a functional suburb of Bielsko-Biała).

The liquidation of poviats. which were the strongest administrative units in terms of the relation between the administrative potential (centrality) of the centre and the size of the area served, involved technical difficulties. The basic units (communes and boroughs) were too numerous to be effectively served by the regional centre. Katowice voivodship was therefore the only one in which the basic units were aggregated/enlarged in 1975, even though in 1973 they had been aggregated nationally. After additional aggregations throughout the 1970s, few areas were left as rural communes while most of them were amalgamated into boroughs. This produced extensive and sizeable cities, which, because of the underdeveloped infrastructural systems, were hardly integrated internally.

The deprivation the local communities of the local administration available on the spot, as well as of the names in cases of the amalgamated places, produced frustration and social disintegration. For instance, the citizens of the borough of Sławków from the former poviat of Olkusz felt to be acutely experienced by the amalgamation into the city of Dąbrowa Górnicza in 1977 not only because they were compelled to travel 20 km to settle any, even purely local administrative matter, but first of all because they were deprived of any local pride to live in a borough having the 13th century urban status (Jałowiecki 1984b).

The new administrative pattern on the local level was generally criticized, since it produced lower accessibility to the local government. On the regional level, people from the areas joined to the Katowice voivodship were rather satisfied by the new appurtenance and the advantages it produced (e.g. better supply) but highly dissatisfied with the way by which it was changed (i.e. without reference to local opinion). The general criticism was reflected by the regional press in Cracow and Opole (i.e. the centres which lost areas to Katowice) which was willingly read in the ceded areas. In the prestigeous model region of Katowice the press was not so liberal. And it was the Cracow and Opole press that was not easily available in the USID from that time. This was a part of a more general process of the muffling of criticism which, although spread nationally, was particularly acute in the USID. It was within the same scheme that the Gdańsk and Szczecin strikes and agreements of August 1980 were discredited in the Katowice mass media ('nothing will change in the USID'). And this was one reason of the USID September strikes of 1980.

Interestingly, it was the large, new and prestigeous investment projects of the 1970s which were the supra-regionally important strike centres. In stating this, it must be stressed that these became large concentrations of the younger generation and newcomers who did not share the Silesian traditionalism. This may be taken as an indicator of social integration in the sense of the adoption of the common national attitudes in this particular region. On the regional scale, social integration is reflected in the general acceptance of Silesia as the common regional name, even in the areas which had been separated from Upper Silesia by the spatial barriers (Rykiel 1985b).

What was characteristic of the USID as opposed to other Polish industrial districts was emigration to West Germany. This must be seen from a historical perspective. The more extensive industrial development of Westphalia and Rhineland throughout the 19th century attracted very considerable migration from less developed eastern areas within the then German labour market, referred to as the *Ostflucht*, which also embraced the Prussian-held Polish territories. Because of its relatively high level of industrialization, Upper Silesia rather successfully entered the common German labour market and it was in this way that migration paths to West Germany developed and then were internalized as a routine spatial behaviour of the Upper Silesian regional community. This pattern remained basically undisturbed until the Second World War.[3] After the post-war re-settlement, the emigration was discontinued during the cold war. From 1957, the emigration was allowed again under the Polish-West German agreement for reuniting families. However, such *de facto* reuniting of families was confined to 1957–58; later departures formed explicitly economic emigration (Grodecka 1982). Yet it may be argued that a considerable proportion of the emigration within the framework of the agreement for reuniting families was 'political' emigration in the sense that they were a reaction to the severe deformations in the internal policy in the 1950s. After the termination of the agreement in 1960, potential economic emigrants were neglected in Poland in the 1960s and the 1970s. Yet the industrial development and the expansion of the regional labour market induced an increase in job turnover (Cordey-Hayes and Gleave, 1974). In the strong region, this involved orientation towards maximization of incomes. In the case of Upper Silesia, the interpersonal communication with West Germany was rather strong and this enabled easy comparisons to be made of the differences in the respective living standards; these, in turn, gave rise to pro-emigration attitudes.

The decision-makers' attitude towards the potential economic emigration was coloured by the frustrations of the pre-war emigration of landless peasants and unemployed workers to whom the capitalist state was not able to provide work on the spot. Even though the post-war potential emigration was of a rather opposite nature, the very term 'economic emigration' was viewed as a social curse. The only framework in which the foreign emigration might have been accepted was therefore another Polish-West German agreement for reuniting families of 1975. This, however, involved social and political complications: hardly any families were *de facto* to be united, at least in the sense that any reunification of families in Germany implied the division of families in Poland. Furthermore, the application of the reuniting of families framework to economic emigration implied that only specified regional groups were involved in. In the USID, this implied a strengthening of the pre-1914 spatial barrier, since hardly any family to be reunified could be found east to the barrier. This must have involved another wave of anti-Silesian antipathies since it seemed obvious to those not allowed to leave that it was Silesians who yet again got another better economic opportunity in history. This, in turn, transmitted the pro-emigratory attitudes to other social groups, particularly the recent immigrants to Upper Silesia (Rykiel 1984). Moreover, to compel those who decided on and succeeded in emigrating to renounce Polish citizenship involved an increase in philo-German sentiments among those to whom the agreement for reuniting families did not

[3] This also applied to the inter-war Polish Upper Silesia because of the Geneva Treaty statements and the relatively weak Polish labour market during the recession of the 1930s.

apply, since they felt it was one way to compass their plans. This development, in turn, involved political complications on the international scale, including a fuss in West Germany about what was referred to as the German minority in Poland, even though the emigration had, in fact, produced a considerable Polish minority in West Germany.[4] Those who had emigrated, notwithstanding their declared national feelings, were obviously found in more disadvantageous position than native Germans, because of their background (i.e. low ability to speak German, the difficulties of social adjustment, etc.), even if their economic situation was considerably improved. As the development after 1980 indicated, it was temporary economic emigration that would be the optimal solution from the point of view of the potential economic emigrants; this was, however, contradictory to the interests of the respective Western countries under the conditions of unemployment in their labour markets during the recession.

CONCLUDING REMARKS

It was superficial to refer to the USID in the 1970s as the prestigeous region when objectively assessing the real possibilities of achieving ambitions. While most expenditures covered the needs of the self-consuming inefficient heavy industry, the limited residual was spent not so much on what was really necessary from the social point of view but rather on what seemed to be showy and to contribute to regional prestige. The establishment of the Silesian University at Katowice can be taken as a good example of this: the University was established even though hardly any suitable location could be found for the new campus, and the money available turned out to be insufficient to built one. In consequence, throughout the 1970s, individual departments and institutes were dispersed all over the conurbation and located in very marginal and unsuitable places. The spatial separation, accompanied by the underdeveloped transportation system, permitted only a low level of integration of the academic community. A negative feedback relationship then developed between poor organization and poor participation of senior scientific staff. The university represented therefore a rather low scientific status because of the lack of experienced scientists, while experienced scientists were rather unlikely to leave their own universities for the new one which had a lower status. Although the new university attracted scientists both economically and by means of the perspective of scientific career, the very process was rather slow, especially in view of the fact that the large, well established, high-status 14th century Jagiellonian University of Cracow was located only 80 km from Katowice.

A similar experience characterised the transport infrastructure. Having been developed throughout the 19th century as an industrial conurbation, the USID had an inter-urban tram network which hardly met modern requirements. Most lines are single-track and do not link neighbouring towns and settlements by the shortest routes; purely local interconnections prevail, therefore, in the network. The intra-regional transport supply is represented by railways, especially that linking the conurbation west-east (Gliwice – Katowice – Sosnowiec – Zawiercie), but this is overloaded since there is no separation of the freight from passenger nor long-distance from local traffic. Because of the limited capacity of the network, a conflict has grown between freight and passenger traffic. It was the former that used to be

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[4] The question of national minorities is, in fact, one of definition. Here, the one which seems accepted in most parts of Europe was applied. In the German tradition, the definition of national minorities used to be aimed merely at foreign countries.

preferred in conflict situations. In result, the share of the railway network in the passenger traffic has been decreasing to reach about 10%. In consequence, the average amount of time spent on commuting to work in the USID equals to 60 minutes, i.e. twice as large as in other Polish urban agglomerations, while the average distance is about 12 km. The railway system needs reconstruction which, however, creates further problems in the densely built-up area.[5] Any endeavour to construct an underground railway system would involve even larger problems in an area with mining operations.

It was only the highway network which was successfully reconstructed in the USID in the 1970s. Even this, however, was spatially limited to the reconstructed Dąbrowa Basin, and the outer ring of the USID while hardly any improvement of the network has been made in the western part of the conurbation since the war. Moreover, this development had specific social connotations, related to the new model of transport which was propagated in the 1970s, i.e. private cars. Again, this stemmed from the line of the industrial lobby while, on the other hand, it contributed to the delay in the reconstruction of the railway systems.

The public inter-urban bus system was developed rather slowly and that collapsed with the energy crisis. The increase in individual transport means at the expense of public transport systems reflected policy aimed at the socially stronger while neglecting the socially weaker who used to be served by the public transport. The deterioration of the public transport system (growing unreliability etc.) resulted in diminishing spatial accessibility. With the fixed time budget, this must have involved the growing spatial and social disintegration of the USID.

To make a somewhat more optimistic conclusion, it is worth noting that a governmental programme was approved in 1982 of the development of the integrated transport system in the USID, with common tariff, which would be a unique case in Poland. The backbone of the system, to be begun in 1986, would be a railway line from north-western part of Gliwice to north-eastern Dąbrowa Górnicza, 72 km long, with 38 stations, parallel to the existent line but having technical parameters which would preclude to use the new line by the freight traffic.

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[5] According to 1956 data, the average population density in the USID was more than three times that of the Ruhr industrial area and more than twice that of Greater London (Pounds 1959).

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GEOGRAPHIA POLONICA 52, 1986

SOCIO-ECONOMIC DISLOCATIONS RESULTING FROM AGRO-TECHNICAL TRANSFORMATIONS IN THE LAKE CHAD BASIN IN AFRICA

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The Lake Chad Basin in Africa is by all standards located within the Arid Zone. The zone is characterised by the strong seasonality of the climate, with a short rainy season and a long intensely dry season. Conditions vary markedly over short and long periods of time as the rainfall varies. It is a harsh environment, definitely one of the poorest regions in Africa, awaiting human action.

The long term variations in climate have left a strong impress on the landscape and especially the soils of the region. Chad Basin areas are floored by dark heavy soils with a high content of fertile clay that causes them to crack deeply in the dry season and to swell so as to prevent the deep percolation of water in the rains. Such soils are extensively developed south of the lake Chad, within the portion of territory which belongs to Nigeria and is taken in this article as an example for illustration of the contemporary problems of development in the Lake Chad Basin. The soils occurring there are of great economic importance and provided the appropriate irrigation – cotton, sorghum and rice can be grown on them in the hot season, with wheat and vegetables in the cool season.

Lake Chad is a drying up reservoire, once extending between Tibesti ranges in the north and the valley of river Benue in the south, with some out-flow of water to the Atlantic ocean. At present the water surface of the lake oscillates considerably following the rain seasons and that coincides with increased discharge of the rivers entering the lake. Those large fluctuations of the water level result in flooding deep inland (up to 20 km along some measured lines). Therefore the areas bordering seasonally flooded swamps are almost useless for agriculture, with population concentrating on fisheries and smuggling. Lands lying adequately far away from water also loose their usability, immediately become dry and exposed to hot winds and sandflows. People living there are consequently dependent on grazing their herds, which are moved in search of pastures. Fodder and water are in short supply and diseases are prevalent.

The two groups, people of the water front and pastoralists thus leave in-between a wide belt of the barren land, potentially productive, conditioned that it is properly watered. This is exactly the main objective of the so called Lake Chad Basin Development Project initiated in mid 1970s by the federal government of Nigeria. Modern technique makes it possible to reclaim the land, bring it under cultivation and settlement, provided the appropriate efforts be undertaken on a large scale. And this is a challenging but also promising task.

The relative well-being of the geographical Sudan, that is the grass land belt south of Sahara, with its animal husbandry, established trade routes and social links within the tribal systems, was abrubtly broken with the colonial era disruptions in almost all African territories and their organizations. Also some trading privileges of Chad Basin have diminished with the beginning of the 20th century. The settlements — here exclusively of mud houses in contrast with the thatched huts that prevail in the southern rain forest, were beyond the termini of the railways from the coast, no longer at the cross-roads of the transcontinental islamic routeways. While the Guinea coast experienced increasing prosperity with the introduction of cocoa, coffee and rubber plantations — the Chad Sahel stagnated. Economies were monetized but the people remained retarded, poor, uneducated, divided and frustrated with their tribal insurance mechanism broken down.

Conditions over the last decades have further deteriorated in result of disintegration of the long established social ties, increase in population, repeated droughts, migrations caused both by poverty and political upheavals in the neighbour republics. The threatening disaster could be to a certain degree prevented only thanks to much more effective now than in the past transportation across the savanna. The decision of the federal government to reclaim and to invest in the Nigerian coastal plain bordering the lake is the action aimed at the promotion both of the discussed area and of nation-wide needs as well. Undertaken in a specific geographical environment, driven by the interests highly exceeding regional prestigious or economic aspirations the project obviously is attracting an extraordinary attention.

Not only in Nigeria, but in the whole of Sub-Saharan Africa growth of food production in the 1970s was not only well below the increase of total population but also well below that of rural population. There is a frightining decline in agricultural production. During the decade 1971–1980 food production declined on the average 2.5 per cent annually with population increase above 3 per cent. This created 'excess demand situation' and is the evidence confirming the existence of food problem in Nigeria since 1960s. The country will not be able to feed itself also in the next decades. In recognition of the critical role of food production the federal government has given the highest priority to agriculture in central investment programmes. Despite the offer of a generous subsidies — the private owners still prefer to invest in non-agricultural sectors promising quick and high returns. To release labour to urban migration certainly is not the goal of the official policy. Rather the increased output per labourer must be recognized as the most feasible immediate short term objective.

In Nigeria, country rich in oil, in 1981 slightly more than 92 per cent of foreign exchange earnings were derived from the petroleum industry while the food import bill was estimated at 2 billion US dollars. The corresponding bill 10 years earlier, was only 80 million US dollars. Not like some other oil exporting countries e.g. the Kingdom of Saudi Arabia or the Emirates of the Gulf, Nigeria was in the near past predominantly an agricultural country. By the independence day, some 25 years ago, agriculture used to supply the percentage of earnings now derived from oil. If we also take into consideration the rapid increase in population we arrive at the obvious conclusion that any government must be concerned with the problem and develop or at least start to develop an agricultural sector of the national economy. There are opinions in circulation which blame Nigerian agriculture for a failure contrasting sharply with rapid and successful development of other economic sectors. The point is that to my mind this is not a question of a failure in keeping an equal pace of development with manufacturing and other industrial activities. Nigerian traditional agriculture was never suited to supply significant surpluses of the produce to non-agricultural population under the conditions resembling what we now call 'market economy'.

If we concentrate our attention on the farming zone extending between the tropical forest in the south and dry Sahel belt in the the north – this was in Nigeria an area of entirely subsistance agriculture which could support only a very limited number of individuals not involved in cultivation, e.g. rulers, their servants, disabled etc. It is also worthwhile to stress that the cultivation was based on the labourers equipped only with the most simple implements – the stick and the hoe. The soil, in absence of manure or fertilizer, rapidly loses its fertility, especially as the hoeing – stick does little more than scratch the surface. After a year or two new land must be used and the old reverts to secondary growth. In time this may be again used, but where population pressure increases it lies fallow for too short a time properly to recover. But still this system avoids the excessive soil erosion. The yields were dependent on not very accurate regularity of rainfall and the ability of the farmer-family to cultivate the plot was first of all *conditioned* by it's capacity to control weeds over the area taken for cultivation. There are of course several other natural constraints which are here intentionally omitted.

Perhaps the most important factor for the problem under discussion well evidenced by the field observations gained by the author, is that the cultivated area within traditional agricultural domains in the northern part of the country is the function of the ability to fight successfully the weeds. Only next come ploughing, watering, soil conservation and so on. Having in mind this consideration one may point out that all the accusations against traditional agriculture that it stays behind the galant displays of all other economic sectors – seem not sufficiently substantiated That is not the question of better performance (as it is too frequently claimed, without paying attention that the margin for 'quality performance' is almost non-existing), but the question of complete transformation of agrotechnical system what directly leads towards entirely new social structure. That literally means the transition from traditional landscape marked by lottery fortune undertakings to the regulated cultivation brought about by an engineering design and application of modern technical achievements similarily as practised in non-agricultural industries.

Most of the Nigeria's population earns its livelihood from agriculture. The transport, processing and trade sectors depend largely on the production of agricultural commodities, and incomes earned in this sector provide markets for domestically produced goods and services. Thus agricultural output is the single most important determinant of overall economic growth and its sluggish record of recent years is the principal factor underlying the poor performance of the indigenous economy. There is in the country a sustained campaign for making Nigeria self-sufficient in food production. It is almost a fashion to express the official verse that agriculture may regain its pre-eminence in the economy of the country. Nigeria is aiming at plowing part of the oil wealth back to the rural areas and, therefore does not attach great importance to cost recovery and a financially self-sustaining agriculture. The Lagos Economic Summit (1980) called for an accelerated growth of the agricultural production based on a high degree of government support. During the 1970s many other African countries directed a substantial proportion of their agricultural investment to large scale government-operated estates which involved heavy capital outlays for mechanization and irrigation. This was the result of the conviction that only a rapid transition to mechanized, high productivity would overcome the stagnation linked with the traditional low-input, low-output methods. It was also considered a reasonable solution to the shortages of skilled and experienced labour. In view of this fact the government willingly decided to compensate local manpower deficiencies through liberal recourse to expatriate technical skills. Focus on irrigation was a response to the droughts of the 1970s which convinced African governments in the arid countries that a substantially larger share of the total food requirements should be produced under drought-proof conditions. The Lake

Chad Project in Northern Nigeria seems to be the direct outcome of these concepts. It is also reasoned that while productivity on the state farms is often lower, the share of marketable surplus is much higher.

Nigeria, possesing enormous oil wealth faces also huge developmental demands, but still the greatest long range economic challenge for the oil boom country is agriculture. In some cases the agricultural development schemes fulfil other than purely economic goals. It was first of all the political will of the federal government that moved and justified before the nation the massive investment necessary to launch and sustain the irrigated farming around the Nigerian coastal plains of the lake Chad.

The country's agricultural potential is not being exploited for a host of extremely complicated factors. These include the imbalances in the economy produced by the spill-over of the oil money which among other things has made agricultural labour rates less competitive and has accelerated the drift of the young to the towns. Nigeria has an ageing farming population. Productivity of virtually all major food and cash export crops have been declining and the country has been importing more and more food, adding to its already worrying import propensity. The high rate inflation and deficit financing, falling earnings from oil export during the recent years make that Nigeria's ability to invest goes down accordingly and the government often has to cut back on its development programmes. This is exactly opposite to what should be required: the needs are so great and complex that it will request far more money than the government can invest in agriculture. The Chad Project, which is only one of many undertakings, can also be endangered by an unfavourable overall situation and financial menace.

The establishment of big farms is all the same a fashionable goal of the government policy and is to be encouraged by a number of fiscal incentives, e.g. income duties relief and prolonged tax holidays for pioneer enterprises, custom free imports of agricultural machinery and generous investment allowances. The government is also ready to go into partnership with private indigenous or foreign investors in the creation of new large scale (foreigners can own up to 60 per cent of the equity of agricultural enterprise). It is possible that certain estates at present under government control may be sold off to private (or cooperative) entrepreneurs via numerous organizations promoting agriculture such as the Agricultural Development Corporation.

South Chad Irrigation Project is the multipurpose and almost impossible for complete objective evaluation undertaking. Generally it is a land reclamation programme based on:

– available investment funds supplied by the government and practically unrestricted in domestic and foreign exchange;

– available water for irrigation from lake Chad;

– suitable in general soils over the project area;

– opening-up of an area only marginally exploited in the past by the scarce pastoralists, therefore there have been no clashes with other interests or major needs of the area concerned.

As is so often the case the overall interest can be divided into:

– agricultural development proper;

– restructuring of traditional societies (tribal nomads);

– general promotion of business, reflected so evidently in all financial privileges related even indirectly to economic growth;

– public demonstration of the official awareness and concern for 'Feeding the Nation';

– creating a show window exposing advancement, modernization, technological progress and impressive picture of space of a new category, perhaps to serve as a model for the purpose of disseminating all the innovations under the supervision of the extension instructors throughout the communities of neighbouring local government areas.

It must not be mentioned that such an exposition of awareness and progress is being frequented almost every day by hundreds of visitors from Nigeria, from Africa, from all over the world. It is not easy for the head of any state to pay visit to Nigeria and not be taken to inspect Chad Basin Development Project.

The operational scheme is the following. The whole project, administered by governmental agency called Chad Basin Development Authority, is divided into several parts, e.g. land, water, dredging, canals, water lifting stations, electricity, road construction, storage facilities, mills, granaries, housing, oil tanks, drainage, transport, repair workshops, hydrobiological research stations, pest and disease control centres, etc. and contracts for the given works are granted to a number of private Nigerian companies. The companies subsequently enter via foreign consulting and constructing firms into supra-national business activities. In principle the designs and machinery are supplied by European and American groups while the core of the field staff labourers is almost exclusively recruited from India and Pakistan.

Chad Basin Development Project area in the first stage extends over 106000 hectares of flat clay plains with water for irrigation obtained from lake Chad in accordance with the relevant agreements already in force with all the republics bordering the lake, namely Niger, Chad and Cameroon. The project aims at the full agricultural utilization of the local environment potential by raising crops both for consumption and for cash.

The area has been basicaly planned for the future family settlement although plantations may be incorporated if suitable growers will be forthcoming. The new holding proposed is four hectares but it is intended that large holdings could be allocated to actual traditional holders of rights to substantial acreages, to avoid social disruptions and clashes. The four hectares holdings will be able, it is believed, to provide an income of four times present incomes from unirrigated cultivation.

The project includes the provision for new villages complete with all necessary services including electricity, air conditioning and gas cookers. Electricity is essential first of all for pumping stations in order to lift up water from the main intake canal to the distributing canals situated on the average 10–12 m above and then again to lift the water about 6 m into branch canal network on the fields level.

The main intake canal is a 30 km channel leading to a deep pool far within the lake perimeter and consequently had to be constructed and maintained across swamps and thick vegetation cover. This unusual feature is a result of the nature of shallow lake Chad, with an average depth of only 2–3 m and consequently with shores squeezing considerably following the seasons. To ensure a constant and sufficient supply of water the end of the intake channel had to be sited in a permanent water pool deep within the lake.

The project started in December 1975 and is being implemented in three stages together with several small experimental pilot farms which are to carry out research work only. The first irrigation water have been supplied in 1979 and in 1980/81 season the first yields have been delivered to the state's granaries so the real take-off could be celebrated.

Only in stage I approximately 5000 km of irrigation canals have been built. Throughout the project area the canals cut the overlying clay into a sand substratum. To prevent the water leaking away into sand an impermeable lining 1 metre thick had to be placed in canal beds. The maximum water requirement of the completed project will be around 100 m^3/s (what is more than the flow of the river Thames in London) and all water must be constantly pumped through consequent lifting stations equipped with electric pumps operated by oil generators. Not mentioning all the absolutely necessary maintenance services — the cost of the project is immense. Particular positions in the expenditure tables reach millions of dollars and extend over two five-year development plans (III 1976–1980; IV 1981–1985) and the true total cost is almost impossible to assess. According to the rough, unofficial estimates made by some employees of the Project Headquarter — the expenditures amounted to somewhat between 25 and 30 per cent of all Nigeria's agricultural development budget for the discussed period of ten years. All field construction works are carried out by hired personnel. Local ownership rights holders from among the pastoralists after compensation at most are engaged in other business in other parts of the country. It is only hoped that when the whole project will be finally completed and trained staff in posts — the farmers with their families will also come and take over the ready farms. Accordingly to regulations elaborated in advance, they will have to pay for agricultural services provided by CBD Authority, the sum being deducted from the proceeds of the sale of produce to the Authority. Losses suffered by farmers can be carried forward indefinitely until they can be written off against profits. In addition farmers would pay an annual charge which would cover the operation and maintenance cost of the project. These are still plans and designs, for the results we shall have to wait to see if all the assumptions be warranted.

CONCLUSIONS

Some facts of more general interest can be drawn out of the above review of the Lake Chad Irrigation Project. The discussed aspects of the Project point to the fact and enhance the thought that the agricultural problems over the world seem rather to sprawl than to diminish. Nigeria, despite the priviledged financial background, declared priorities and understanding of the problems, each year is more distant from food selfreliance. Agrotechnical transformations take the long period of time, rarely they can be effected by the decrees. Well known since long time now agricultural projects in different parts of the world financed from the outside sources without consideration for economic calculations continue to be implemented. The point in case here is not how to quicken the pace of agricultural development or how to correct the polarization but how to effect the complete transformation of the entire area or even to overcome the stages of development. To be sure there has been already a multiplication of projects and a proliferation of programmes to aid the rural poor and effect social progress but there has been no fundamental change in politics or strategies to rehabilitate traditional societies. So far no arrangements have been done for monitoring change in social behaviour of the expropriated herdsmen and for examining the interrelationship of various factors in the process of transformation, measured in terms of concrete indicators, as a guide to further planning and management.

Lake Chad Project is situated beyond the usual set-up of functional linkages of the urban-rural operational scheme generating growth impulses in accordance with economic incentives, economic profits and is out of typical patterns of innovation diffusion. In this respect it can be said that the project enhance the Nigerian pattern of development which is characterized by marked imbalances between the various states and between the various developing areas. Thus the general picture of the development landscape is largely that of enclaves of irrigated lands or industrialized spots in a few favoured locations markedly contrasting with vast poor and underdeveloped areas.

The frontier (or marginal) lands in the tropics are not well suited for food production. This is always true if they are located in zones characterized by the shortage of water. Then heavy investments give correspondingly low yields,[1] though in terms of social objectives the action may be successful. There is always a danger that in a long run the marginal lands dependence on outside subsidies will increase.

The project hopefully is designed to facilitate the migration of people to the newly reclaimed area and to be sure such an attractive opportunities must move people. But the site is distant and unique like dam construction far away. It may possibly become the centre of modern intensive cultivation facilitating the innovations for the neighbouring areas around lake Chad, but who and when can rise enough money on all shores of the lake? Perhaps all tentative farmers of West Africa may be expected to benefit from this experience. If we assume that the project achieves full success — it will not only be an agricultural area but also an important dynamic growth centre for Northern Nigeria and the whole West African Community.[2]

Whatever the motivation such efforts as Lake Chad Project represent the common belief that money invested in agriculture can not be totally wasted and after all — apart from short term benefits — they may present the sound investment for the future. Especially in Sahel countries it is accepted that without new irrigated areas they will face ever growing threat of increasing need for food assistance. Nevertheless such projects, being a specific mixture of incidental opportunities and creative initiatives of far-seeing individuals can not serve as a model solution for the impoverished greater part of the world.

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[1] According to initial estimates, investments left apart, the cost of 1 tonne of rice harvested on the project area is roughly four times the cost of 1 tonne of commercial rice available on the coasts of West Africa.

[2] ECOWAS — Economic Community of West African States

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GEOGRAPHIA POLONICA 52, 1986

THE ROLE OF CITIES IN GLOBAL INTEGRATION PROCESSES

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INTRODUCTORY REMARKS

One of the basic expressions of human activities is the development of contacts. They may be more or less intensive, both when we analyse them from the viewpoint of civilization processes or when we approach them as individual cases, i.e. countries and societies. In the present era the degree of intensity of the contacts has, of course, reached the relative historical maximum, while the rate, at which this phenomenon is developing, rapidly accelerates in either local, regional or global sphere.

Political and economic-cum-technological transformations, which have been taking place following World War II, seem to be the most important of all causes contributing to a frequent occurrence of contacts, especially at the international level. First of all, the "active areas" seem to have increased since new countries and nations have appeared on the political arena. They demand that their rights within the communities of our globe are fully recognized and that conditions are created for them to enter the path of development. As a consequence, those countries try to develop their external contacts and play an active part in world affairs. The need to enter into contacts and to undertake integration activities at the regional and global levels also arises from the problems that crop up in association with man's economy and the technical civilization of our time. The development of this civilization requires that high socio-economic costs are defrayed by the whole humanity, which will go down only when all countries will participate in common endeavours. It seems worth while recalling here W. Brandt's (1980) very adequate words that such problems as the depletion of renewable and non-renewable resources throughout the planet, heightened environmental and ecological danger, increased difficulties in supplying enough food for the world's rapidly growing population, or the dramatic expansion of urbanization processes are not concern of separate nations but are the whole world's responsibility. Therefore, irrespective of the fact in what political or ideological system they occur, these problems must be internationalized, arouse common interest in the need for undertaking complex efforts, aimed at their identification and solution.

The broad sphere of a common cultural heritage, left by many generations, and current achievements in the sciences and arts, requiring the concentration of contacts and exchange of results yielded by creative thinking, are of great importance for the stimulation of closer contacts between the nations. Similarly, we cannot forget the impact on the development of the international links exerted by all manifestations of religious, humanistic, social, professional and other movements. Though the contacts and integration activities are set up in an institutional form or develop spontaneously, often incidentally, all of them play an important role in the process of the evolution of a political-cum-economic or socio-cultural global space. The character of those contacts and integration activities is moulded by governments, political systems, economic potentials, as well as international factors and individual initiative groups. The development of the contacts is made easier by an explosive growth of the telecommunication infrastructure, in the broad meaning of the term, i.e. using W. Rhynsburger's (1980) term, of the complicated network of the "global circulation".

THE CENTRAL FUNCTIONS OF THE NEW CATEGORY

This paragraph I would like to start with answering a few questions like: In what way are these contacts and integration activities expressed? In what do they find their strongest reflection? Where does their realization take place? The symbol of our time is a concentration of meetings, conventions, congresses and symposia, exhibitions, fairs, etc. International working groups and research institutes, as well as agencies concerned with cultural affairs and the arts, are nowadays called into being much more frequently. There is a mushroom growth of all the types of world-wide organizations. The form of multinational corporations is becoming quite universal; since they amalgamate with the agencies of the international capital, new transnational structures are thus created (Susman and Schutz 1983). In turn, states conclude new agreements and thus form regional and supraregional, economic and political communities. All these contacts and integration activities lead to a greater participation of transactions with a varying material and spatial scope in the life of societies. This is a characteristic causing that the civilization of the present era is sometimes denoted as "civilization of transactions" (Gottmann 1967). The contacts and integration activities are primarily pursued in cities, since the latter provide best conditions for their realization. Though this is a truism, it seems worth while pointing out that cities, irrespective of the stage of their historical development, have always played the role of focuses of human activity, otherwise they could not have existed. The dynamism of this force depends upon general conditions under which the city has been developing and upon individual conditions, specific of every city. The city is a source of material and non-material goods, which it transfers to the outside, and at the same time it is a recipient of products of human thinking and work, coming from the outside. It is also an important point for the flows of people and information, a place where ideas clash and opinions are exchanged. Thus, the city is an essential factor contributing to the formation and transfer of new values and patterns.

The processes, taking place in the development of the city, are based upon activities that can be denoted as feedbacks. These processes are the more complex the more diversified is the structure of activities pursued by the city and the areas with which it enters into contacts. In other words, the field of its contacts depends on the activeness of the city and its partners, and on the size and variety of exchanges taking place between them.

Functions, without which the organization and promotion of the contacts and exchanges cannot be pursued, are one of the most important factors determining the city's activity. Its functional competence in this respect determines the city's position in relation to other cities in the country, region, or the world. The scale of differences is here very wide, since the ability of cities to develop and in particular to adapt its functions to the growing and changing tasks, lying before them, is unequal.

However, what should a modern city do to adapt its functions to the changing tasks? Would it suffice to expand the range of the functions carried out so far, or should a new category of functions be introduced?

To provide answers to those questions we may refer to certain ideas expressed by J. Gottmann, who has often analysed urban functions. In the light of Gottmann's views we should first of all underscore the fact that the modern socio-economic development of the world leads to a growing significance of a "non-visible technology", revolutionizing all the spheres of man's activities. This technology is very specific since it implies a selective transformation into information blocks of a maximally ample material on the achievements of sciences and technology, and therefore makes it possible to reject the traditional approach to questions, put before us, and offers new, innovatory solutions that bring about qualitatively new stages in the civilization progress.

This type of activity can be classified as the fourth, fifth or even subsequent sector of economy (Gottman 1974). The development of the fourth sector is dynamic but in principle it occurs only in the highly industrialized areas. Moreover, it is foreseen that throughout the nearest half-century the discrepancy between the highly industrialized countries and the Third World will be aggravated in this respect. The countries, rated now as very highly industrialized, will step out of the era of industrialization and enter the era of the societies based upon the production of services and a new type of information blocks. Thus, they will be oriented towards the expansion of the fourth sector. The remaining countries will at most pass from a lower to a higher stage of the economy of the industrial or agricultural type.

This is determined by the possibilities to build up foundations for the development of sophisticated activities, represented by the fourth sector. Therefore, urban centres, and mainly those which are characterized by specific conditions, are again the cradle and the place of growth for the fourth sector.

J. Gottmann (1974) starts the enumeration of necessary conditions with the proper "infrastructure of work" (libraries, research institutes, laboratories, etc.) and well-trained staffs. To maintain permanent contacts and exchange of experiences or information with the international agencies specializing in the domain of the fourth sector is of greatest significance. Moreover, the concentration of auxiliary technical-cum-organizational services, as well as of well-developed general services, is absolutely vital. Only in such conditions — says J. Friedmann (1967) — can a development, understood as a process of innovations not only in technical but also in social domains (Boudeville 1971; Goddard 1978) be achieved.

The new quality of the domains classified as the fourth sector implies that the functions have also new qualities. Gottmann (1978) believes that this phenomenon consists of the transformation of simple central functions into pluralistic central functions of a complementary character. We may therefore say that these are the forms of the functions of a higher category; their very important characteristic is the flexible development and the ability to amalgamate and penetrate.

The role of the focuses of attention, played by the central functions of the new category, is not limited to the area of the city and its regional hinterland only, but spreads also over dispersed space, distant in the physical sense. The last case refers mainly to the city's role as organizer and promoter of contacts and integration processes at the supraregional and global levels.

THE NOTION OF A CONTEMPORARY LARGE CITY

We may assume that the new category of central functions is associated with large urban centres. A closer analysis of this problem reveals that this assumption is not precise. The definition of a large city contains two characteristics: a simple one, which is easy to designate, and a complex one, for which there are no unequivocal criteria. The first one is the number of inhabitants; the calculation of this index is a statistical operation and its degree of accuracy depends on the organization of the administrative apparatus in the given country. The second characteristic is the role of the city as a political, economic as well as cultural centre, and can be quantified only partially. This index must be weighed up, but such an assessment always contains a grain of subjectivism, which may be criticised.

In view of the difficulties, which arise when the second characteristic is designated, for general purposes comparisons of cities are based upon the index of the number of inhabitants. However, the character of the modern process of the world's urban development makes this measure inadequate. The image, which we obtain by using the number of the city's inhabitants, is only partial and does not provide any information about the essence of the problem, i.e. about enormous differences in the development of the cities of highly developed countries and those in the Third World's countries. We cannot put the equality sign between the cities of those two groups of countries on the basis of the comparison of the number of their inhabitants. A more adequate comparison may be made on the basis of their functional significance in the global space.

Leaving a thorough analysis of the problem aside, we may indicate that modernity, which is an attribute of the contemporary cities in developed countries, enters the Third World cities only at random and is not structurally linked with the organism not only of the country as a whole, but even of the city. It is also a rare case when this modernity is generated by internal forces, though dependence upon external centres is quite strong. Therefore, the largest cities in the Third World are not partners for the urban centres of the highly developed part of our globe. In the network of large cities they remain the nodes of a lower rank, even often in relation to middle cities in highly developed countries. Moreover, *inter alia*, the cities of the Third World do not play any greater role in the integration processes occurring on the global scale. It is quite clear, however, that they endeavour to have a more prominent place in the integration processes on the supraregional and regional scales in the area of the Third World.

PROBLEMS CONCERNED WITH RANGING THE CENTRES OF INTERNATIONAL INTEGRATION

The identification of the cities participating in the processes of integration, the assessment of their role and an arrangement according to the degree of their significance for those processes might be an interesting task, which, however, requires a more through analysis than that which could be described in a paper of this size. Therefore, I have only marked certain methodological problems and outlined the first approximated results obtained in research. To begin, I would like to make it clear that in the analysis of this subject we are to face three important problems.

The first problem is concerned with the fact that the criterion of the selection of integration factors is not very precise since it must embrace in general all those factors and elements, which make contacts easy, inspire closer relationships and lead to the integration processes. Therefore, the clearly defined substances are accompanied by unsettled ones.

The second problem is that various integration factors are to be taken into consideration, such as: functions, values, and circumstances, which can hardly be separated one from another and as a consequence singled out as diverse categories.

The third problem is associated with the compilation of complete and up-to-date factographic material, which in certain conditions is not possible.

The next question to decide is what factors and elements, favouring integration processes, should be taken into consideration, and to arrange them in groups. Here, I would like to suggest the following classification:

– an advantageous political and geographical situation of the country and an easy access by well-developed transport networks;

– a high organizational level of the city regarding the infrastructure of the third sector;

– the extent of the fourth as well as derivative sectors operating in the city;

– rich traditions and an up-to-date cultural development;

– an expansive and flexible government of the state.

Every group listed above contains numerous factors and single elements of various categories. The frequency of their occurrence and intensity of the development determine the degree of the city's current as well as potential ability to participate in integration processes.

Finally, we should decide what forms of the contacts would be recognized as the manifestations of the integration process. In this analysis the following factors should be taken into consideration:

– co-operation between various institutions and organizations of the transnational character, global and regional;

– participation of the city in the organization of the most important congresses, meetings, international agreements, Olympic Games, etc. by providing for them the place where they can be carried on;

– broadly understood financial, consultative, legal, expert and other services on the international scale;

– participation of the city in international transport.

The manifestation of the integration process, listed above, have been assigned to 19 detailed groups, denoted as organization, namely: organizations with universal competences; financial, credit, insurance and stock-exchange organizations; economic organizations and economic declarations; research organizations, congresses; political and military organizations, political and ideological declarations, political conventions; juridical organizations; social, health, educational services; organizations dealing with cultural affairs and the arts, mass media organizations: organizations concerned with transport and communications; organizations concerned with forestry, fisheries, mineral raw materials, agriculture and industry including nuclear energy; trade and advertisement organizations; tourist organizations; professional organizations; trade unions' organizations; sport organizations; organizations concerned with family affairs, social care and welfare; religious organizations; women's, youth and students' organizations; organizations for environmental protection.

On the basis of these 19 groups 112 cities with a population of over 1 million people and 33 smaller cities were selected; the criterion used in the selection of smaller cities was their participation in the international integration movement, even if minimal.

It has come out that the number of cities which play an important role as the international centres on a global scale is very small.

– Five, i.e. Paris, London, Brussels, Geneva and New York, play an outstanding role.

– Five, i.e. Rome, Washington, Zurich, Tokio and Vienna can be classified as decisively active.

– Paris, Brussels, New York and London are important cities also on the supraregional scale.

– The remaining cities occupy more distant positions, both regarding the integration movement on a global as well as supraregional scales.

The lists made during the analysis make it possible to identify the most common forms of integration contacts in the most active cities. These are: contacts in financial and economic fields, in the sphere of science and culture, and in transport and social services. Contacts regarding the protection of natural environment are the least frequent.

FINAL REMARKS

Conclusions we can draw out of the outlined research problem may be of general or detailed character. The most general conclusions seems to be the fact that cities play an important role in international integration. The cities where integration activities are well developed both on the global as well as the supraregional scale are predominantly large, though also certain smaller cities cannot be disregarded in this respect. The role fulfilled by those cities requires that certain specific conditions exist, of which the functions of a complementary character are among the most important.

Though the number of cities playing an outstanding integration role is small, their activity is very intense. This is an evidence that the modern world is wounded up by a network of numerous linkages, which reflect various images of the world's space. The densest network is found in Europe, the cities of which are very active in the field of global and supraregional integration.

We should also take notice of the Third World's conscious policies, aimed at the development of own urban centres, which might be able to play the role of organizing and expanding the various forms of supraregional linkages.

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GEOGRAPHIA POLONICA 52, 1986

PROTECTION OF THE HUMAN ENVIRONMENT AND TOURISM: POSSIBILITIES OF COOPERATION OF TWO SPHERES OF HUMAN ACTIVITY

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INTRODUCTION

The topic of the present article, as presented in the title, requires the clarification of two issues. The first issue, and perhaps the more important of the two, concerns the different status of human environment protection and tourism,[1] respectively, in the national economy and socio-economic planning. While tourism, in a number of countries, is an established branch of the national economy and is thus subject to socio-economic planning, environmental protection is restricted to the activities of scientists, nature conservationists, people involved in maintaining historic buildings and monuments, etc.; in other words, it does not have the character of economic activity.

The extent to which the aims of environmental protection find their reflection in socio-economic planning is limited to guidelines in the form of prohibitions and warnings with regard to various manufacturing and service industries. Thus, these aims are not aims in the strict sense of the word, and they must be viewed as having only an indirect role in socio-economic planning, with no sanctions concerning their observation.

The second issue to be clarified is the more or less precise formulation of the object of protection, i.e. the resources which determine the operational basis for each of the activities under consideration. Whereas it is possible to identify precisely the resources exploited in tourism, the term "human environment" covers an unusually wide range of objects, or elements, described as "useful", but not explicitly defined as indispensable. In these circumstances, it seems essential to embark on a discussion aimed at defining the components of human environment, and thus also the objects of protection, if this article is to fulfil the role of a comparative analysis of those two fields of human activity. Here, only an attempt of a "stock-taking" nature will be made as a way of opening the discussion.

[1] Tourism is understood here as tourist industry, i.e. not as touring and recreation, but as the rendering of tourist services and all the activities necessarily preceding the rendering of those services.

HUMAN ENVIRONMENT

The term "environment" is used in various senses in works on spatial planning and management, culture and socio-economic issues. However, the point of reference for environment is always man or a social group, and thus it could well be said that most frequently the term covers all the material structures and their elements that man encounters in all the aspects and activities of his life. Polish works on spatial planning and policy stress the growing importance of human environment, and contain passages which can serve as its definitions. One of them states that: "This expanding domain should incorporate two fundamental problems:

1) the problem of physical environment including the environment created by nature and the environment transformed by human activity (the material substance of the environment, technical infrastructure, settlement network, etc.),

2) the problem of social environment seen as a network of social relations" (Kukliński 1984, p. 7). Another definition describes human environment in the following way: "Thus human environment is composed of the spatial pattern of the resources created by nature, and those created and transformed by man, and of all the processes of utilizing geographic environment" (Goryński 1982, p. 20). It is necessary to supplement Goryński's view with his definition of the culture of environment. This is what Goryński says (ibid., p. 186): "By the term [culture of environment] is meant the state of needs and values, and the stock of knowledge, art and practical abilities in the sphere of shaping and spatial utilization of human environment". We can see that the emphasis is on the culture of shaping and, what is even more important from our point of view, on the culture of utilizing human environment.

The protection of natural and cultural environment is also discussed in the contex of the development processes of countries and regions. In this connection assessments are made of the achievements (or their lack) in the field of ecology. Interesting remarks on the matter are to be found in an article by J. R. Lasuén (1974, p. 3, 7 and 9). Lasuén proves ecology's weakness for social decision making and points out an essential fallacy of ecologists' analyses stating that: "What is incredibly naive is to hope that the mere indication of danger will set up forces to correct the disastrous course". He criticizes ecologists for calls to halt growth processes, saying that: "The political and social repercussions of zero growth would be much graver than the ecological dangers envisaged". Lasuén formulates his opinion on development in the following way: "Development is a socio-economic-political process of change towards more equality, better living conditions and more freedom". The author stresses that within the framework of development processes, man should have easier access to attractive "rest and health environment". The conclusion is self-evident: tourism does not interfere with the protection of human environment. On the contrary, it contributes to the preservation of the values of the environment and it contributes to the development of regions, and in that number, peripheral regions as well.

The question of human environment has recently appeared in works devoted to the analysis of the causes of the present crisis. For example, Knud E. Sabroe (1984, p. 2 and 4), in a material he recently presented,[2] comments on the term "crisis" in the following way: "The crisis concerns not only economy but the whole way of life of the modern industrialized (welfare) society... The crisis of society

[2] At an international conference on Regional Dynamics of Socio-Economic Change, Experiences and Prospects in Europe and Latin America, Warszawa — Grzegorzewice, September 1984.

includes elements of an ecological, a political and a mental health crisis". And he goes on to elaborate: "... mental wellbeing is a result of the interaction between a person's expectations and the actual yields of the environment".

It seems necessary to reduce the multiplicity of material objects included in the human environment (not to mention the actions of and relations between people) to the dimensions appropriate for the interaction discussed in the present article, i.e. the interaction between human environment and tourism. Therefore, aiming at a reduction of the number of those elements, we shall apply a homogeneous criterion of functionality. The functions of tourist services are well known. The question emerges, however, what functions are we to ascribe to some of the material objects and their complexes, in order to be able to isolate them as specific elements of the human environment, correlated with the exploitational resources of tourism?

No doubt, we shall have to include the functions of protecting man against and preventing the burdens and stresses resulting from the contemporary technological civilization. It is worth noting here that the ecological catastrophe and the upsetting of mental balance in people, are usually connected with the developed countries (K. R. Sabroe); sometimes they are even regarded as the "privileges" of the rich (J. R. Lasuen). The wide literature on this subject names various symptoms as those most important and it recommends various courses of preventive action. A brief review of the views of a number of authors allows us to make the following recapitulation:

The human environment includes everything that can relieve or alleviate the effects of the technological civilization, computerization and automation, in particular with respect to work, life at home, education, entertainment and recreation (Bańka 1973). Moreover, the human environment includes all kinds of amenities, natural or man-made, that serve to counter-balance the drawbacks of living in big cities or in contact with industrial processes (Mumford 1966; Mills 1966; Ward 1983). Some other writers view the function of human environment as that of a remedy for inadequate housing, for the excessive concentration of people in residential areas, and for the faulty lay-out of the transportation network infrastructure (Lasuen 1973; Michajłow 1976; Ward 1983).

Applying the above to social psychology, it could be said that the human environment consists of a large set of amenities, freeing man from threats of disease (somatic and mental), states of fatigue, a sense of alienation, the destruction of personality, the stresses caused by noise and contacts with an excessively large number of people, and finally from the state of being severed from the traditions and cultural heritage of a given community.

Until recently, the human environment was identified exclusively with the natural environment (*Człowiek i środowisko*... 1976). This field of interest and the scope of the postulated protective measures with respect to what constitutes the human environment, has lately been much enlarged, although undoubtedly the focus of interest still centers on a rich and varied natural environment, on pure air and clean surface water, as well as on the exclusion of excessive noise. The importance of man's participation in the cultural heritage points to the great role of historic buildings, monuments of national and regional culture, skansens of architecture and folk art, etc. In this context, the problem emerges of the protection of specific areas containing the various components of the natural and man-made environments.

One can hardly fail to notice that the desired effects of protecting human environment depend largely on the abandoning of harmful activities, such as air and water pollution, the emission of noise, the appropriation of natural and cultural environment areas, or the decomposition of the natural landscape. The harmfulness of such activities applied both to man and to the protected areas affected by the harmful activities, as the loss of even one of their components may result in those areas losing the values man is looking for. Equally important is preventive acton consisting in the protection of historic buildings and natural treasures, the purifying of water reservoirs, the proper cultivation of forests, etc. Thus, it can be seen that the abandonment of harmful activities and the embarkation on preventive action are both dependent on a number of administrative bodies at the national and regional levels, including centres of socio-economic and spatial planning.

Finally, to complete the picture of activities contributing to the protection of human environment, one must mention one sphere of services. A man under stress, a frustrated man living in a period of leaping growth of the technological and industrial civilization, is looking for a ready-made "product" to cure him of all the stresses, frustrations, and alienations, a "product" which would be offered to him at a pace equalling the rapid pace of the processes which destroy him. This "product" usually consists in efficient services in such fields as recreation, sightseeng, entertainment, culture, etc. These services contribute to the so-called accessibility of the desired natural and cultural goods.

To sum up, we can say that the desirable utilization of the human environment depends on:

– the accessibility of elements, and complexes of elements, of the natural and cultural environments,

– the accessibility of areas constituting genuine or quasi-enclaves of human environment,

– the protection of such objects and areas against devastation or decomposition,

– preventive action against self-generating processes of the degradation of utilizable values, and reconstruction of destroyed values,

– organization of all kinds of services facilitating the "consumption" of the values of the elements, complexes of elements and areas of human environment,

– consistent activities by administrative bodies with respect to the supervison and implementation of the protection and conservation of selected objects and areas.

We shall restrict our analysis of the relationships between human environment and tourism to an object-based approach to the resources of human environment, broadening it to include the organization of tourist services as an activity enabling the utilization of the natural and cultural environments.

THE TWO FACES OF TOURISM

Tourism, as an economic activity, is aimed at maximizing economic effects. Tourist management must take into account the interests and the good of the tourists. This determines the desired numbers of tourists, i.e. the volume of tourist trade, and, as its corollary, the economic effects in terms of profit and profitabilty. At the same time tourism has to deal with the problem of short- and long-term profitability and economic effectiveness of its investments. This problem is connected inalienably with the protection of the so-called tourist values, i.e. that which attracts tourists to a given area. The protection and conservation of those values depends on the ability of looking at things from a long-term perspective. Immediate exploitaton of those values in the name of maximum profit is a very short-sighted resource management policy and one which leads to a "tourist erosion" of an area. What is left as a result of such a policy is costly service infrastructure, e.g. hotels, in an area depleted of attractions. This leads to a fall in or loss of tourist traffic and the unprofitability of amenities which have not been fully exploited.

Both exploitation versions are to be found in the activities of tourist enterprises. The choice of one or the other depends largely on the nature of the firm (private, co-operative, state, etc.) and the degree of control by economic and spatial planning centres. The exploitation pattern is also greatly influenced by local authorities and the strength of the local community (Great Britain, Holland, and West Germany, for instance, are notable for their local community protests and restrictions on tourist developments which destroy valuable or unique areas).

The operational basis for tourist services is formed by the resources of the natural and cultural environments. The location of those resources determines where tourist amenities are to be constructed and where recreational services are to be rendered. This dependence of tourism on an area's inherent resources has two basic consequences. One is the fact that the lasting nature and constant attractiveness of the components of those resources determine the economic performance of tourist enterprises. Moreover, through its investment in the service infrastructure and the rendering of its services, the tourist industry makes it possible for tourists, domestic or foreign, to have direct contacts with both kinds of environment; tourism also augments the attractiveness of these environments. Tourism has, thus, an important role in the process of increasing the physical and consumptive accessibility of valuable natural and cultural environments.

The comparative analysis of the convergent and divergent aims of human environment protection and tourism that will be undertaken here, will deal with an exploitation pattern for tourism which takes into account a long-term policy of protecting tourist values and attractions. It remains an open question, transcending the scope of the present article, how and through what administrative and economic measures tourist enterprises can be forced to choose such a pattern (presumably each country, depending on its economic system and the principles of management of social wealth, will adopt different and specific means such as directives, prohibitions or economic mechanisms).

THE PLANES OF CONVERGENCE AND CONFLICT BETWEEN HUMAN ENVIRONMENT PROTECTION AND TOURISM

From what has been said so far, it can be seen that the human environment and tourism have convergent spheres of protection. In each the focus is on the natural and cultural environments' resources, and on actions to prevent the diminishing of the cognitive and recreational values[3] within these two kinds of environment. What is of importance here is the joint interest in protecting areas endowed with special natural, climatic and landscape values. These who speak out for the protection of these values, and they represent both the above-mentioned activities, point to the fact that a total or partial qualitative or quantitative loss of one element in the human environment may lead to the decrease or at least transformation of the values of the whole complex. Furthermore, they also indicate the negative influence of deterioration processes in one of the elements on the disappearance, along with time. of the recreational values of a given natural complex (for instance, the cutting down of a forest may result in changes in climate and in the state of surface and subterranean waters).

Thus, in the case of human environment, as well as tourism, the most highly valuated areas are those with elements of the cultural environment within a valuable natural environment. There is a preference for rich and varied areas of open

[3] The term "recreational values" is understood here not only as being concerned with pleasant ways of spending leisure time, but also as referring to the processes of relaxation and elimination of all kinds of stress caused by the technological-industrial revolution.

space. Urban areas containing objects of historic and cultural interest are also the focus of both tourism and human environment protection.

The striving to preserve the values of the natural environment, and the objects, or groups of objects over a certain area, belonging to the national or regional culture, sets both of the discussed human activities in opposition to all economic and technological moves which could diminish or distort those values. This opposition is especially strong where industry or the technological infrastructure attempt to encroach on and appropriate or pollute these areas. However, both tourism and human environment protection find it possible to coexist and cooperate with agriculture, forestry and water management.[4]

Both tourism and human environment protection show a tendency to create closed enclaves. These enclaves are formed in areas under protection and for the exclusive use by tourism and human environment protection. While this is more frequent and more consistently successful in environment protection, it rarely or almost never succeeds in tourism. In this respect, environmental protection's achievements include the establishment of national parks and nature reserves. Both of these are legally protected areas and are the fruit of environment protectionists' efforts at a time when the term "environment protection" was not even known. The present activities of protecting the human environment follow in their footsteps, and are aimed at creating new national parks and nature reserves for the gradually disappearing species of animal and plant life.

In the field of protecting the cultural heritage, a notable achievement, of importance for both tourism and environment protectionism, has been the international categorization of historic buildings and monuments. It has created a legal basis for the protection, renovation and maintenance of those historic buildings and monuments.

The controversies and conflicts between human environment protection and tourism emerge in the sphere of utilizing areas of equal value to each of them. At this point, we should remember about the origins of the two activities: it is important to note that tourism has an economic character, while human environment protection does not. This fact leads to some significant consequences. Tourism is a kind of activity where use is made of quota and indices to calculate economic effects. No such parameters are applied to human environment protection, and what is more, it is not possible to identify the actual users of the human environment. Writings on human environment often express the view that the protected areas are for "people in general" (Pioro 1983), or that what is involved is "the creation of conditions for a sanctuary for human beings, where it would be possible to return to a state of individual personality" (Mumford 1966). These are semi-philosophical, semi-literary formulations, giving rise to a view that knowledge of utilizing environment already protected for man, is only in its beginnings. In effect, what we see is an enterprising attitude on the part of tourism, and signs of a lack of conception on the part of human environment protection with regard to the utilization of protected areas. The question might thus be posed: what is the object of the dispute between tourism and human environment protection concerning the utilization of areas of equal value to each of them? The answer is that it is the threat of destruction of all the values of the natural environment in protected areas due to over-intensive tourist exploitation. Extreme examples of the strength of such fears and protests by environmental protectionists can be seen in those instances where tourism attempted to make inroads into the enclaves of national parks. No larger

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[4] For a discussion of the coexistence between tourism and branches of economy usually considered to be in conflict with tourism due to their joint utilization of land, see M. Stalski (1981).

groups of tourists are allowed into such parks and any longer stays in these areas are out of question.

PROPOSED WAYS OF OVERCOMING THE IMPASSE

The dispute between tourism and human environment protection can be solved or alleviated by imposing quantitative barriers, known in tourism, on land utilization. Actually, the planning of tourist traffic on the basis of flow and intake capacity norms for recreational areas and amenities, excludes the mistake of too intensive exploitation leading to a deterioration of the environment. This view is expressed by R. F. Dasman, J. P. Milton and P. H. Freeman (1980, p. 223): "A well-planned tourism can substantially assist both in the assessment and the protection of the environment's quality". Quantitative and qualitative indices concerning the intensity of utilizing tourist areas may find application in the protection of typical enclaves of the human environment, but it should not be forgotten that areas of tourist expansion coincide with them. Tourism has had considerable achievements in creating such enclaves, and these have also been achievements for the protection of human environment. Protected spa areas in Poland, for instance, have strict norms and restrictions regulating the construction of houses and industrial plants there. The creation of areas of protected landscape, postulated by Polish tourism, is also a proposal extending the enclaves of human environment. It may be believed that conscious, planned management of the resources of the natural and cultural environments will result in the preservation of areas which meet the standards of human environment. Moreover, tourist services, with their socio-economic function, may become a "shield" for the enclaves of human environment against incursions by ruthless businessmen looking for profits in the exploitation of every green area by the manufacturing or construction industries.

It is against those who believe in the power of money and in measuring effects by economic calculation, that tourism can shield the areas of human environment from the charge of their unproductive nature. Of course, to take away that odium from the enclaves of human environment, tourism should universally enjoy the status of material services.[5]

Entering the sphere of economic arguments concerning the purposefulness and the directions of economic growth, we should point to the reasons for underestimating the importance of the human environment (and its protection) and tourism by economic leaders, and even to the fallacious nature of the economic calculation they use. Thus, one of the major sources of errors in spatial amanagement made by contemporary economics is the inability to estimate the value of the elements of natural environment destroyed when new industrial plants, new housing developments and new networks of technological infrastructure are sited in such areas. When green areas are devastated in the course of the development of manufacturing industries, there is no price tag attached to them and no estimation of their value takes place. In other words, we are not able to calculate the "costs of growth". Boekema and van der Straaten (1983, p. 279) point out the reason why it is not possible to bring to an end the calculation of negative external effects: "The function of the environment and the damage done to them carry no price tags; the goods are scarce but they

[5] In a number of countries with centrally planned economies, tourism is included in the non-material services sector. This results in a number of negative phenomena, the major of which is the low priority given to tourism in national economic plans, which affects the financing of investments and of modernizing tourist amenities.

have no market price; unfortunately, for lack of price data the cost-benefit analysis could not be brought to a successful end". The same authors say that: "The crucial question 'How much is nature worth to use?' cannot be answered with the instruments at our disposal ... Another question has to go unanswered as well, namely 'How do we value the goods produced and consumed at the expense of the environment?'".

The lack of the postulated instruments of qualification and calculation makes it possible for manufacturing industries to appropriate and destroy valuable elements and areas of the natural environment, and, furthermore, leads to an incomplete calculation of the social value and prices of the products they manufacture and supply to the market. This problem has long been affecting tourism and has not been solved up to this day. Attempts have been made to estimate the value of natural landscape and when these areas were destroyed there were attempts to assess their nominal value through a calculation of lost turnover and profit of tourist enterprises (Stalski 1979). This was a proposal intended at opening a wider debate. Unfortunately, this debate faded away, and there is still no method of calculating the value of elements and complexes of elements in the natural environment. One should hope that this gap in the calculation-based economic decision-making will be bridged and that this will curb the irresponsible management of areas valuable as human environment. The price of land and its recreational values, utilized or destroyed, could favourably influence the calculation of prices for tourist services, and it could also lead to a more economical management of natural resources within the policy of tourist areas management.

Another regulatory instrument in the field of spatial management (including the enclaves of human environment and tourism) is, along with economic calculation, spatial planning and regional development planning. Says A. Kostrowicki (1982, p. 218) about space: "It [space] is not only the expression of the siting of particular structures, and arena on which 'there take place' all social and natural phenomena, but, through its parameters, it activates and determines the 'costs of benefits' which stem from the interaction between man and the environment". It is those "costs of benefits" which could be a proof of the correctness of decisions in spatial planning. It is spatial planning which has at its disposal a stock-list assessment of all the elements in space, and it is spatial planning that can adjust siting decisions in such a way that would bring about the least losses in nature and its resources.

In this regard, one must mention the longstanding dispute and the lengthy process of persuading economic planners to make use of the knowledge and methods of spatial planning. Future is going to show who will become the winner in the dispute, and whether the integration of the aims of those two schools of planning will take place.

It is very significant that branches of economy which show high land use intensity and which deal in production or services based on the resources of the natural environment (or which are aimed at increasing those resources) are looking for the support of spatial planning in their utilization of land and their development. These branches of economy include, above all, agriculture and forestry, as well as tourism. Thus there appears to be forming a "bloc" of industries which, protecting their own interests, act indirectly for the preservation of the values of the human environment. One should not forget that plant vegetation in farming and forest areas is the "backbone" of the natural landscape. What is more, this vegetation contributes to the purity of air in cities and urban agglomerations. From all this it follows that the development and improvement of spatial planning methods can determine what comprehensive decisions are made with respect to the protection of various elements in the human environment.

RECAPITULATION

The identity of the substance protected for the preservation of the human environment and for tourism is self-evident. Tourism serves to introduce the processes of protecting human environment into the world of economic motivations and arguments. Moreover, tourism consciously, i.e. in line with its tasks and aims, utilizes areas under human environment protection. It is tourism, through its recreational programmes, that makes it possible for people to, in a way, consume and perceive the various elements of the natural and cultural environments.

Both tourism and human environment protection are consolidating their efforts in order to defend valuable areas against technological, urban and industrial expansion as harmful phenomena resulting from modern civilization. This defence could be much more effective if modern economics adopted and made use of estimates and prices for the natural environment destroyed in the course of siting new industrial plants, and urban and technological infrastructure developments.

In an area of leaping growth of the technological-industrial civilization and the serious warning signals about the threat to the human economy, human environment and human personality (U'Thant's Report, Brooks' Report, the First Rome Report), man's living conditions are becoming the focus of attention. There is not only the problem of hunger, pollution, disease, but also the problem of being able to realize the basic social aspirations of man. Many contemporary schools of social psychology adhere to the view that technological development and computerization as well as life in big cities have a detrimental effect on people and their partners at work, at home and in the community, to the extent that those basic aspirations are not being realized. With things being what they are, the human environment is not only to protect the soma and the psyche of people living in gigantic blocks of flats in horrifying cities, but is to be a "paradise promised", where people could escape from the monotony and strains of everyday life, to find their own personality in contact with nature and history. The pace of modern life, and the rhythm of those escapes, require an inconspicuous but efficient "guide" to provide a programme for the respite and to facilitate its realization.

At the present state of affairs, it is not only imperative to save and preserve the human environment, i.e. complexes of areas of the natural and cultural environments, but it is also necessary to facilitate their purposeful utilization, their "consumption", in such a way that would best serve to regenerate physical and mental strength and to reconstruct man's personality.

In this context it is difficult to speak of tourist services as the best solution for facilitating the postulated utilization. Nonetheless, tourist services are a field of human activity, where a lot of knowledge and experience has been gathered. These should serve as a basis for improving and expanding those services, so that the "paradise promised" could be made accessible to all who wish to take a break from the blessings of modern civilization.

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Cena zł 560.–

ISBN 83-01-06753-5
ISSN 0016-7282