GEOGRAPHIA POLONICA

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BOOK REVIEW

INTERMEDIATE LAYERS
IN THE KNOWLEDGE-ECONOMY SYSTEM

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ABSTRACT: The knowledge-economy system is so complicated that its description and analysis with the help of the calculus of correlations between inputs and outputs can only yield approximate results. These can be useful when arguing for an increase in research and development outlays, but tend to be disputed when passing from correlations to a cause-and-effect analysis, as critics demand elucidation of relationships between inputs and the outputs. The present author is of the opinion that the most practical way of solving this problem is to identify the structure of the model mapping the knowledge-economy system. If data necessary for a deterministic approach to modelling are missing, a probabilistic approach employing Markov chains be found to be useful. In the final part, the author suggests using neural networks, which make it possible to expand correlation links and hence to enlarge the basis of explanatory reasoning.

KEY WORDS: knowledge-economy system, identification of model structure, intermediate layers of system, probabilities of change in system states, effects of changes in states.

INTRODUCTION

In the rapidly growing literature on the role of knowledge in economic development, it is publications on the input-output type of relations that predominate. These try to determine the rate of return as a synthetic measure of the efficiency of inputs, but the calculation is difficult where the inputs for the development of knowledge produce intermediate, accessory effects, ones that are hard to measure or that appear after a longer period of time. This weakens the argumentation of proponents of greater inputs for the development of knowledge as they seek to argue their case with those defending the state budget.

While it is possible to establish a strict correlation between outlays on education and science and economic growth over a longer time period, the conclusions as to a cause-and-effect relationship drawn on this basis tend to be questioned. Statistical covariation expressed in coefficients of variation can be misleading, and the covariation like that of the inputs for the development of knowledge can

also be displayed by other causative factors of economic development. Examples are quoted of the lack of any correlation, usually over short periods of time, between an increase in the number of people employed in research and applications and economic growth. In fact, such cases happen when scientific-technological infrastructure is insufficient and innovation-oriented forces in the socio--economic environment weak. Besides, in the initial period of the stimulation of knowledge development to achieve economic effects, the newly-employed staff may still lack research and technological experience and thus be of rather low productivity.

Naturally, the use of the input-output relation and the rate of return in the development of knowledge is justified. Being simple, these notions can be employed to popularise the role of knowledge in the modern economy, though they are not sufficient as the intermediate layers of the relationship need to be penetrated[1]. These "latent layers" are not usually available for statistical observation and practical experience, but they need to be deciphered if the mechanism by which the system operates is to be identified, along with the processes transforming inputs into effects. So far, satisfactory ways of deciphering these layers have not been proposed. Obstacles to the process are both the high degree of complexity of the problem and the insufficiency of information about the mechanism underlying the transforming processes.

Nevertheless, the identification of the intermediate layers between inputs for the development of knowledge and economic growth helps (1) to build knowledge on this complex system now constituting the main factor behind economic progress, (2) to facilitate the design and correction of scientific policy through the reconstruction of intricate relations in the intermediate layers, and (3) to strengthen arguments for the development of knowledge in discussions on the state budget and priorities of budget policy.

These goals can be achieved through: (1) identification of the structure of the knowledge-economy system, (2) reconstruction of the network of links among entities found in the system, including the intermediate layers in which the economic surplus is generated, (3) definition of the intermediate layers in probabilistic terms, and (4) with the help of neural networks, anticipation of the effects of operation of a system with an ill-defined structure.

IDENTIFICATION OF SYSTEMIC STRUCTURE

The deciphering of the intermediate layers of the system requires that the pattern of relations presenting the effect of input signals on output signals be defined. This can be achieved: (1) through a knowledge of general rules govern-

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ing the given domain of reality (with this type of reconstructing of an internal process being termed modelling); and (2) through observation and measurements of the system's input and output signals and consequent inference regarding the transition process. This means of penetrating the process of signal transformation, termed identification, results in the provision of a model of the system. It competes with the model based on the knowledge of the general rules of system operation, but can also be a complementary research tool (Nahorski 1991; Soderström, Stoica 1997).

In our case, the input signals are outlays on education and science. They generate knowledge which accelerates growth and improves the efficiency of the economy. These results are the output signals.

The identification of the knowledge-economy system as described in mathematical terms is carried out via the following steps:

1. The choice of the class of model. The class is well chosen if it fits the properties of the system. Systems and their models can be, for example, linear and non-linear, or static and dynamic. The choice of the class is made on the basis of a prior knowledge of the given problem situation and earlier research experiences.

2. The definition of the structure of the model. Within each class many structures can be built. For example, linear models can be univariate and multivariate, employing one equation or many; dynamic models can have the form of differential equations or difference equations. The definition of the structure entails the choice of independent and dependent variables which are believed to express actual relationships holding in the system.

3. The estimation of the model, i.e. determining of the values of parameters for the adopted structure of the model on the basis of data obtained by observation.

4. The verification of the model entailing examination of goodness-of-fit to the real system. If the model gives a poor fit, an attempt is made to build a more adequate one.

In non-mathematical terms, the process of transition from input to output signals can be described as follows:

1. There are relations inside the system between the creativity of scientific institutions and innovativeness of R&D units, and the innovation capacity of enterprises and the administration. There is also feedback, i.e. the demand of enterprises and the administration for innovations can inspire basic and applied research. A model of this kind describes the generation and use of knowledge, usually in large-scale ventures, controlled and financed by public institutions. It is sometimes called a linear model. Recently the scope of its applications has diminished.

2. Intermediate layers in the knowledge-economy system include technical infrastructure and the socio-economic environment. They create the innovative climate and take part in transforming inputs into effects. They are elements of the transformation mechanism and external economies.

3. Creativity, innovativeness and entrepreneurship are attracted by and concentrate in large metropolitan areas. It is there that large-scale economies and multiplier effects are produced. These economies and effects can be found not only in the economy, but also in creative and innovative activity. Metropolitan areas are an intermediate layer in the knowledge-economy system when the system is considered in its territorial dimension. Situated in this layer are the biggest resources and strongest mechanisms transforming inputs into outputs.

4. Scientific-economic networks. The links and interactions among economic, R&D, and research units at various levels have tended to become stronger recently: inside large enterprises, among enterprises, between enterprises and the administration, among regions, among countries and groups of countries; and finally, at the global level. These links and interactions take the organisational form of networks, especially economic networks. Networks create conditions for a more intensive flow of knowledge and its enlargement by learning.

5. The intermediate layers in the knowledge-economy system also include filters, which may be of the absorbing, interference or polarising kinds. Absorbing filters absorb some or all inputs of the labour and financial means earmarked for science, with the result that these inputs yield either effects which are less than proportional, or no effects at all. A filter of this kind may be provided by an inefficient institutional structure of science and the economy. An example of input absorption is the allocation of means for misconceived scientific and economic projects. Absorbing filters can also absorb part of the outlays on science if these are too small to trigger the mechanism of a positive impact on the economy (thanks to their not exceeding some critical mass).

In our system, interference entails an influence of one kind overlapping with one of another kind. Such that there is a reinforcement or weakening of the resultant effect. For example, there is an opinion that the 1990 reform of the Polish economic system left the R&D units of industry and agriculture, working mainly for big, state-run enterprises, with considerable surpluses of service capacity because of the decline or total disappearance of demand on the part of those enterprises for R&D work. The small and medium-sized private firms that appeared in great masses at that time were not interested in such services because, having mainly been set up in trade and services, they most needed, not only capital, but also legal and economic advice. As a result, R&D units had to reduce their activity, or were liquidated.

Polarising filters slow down the development of clusters of innovative enterprises. One reason may be a poorly-developed market for skilled labour (researchers, engineers, organisers and managers). A well-developed market is favourable to (two-way) flows of highly-qualified staff between scientific institutions, application-oriented firms, and manufacturing enterprises. Such flows are an indispensable condition for learning and innovation growth, and hence for the concentration of modern, highly profitable kinds of activity.

Intermediate layers also develop under the influence of the concrete condi-

tions of place and time in which the knowledge-economy system operates. There may be a period during which the feeding of the system slackens off, due to the emigration of talented scholars, or else inflation reduces the real value of financial outlays. On the other hand, the system in a region may be given a boost when a new university, higher vocational school, or private research institute opens.

PROBABILITY OF A CHANGE OF STATE. MARKOV CHAINS

If a measurable identification of the knowledge-economy system in the form of a deterministic model is hard to achieve, owing to an intricate pattern of interrelations and a scarcity of data, then other models should be sought. Below we shall test a probabilistic approach and one offered by the theory of neural networks. In the probabilistic approach, we shall use a model based on Markov chains in which the web of cause-and-effect relations of a deterministic nature will be replaced with the probability of a change of state. In turn, neural networks make it possible to get round this obstacle altogether. They transform input information into output data *via* complicated interactions of neurons throughout the network, including intermediate layers. The network operator receives the final result, but does not enquire into the highly intricate processes taking place in the intermediate layers.

In the Markov model the system of variables describes several clearly-defined and mutually-exclusive states[2]. At each point in time the system is in one and only one of those states. Whatever the state of the system at any time, the probability that it will change to another of those states at the next point in time depends exclusively on the state at that time. This means that the probability of transition of the system to the next point in time does not depend on how the system has arrived at its given state. This property of the system is called a Markovian property, or no memory. The state of the system at the next point in time is calculated by multiplying the state vector of the previous point by the transition probability matrix.

It follows from the probabilistic nature of the Markov model that it is suitable for the study of mass phenomena. In the case of the knowledge-economy system, it can be useful in the study of a large community of entities making outlays on research, implementation, and innovations. The community embraces enterprises, R&D units, higher schools, research institutes, technological parks, innovation centres, information centres, and gmina and municipal offices[3]. The model is not suitable for the study of big individual research and development projects financed by public institutions.

By applying Markov chains to the study of the behaviour of large com-

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[2] The mathematical form of the model was taken from Searle and Hausman (1970), chapter 8.
[3] In this chapter the term knowledge-economy system refers to a community of this type.

munities of scientific and economic entities that are components of the knowledge-economy system, the following results can be obtained:

1) the probability with which we can assume that, given a specific transition probability matrix, the knowledge-economy system starting in an initial period (e.g., a year) in state 1 will remain in this state or change to state 2,..., N;

2) total expected rewards after 1,..., n periods, with the given transition probability matrix and reward matrix, and assuming that the system is initially in state 1;

3) maximum expected rewards after 1,..., n periods, assuming that the system is in state 1 and in each successive period optimum decisions are made; and

4) the state of the system arrived at after a long time (a steady state). It is possible to calculate steady-state probabilities of states and a steady-state expected reward per period, and to choose a decision rule that will maximise steady-state rewards per period.

Below we present ways of arriving at the above results. We shall consider a knowledge-economy system which can be in one of the following three states: (1) of low outlays on science (e.g., 0.45% of GDP) and short-term rewards sufficient; (2) of larger outlays on science (e.g., 0.75% of GDP), and rewards satisfactory; and (3) of much larger outlays on science (e.g., 1.25% of GDP) and rewards good.

The operation of our system is characterised in a synthetic way by the inputs made and outputs obtained when the system is in the given states at the given time moments. The cost and reward matrices in the particular states are presented in Tables 1 and 2, and the transition probability matrix in Table 3. We can affect the operation of the system by employing either of two variants of scientific policy: (1) the maintaining of the existing state (a passive policy), or (2) the changing to a higher or the highest state (an active policy).

A comparison of the cost and reward matrices shows that the system produces a growing surplus while changing from states 1 and 2 to the higher states. When it reaches state 3, it maintains the high surplus, and when it reverts to states 2 and 1, the surplus is reduced. The system has a chance of changing from state 1 to state 2, and of maintaining states 2 and 3 once it has reached them. Other transitions are possible, but less probable.

Table 1. Matrix of costs borne by the system on changing from state to state.

From To	State 1	State 2	State 3
State 1	0.60	0.80	0.70
State 2	0.70	0.70	0.65
State 3	0.75	0.70	0.60

Table 2. Matrix of rewards gained by the system on changing from state to state.

From To	State 1	State 2	State 3
State 1	0.85	1.10	1.25
State 2	0.91	1.15	1.30
State 3	0.95	1.15	1.40

Table 3. Transition probability matrix.

From To	State 1	State 2	State 3
State 1	0.20	0.50	0.30
State 2	0.10	0.70	0.20
State 3	0.10	0.30	0.60

On these assumptions, the mathematical apparatus of Markov chains was used to calculate the values of all the mentioned characteristics of the system[4]. Presented below are the results for two periods of the system's operation: after 5 and 10 years. The results are given in Tables 4, 5 and 6.

Table 4. State probabilities.

	After 5 years	After 10 years
State 1	0.1111	0.1111
State 2	0.5376	0.5370
State 3	0.3513	0.3519

Table 5. Total expected rewards.

	After 5 years	After 10 years
State 1	5.850	11.811
State 2	5.894	11.855
State 3	6.100	12.063

Table 6. Maximum rewards (results of optimum decisions).

	After 5 years	After 10 years
State 1	5.850	11.811
State 2	5.894	11.855
State 3	6.100	12.063

State probabilities after five years were close to the mean for transition probabilities, and almost did not change over the next five years. In both periods, the most probable transition is that from state 1 to state 2. If the probability of transition to higher states is to increase, it is essential to raise outlays on science, including investment outlays. It is a necessary condition, and given an optimum scientific policy, a sufficient one.

Total expected effects (rewards) change with time, but differences between the particular states are only slight. The effects are calculated using Markov chains with rewards. It emerges that the optimum values are the same as the expected values. They are calculated by maximising the rewards (effects) for each state and each possible initial state (the optimisation of operations in Markov chains). The result is convincing, but requires comment.

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[4] The calculations were made by Dr A. Marciniak, Institute of Informatics, Poznań Polytechnic.

The gradual reduction of outlays on science (as defined by % GDP) forced the elimination of relatively less effective activities. Over several years, the repeated elimination brought the system to a state which was formally optimal given the resources available (obviously, it did not meet substantial criteria of optimality). This was an optimum in the Pareto sense, that is, given the resources, it was impossible to improve efficiency by shifting outlays among the particular activities. Small outlays satisfying minimum needs did not create conditions for variants of scientific policy, for the choice of various goals and ways of achieving them. The optimum policy was a passive one designed to maintain the existing state. An active policy disturbing the equilibrium at the minimum level could only disrupt relations among system elements which had gradually formed under budgetary pressure.

What is the probable development of the system in question over a longer time perspective? We can find an answer to this question by calculating the steady state of the system. The results are as follows:

– steady-state probabilities of states (b_i)

$$b_i = \begin{bmatrix} 0.1111 \\ 0.5370 \\ 0.3519 \end{bmatrix},$$

– the expected steady-state reward per period of a development process (g), irrespective of the states in which the system makes the transition:

$$g = 1.1923,$$

– the maximum steady-state reward per period (g_{max}):

$$g_{max} = 1.1923.$$

The results lead to rather pessimistic conclusions:

1. The transition of the system from a low to a satisfying state is not certain. The probability of the transition, even in the long time perspective, amounts to 0.5370.

2. There is no chance of improving state efficiency by optimising scientific policy. The expected and maximum steady-state rewards are the same. The result can be explained like this: scientific policy is limited by the existing state, which does not offer the freedom of movement and choice. Room for movement and choice can be made by increasing outlays on science.

Table 7. Matrix of increased rewards gained on transition from state to state.

From To	State 1	State 2	State 3
State 1	0.85	1.10	1.50
State 2	0.90	1.20	1.70
State 3	0.95	1.25	1.90

We add new assumptions to those adopted in our calculations so far: first a changed efficiency (rewards), and then a modified probability of transition. Namely, we assume that the existing equipment and outlays on science will be put to a better use. The increased level of efficiency is presented in Table 7. Its elements express higher efficiency on transition to state 2, and even higher in state 3. This assumption should not engender any reservations, because higher states are assigned larger outlays and higher efficiency. With these modified assumptions, the following results were obtained (Tab. 8 and Tab. 9):

Table 8. Total expected rewards.

	After 5 years	After 10 years
State 1	6.6507	13.5430
State 2	6.7008	13.5912
State 3	7.2617	14.1578

Table 9. Maximum rewards (results of optimum decisions).

	After 5 years	After 10 years
State 1	6.804	13.987
State 2	6.993	14.175
State 3	7.379	14.562

– The expected steady-state reward per period

$$g = 1.3785.$$

– The maximum steady-state reward per period

$$g_{max} = 1.4366.$$

To what extent did the performance of the system improve after the introduction of the assumption of an increase in efficiency without an increase in outlays on science? The new state was compared with the initial one and the per cent increase in the total expected rewards calculated (Tab. 10).

Table 10. Percentage growth of states as a result of improved system efficiency.

	After 5 years	After 10 years
Total expected rewards		
State 1	13.7	14.6
State 2	13.7	14.6
State 3	19.0	17.4
Maximum rewards		
State 1	16.3	18.4
State 2	18.6	19.6
State 3	21.0	20.7

– The percentage increase in the steady state:

$$\Delta g = 15.6\%,$$

$$\Delta g_{max} = 20.5\%.$$

The following conclusions can be drawn from the above calculations. The effects of system performance are better than in the initial year, both after 5 and 10 years. The expected total rewards after 5 years grew from 13.7% in state 1 to 19.0% in state 3, and after 10 years, from 14.6% to 17.4%. The decrease in efficiency in the second five-year period means that the reserves of an increase not involving larger outlay have become depleted.

The maximum rewards grew from 16.3% to 21.0% after 5 years, and from 18.4% to 20.7% after 10 years. The bigger growth of maximum than expected rewards means that, given a steady level of outlay, an optimum scientific policy can produce additional effects. However, this possibility wears out with time.

The steady state settled at a level lower then the state after 10 years, especially where the expected rewards were concerned. One can conclude, therefore, that over a long period of time a system whose development rests solely on an increase in efficiency without an increase in outlays loses its dynamic.

Let us now change the assumptions and make system efficiency constant (at a higher level), while changing the probabilities of state-to-state transitions. The transitions can take place as a result of an increase in outlays on science, including investment outlays. The considerable increase in transition probabilities, in terms of economic growth theory, means that a strong push has been made.

A new probability matrix is presented in Table 11. As can be seen, under the influence of increasing outlays there is a growing probability of transition from state 1 to state 2 and from state 2 to state 3, while the probability of maintaining state 3 remains high.

Table 11. Transition probability matrix after increasing outlays on science.

From To	State 1	State 2	State 3
State 1	0.1	0.7	0.2
State 2	0.1	0.3	0.7
State 3	0.0	0.1	0.9

What were the effects of an increase in the outlays on science? They are presented in Table 12 and in the steady-state data.

– The percentage increase in the steady-state:

$$\Delta g = 28.4\%,$$

$$\Delta g_{max} = 23.3\%.$$

In the system considered, the rewards gained through an increase in outlays on science are greater that those obtained solely through an increase in efficiency

Table 12. Percentage growth of rewards as a result of increased outlays on science.

	After 5 years	After 10 years
Total expected rewards		
State 1	18.8	23.7
State 2	26.7	27.6
State 3	23.0	25.6
Maximum rewards		
State 1	17.0	20.2
State 2	21.4	22.4
State 3	21.1	22.2

with a constant level of outlay. In state 1, for example, the outlays on science make the expected rewards grow by 18.8% after 5 years and by 23.7% after 10 years, while there is an improvement in efficiency by 13.7% and 14.6% respectively.

Maximum rewards also grow faster as a result of an increase in outlays than in efficiency, but slower than the expected rewards. In state 1, after 5 and 10 years the outlays improved the rewards by 17.0% and 20.2%, and efficiency by 16.3% and 18.4% respectively. The slower rate of increase in the efficiency of new outlays can be explained by reference to difficulties with the launching of research and technologies, the acquiring of new experience by research and engineering staff, and a lapse of time between outputs and inputs.

In the stationary state, i.e. one persisting over a long period of time, the efficiency of outlays on science, especially the expected efficiency, is much higher than after 5 and 10 years. If we consider that the system in question consists of a large number of independent entities, the higher expected efficiency in the steady state can be accounted for by the fact that after 5 and 10 years the market mechanisms in the science-economy system failed to make all those elements adjust in such a way as to form an arrangement producing maximum results. What is more, processes of spontaneous co-ordination produced better results than strict maximising rules (28.4% as against 23.3%).

The results obtained so far make it possible to compare the growth in rewards due to an increase in productivity and an increase in outlays. In every state the increase in rewards resulting from an increase in outlays is bigger than that resulting from an improvement in productivity (cf. Tables 10 and 12). As a consequence, the proportion of outlays on science in the total increase in efficiency of the science-economy system is higher than that of productivity. In order to measure both proportions, let us use the steady-state data on the assumption that these express long-term trends free from periodic oscillations and incidental disturbances. We obtain the following relations.

Let us now abandon the assumption that productivity improves first and when its reserves not involving outlays have become depleted, the system switches to an increase in outlays on science. To establish the total increase in rewards, i.e.,

Table 13. Proportions of productivity and outlays on science in total rewards
of the science-economy system.

	Expected rewards	Maximum rewards
Proportion of productivity	0.35	0.47
Proportion of outlays on science	0.65	0.53

that brought about by the increases in productivity and in outlays on science, the
state of the system in the initial year was compared with a state after the produc-
tivity had grown and outlays made. The results of the comparison are presented
in Table 14.

Table 14. Percentage growth of rewards as a result of a simultaneous increase in productivity
and in outlays on science.

	After 5 years	After 10 years
Total expected rewards		
State 1	35.1	41.9
State 2	44.0	46.3
State 3	46.4	47.4
Maximum rewards		
State 1	36.1	42.4
State 2	44.0	46.3
State 3	46.4	47.5

– The percentage increase in the steady-state:

$$\Delta g = 48.5\%,$$

$$\Delta g_{max} = 48.6\%.$$

The main conclusion that can be drawn from the analysis of this table con-
cerns the occurrence of synergistic effects when an increase in productivity
co-occurs with an increase in outlays on science. The conclusion can be con-
firmed by summing up the relevant terms in Tables 10 and 12 and comparing the
totals with those in Table 14. The last are always greater than the totals of the
two previous terms. The differences are the additional rewards resulting from the
interaction of the growth of productivity and outlays.

For example, the expected rewards in state 1 after 5 years grow by 13.7% as
a result of an increase in productivity, and by 18.8% owing to an increase in
outlays. The total increase amounts to 35.1%, i.e. is greater by 2.6%. The synerg-
istic surplus also occurs in a long-term approach. The total increase, which is
equal to 48.5% in the steady state, is greater than the sub-totals in steady states,
viz. 15.6% and 28.4%. The surplus amounts to 4.5%.

The results obtained in the experiment concerning the behaviour and proper-
ties of a hypothetical science-economy system can be summarised as follows:

1. The rewards of the system can grow periodically owing to an increase in productivity without outlays on science. However, they decrease with time. The dynamic for productivity slackens if it is not sustained by new outlays. In state 3 the rewards after 10 years are smaller than after 5 years.

2. In a period of system stagnation at a low level (the initial period) there is no chance of improving efficiency by optimising scientific policy. Budgetary limitations force an allocation of resources close to the optimum and do not leave room for shifts and the choice of a better variant.

3. The rewards of outlays on science gained by the system as a result of the optimum policy are smaller than the expected ones. This can be explained by reference to the costs of overcoming the initial inertia of the system, and of the gaining of experience by research and engineering staff, and in terms of the lapse of time between outputs and inputs.

4. Scientific policy produces the highest additional rewards if it is oriented towards an increase in the productivity of scientific work: and an increase in the outlays on science simultaneously.

5. The proportion of new outlays in the total rewards of the system is higher than the proportion of productivity. This means that the science-economy system is capital-demanding. Scientific policy should take this feature of the system into account.

6. The system shows clear synergistic effects. The total rewards obtained by an increase in outlays and productivity are higher than the partial rewards of either of these factors.

7. Over a longer period (the steady state) the rewards are higher than those after 5 and 10 years. In the conditions of a multitude of entities being involved and the system being complex, it emerges that a 5–10-year period is too short for market mechanisms and the rules of scientific policy to arrange the elements of the system in a manner producing maximum rewards.

8. In the steady state of the system, expected rewards coincide with maximum ones. The maximum rewards are only 0.1% greater than the expected ones (48.6–48.5%). This is proof of the low effectiveness of the optimisation policy in the conditions in which the system under study functions and develops. Such a policy is indispensable and may be effective when the budget earmarks substantial means for selected large-scale scientific-technological projects. With a large number of entities, freedom of their operation, and high fragmentation of outlays, the policy should create conditions favourable to activity and efficiency, and to the competitive growth of entities.

The method presented above makes it possible to observe the states of a system with an intricate structure and latent properties that are inaccessible to plain observation and everyday experience. It accommodates the level of development of the system, the contribution of factors that feed it, the efficiency of its operation, long-term growth tendencies, and the efficiency of policy. Hence, it can be an instrument helpful in the modelling of such systems and the devising of a policy for their development. The conducted experiment yielded convincing results that can be interpreted in a sensible way.

The high degree of complexity and latent properties hinder the application of deterministic models in identifying relations among state variables, rules of movement, and steering variables. Hence there is justification for suggesting that models employing the notional apparatus of the calculus of probability might be more suitable. This suggestion is the assumption underlying the present chapter.

The results obtained require one more comment, namely that they should be interpreted as relative or ordering quantities. In this form they can be useful in a number of applications, for example the forecasting of relative growth, the drawing-up of relative growth scenarios, the comparing of expected and maximum rewards, the comparing of steady states and the determining of relations among growth factors.

CONCLUSION

Arguments for financing research and development rank lower in budgetary decisions than purely economic and political ones. These decisions often do not match the generally-accepted slogan that creativity and innovations are now the principal driving force behind socio-economic development. Scientific circles, convinced about the truth of the slogan, draw the conclusion that they should strengthen their argumentation explaining the dependence between socio-economic development and the support given to creativity and innovations.

Studies made in many countries have corroborated the correlation between financial outlays on R&D and economic growth. However, there have been cases in which no such correlation has been found. This may have reflected outlays too low to reach the critical mass necessary to produce the effects registered in those countries where such outlays were high. Another reason may have been insufficient support for private R&D projects by public institutions. Low efficiency may also be a passing phenomenon resulting from a shift of effects in time. Investments and employment in the field of R&D do not produce immediate results; hence R&D outlays have to be correlated with results that come years later.

The present author suggests two approaches to the elucidation of intermediate layers in the knowledge-economy system. What he considers the most practical is the identification of the structure of this system, that is the building of a model in which input-output relations would accommodate a few additional variables describing the intermediate layers.

This approach may be made difficult by the lack of data concerning some of the variables and relations among them. The author suggests that a deterministic approach can be replaced by a probabilistic one in such cases, with deterministic dependences being replaced by probabilities of change in system states. In this solution it would be possible to associate the probabilities of system states with the effects specific to the particular states. The author has tested this concept numerically, and obtained convincing results.

Finally, the author suggests using neural networks in the study of the knowledge-economy system. Networks allow for a far-reaching extension of the correlation links occurring in this system. Although their nature precludes an interpretation in cause-and-effect terms, this extension ensures that such an interpretation is more justified than in an ordinary calculus of correlations.

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ENVIRONMENT AND PLANNING, OR POSSIBLE APPROACHES TO THE ENVIRONMENT IN PHYSICAL PLANNING

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ABSTRACT: The natural environment and its place in physical planning can be approached in a variety of ways. In an extreme case, the environment can be treated as the subject matter of a plan; alternatively, it can be one of the elements constituting the subject of planning. It can be treated as material defining the spatial framework of development, or as its factor and limitation, etc. The way we approach the environment depends primarily on how we understand the nature-man relationship, and what model of the operation and development of nature we adopt. Two such models can be considered: (1) of the autonomous development of nature, and (2) of controlled nature-man interactions. In the latter, two types of interaction are involved: of the spatial integration or spatial separation of nature and man. These assumptions can underlie various approaches to the environment; their elucidation is the subject matter of the present paper.

KEY WORDS: natural environment, physical planning, nature-man relationship.

INTRODUCTION

The process of the human use of the natural environment can be described, in a very simplified way, as the use of natural resources and the release into the environment of man-made elements, which are in fact natural resources transformed to a greater or lesser degree. This is the kind of behaviour we deal with in practically every inhabited or used place on Earth. The differences are only in the type of resources, the man-made elements released, and the density of their distribution. Other differences concern relations between man-made elements and their locations.

The above process leads to the creation of a new living environment in which natural and man-made elements coexist. It constitutes a whole whose functional character justifies its treatment as an interactive system with two subsystems: (1) the natural environment, and (2) a man-made environment. There is growing

awareness and ever more planning in the way the relations between these two subsystems are developed, relying on various models of the structure of the system as a whole. This process is called spatial development, or space economy, and consists in the expansion of man-made elements (or rather the man-made subsystem) into the natural subsystem. Assuming this process to be ever better planned and controlled, another assumption has to be made, namely that it will be underlain by a variety of approaches to the environment and its organisation, structure and operation.

The aim of the present paper is to describe the introductory stage of the process of shaping man's living environment, that is, defining the approach to nature, or the natural environment.

A GENERAL MODEL OF MAN'S LIVING ENVIRONMENT

Several different interactive models of man's living environment can be built, from the very simple to the highly complex. For the purposes of this paper, it will be enough to consider a very simple model resting on the assumption that man's living environment is a system with two component parts: a natural and a man--made (human) subsystem, with an interactive relation holding between them. The model is a version of V. Leontieff's input-output model.

The above interactive model (Tab. 1) is a matrix whose elements are vectors. They describe the relations that hold in the subsystem of nature (N) and that of man (E), as well as inputs of the natural subsystem into the human subsystem (I) and the effects that the human subsystem has on the natural one (O).

Table 1. Interactive model of the man-nature system.

	Human subsystem	Natural subsystem
Human subsystem	E	O
Natural subsystem	I	N

Source: Chojnicki (1971).

It should be kept in mind that the natural subsystem (N) is primary in relation to the human one (E), and that the human subsystem develops at the cost of nature (cf. Chojnicki 1971, 1988; Lipiec 1972; Regulski 1982; Parysek 1997).

INTERACTIONS IN THE HUMAN ENVIRONMENT

Since our considerations concern the human environment, it is justified to treat the relations holding in this system as ecological ones. Thus, we can consider the following relations (after Odum 1971):

- *neutralism*, when two elements occurring in the same environment do not affect (interact with) each other;
- *direct competitive interaction*, when two elements interact, usually inhibiting each other's growth;
- *competition for resources*, which consists in indirect, mutual growth inhibition in the conditions of limited natural resources;
- *amensalism*, when one element is inhibited or destroyed and the other is unaffected;
- *commensalism*, when one element benefits without harming or otherwise affecting the other element;
- *parasitism and predation*, when one element develops at the cost of the other;
- *proto-cooperation*, when mutual interactions are beneficial to both elements, though not indispensable for their growth; and
- *mutualism*, when the interactions are beneficial and indispensable to both elements.

The above types of interaction can be divided generally into two meta-types: negative ones, i.e. competition and amensalism, and positive ones, including commensalism, proto-cooperation, and mutualism.

With reference to the human environment system, most of the interactions occurring between the socio-economic and natural subsystems are negative in character. Special attention should be paid to competition, which in natural ecosystems means that two organisms strive for the same thing. In a system which is a combination of natural and man-made elements, there is competition between components of these two different subsystems, which may result in one component (natural) being replaced by the other (man-made). In ecology, this is termed the competitive exclusion principle (Hardin 1960). In developing an area, man takes over open spaces and gradually eliminates natural vegetation by replacing it with building, for instance houses, industrial plants, or communication routes. The man-made elements introduced into the natural environment push nature out, which means that the development of any area takes place at the cost of natural elements (Bauman 1991). In the human environment system one can also observe the relations of 'predation' and 'parasitism'. They represent the detrimental effect of the socio-economic subsystem on the natural subsystem (particulates, smoke, gases, waste).

It is much more difficult to trace positive interactions between the subsystems, or their components, of the human environment, that is, a beneficial influence of man-made elements on nature. An example may be the increase in bird populations in towns, or designing public green spaces (parks, gardens, woodlands) which can become ecological niches of various kinds. These spaces can be a sanctuary for many rare species of plants and animals, especially if they develop into a microsystem. By facilitating migrations, they can help enrich genetic codes of animals with new genes, which protects their successive generations from decline.

PLANNING THE HUMAN ENVIRONMENT
IN TERMS OF MAN-NATURE RELATIONS

The state of man's environment, which results from his impact on nature, defines general ecological conditions. It depends on whether nature is understood as a system developing in an autonomous way (independently of man and the socio-economic subsystem he organises), or whether its development is treated as a result of the taking into consideration and intentional planning of the man--nature relations.

The perception of the development of nature and the planning of the human environment will always depend on:

1) how we understand the man-nature relations, and
2) what model of the development of nature we adopt.

Various models of the development of nature can be built, among which two figure most prominently, namely:

1) a model of the autonomous development of nature, and
2) a model of its development resulting from controlled man-nature interactions.

Similarly, two types or categories of man-nature relations seem to be especially significant in determining the approach to nature and its use by man, namely:

1) spatial separation of nature and man, and
2) spatial integration of nature and man.

This differentiation underlies a model in which four attitudes towards the natural subsystem (nature) can be distinguished (Tab. 2), namely:

1) conservation of nature as a whole and of its resources (A in Tab. 2),
2) controlling nature development (C in Tab. 2),
3) making human behaviour dependent on natural processes (B in Tab. 2), and
4) conservation of valuable semi-natural features of landscape (D in Tab. 2).

Approaches 1 and 4 need no explanation. Approach 2 denotes a situation in

Table 2. Perception of the development of nature and man.

Development of nature	Man-nature relations	
	spatial separation of nature and man	spatial integration of nature and man
Autonomous	conservation of nature and its resources (A)	making human behaviour dependent on natural processes (B)
Result of man-nature interaction	controlling nature development (C)	conservation of semi-natural values of landscape (D)

Source: Adapted from *Sustainable development. A cultural approach*, 1992, Brussels, A report for the FAST Programme, Theme C, Global Perspective 2010, Task for science and technology, 21.

which natural elements compete with man-made ones in a given area. Approach 3 is a sort of natural determinism, or at least so-called 'deep ecology', which seems to be a gross oversimplification of the observed reality.

The approaches presented above are rather one-sided. However, they rest on the basically correct belief that nature is a good whose use should be particularly rational and economical. This is the operating assumption of all kinds of ecological movements, including the extremist Greenpeace.

However, control of the human environment usually requires a more active treatment of nature resting on the assumption, of course, that it is an extremely valuable and limited good, and that it is a non-renewable resource.

In accordance with these approaches, the natural environment can be used in six ways (though there may not be actual use in every case):

1) it can be left untouched (and be used exclusively and only exceptionally for scientific purposes),

2) its use can be very restricted, keeping the natural state of the abiotic components and natural localities of the biotic ones (reserves, national parks),

3) abiotic and biotic elements can be exploited to a limited extent, and added artificial elements kept to an indispensable minimum (landscape parks, protected woodlands, recreational areas),

4) biotic elements can be put to intense use (forestry, hunting, gathering, grazing),

5) artificial plant cultures can be introduced (agriculture, horticulture, afforestation), and

6) man-made elements can supersede natural ones almost completely.

And although any variant of environment use can be accommodated in the planning process, the last two are those that actually count. One can construct many classifications of this type. However, the discussed ways in which the environment can be used are those that can commonly be found in the geographical reality of modern times, also in Poland.

The perception of nature, especially the awareness that man's existence depends on the properties of the environment, defines man's attitude towards nature. The perception and the attitude are a resultant of many factors. A crucial role is played by the cultural background, the systems of values and ethical standards followed, and the outlook on the world (von der Wurff 1992). In search of harmony in the co-existence of man and nature, religious or even theological motifs are often employed (Root 1985).

We can distinguish four attitudes towards the natural environment with underlying religious inspiration (Tab. 3):

1) a 'dominion-over-nature' orientation, which in Lynn White's extreme opinion is the main element of the Judeo-Christian tradition responsible for the present environmental crisis;

2) a 'stewardship' orientation defined by White's critics, interprets the same tradition in a different way;

Table 3. Attitudes towards the natural environment.

Orientations	Dominion over nature	Stewardship	Participatory	Unity with nature
Attitude towards nature	Often absolute gap (metaphysical discontinuity) between man and nature. Related to dualistic and/or rationalistic philosophies, or inspired by religion	Man connected with, or even dependent on, nature, mainly because of its potential and significance for socio-economic life. May also be inspired by religion	Man essentially connected with other life-forms in ecosystem, which is perceived as community of vulnerable and autonomous partners. Differences between man and other life-forms not absolute (though important) and form a continuum	Differences between man and non-human nature are not absolute, and sometimes even perceived as minimal or irrelevant
Evaluation of worth of nature	Nature has no intrinsic value	Nature has more than mere utility value	Life-forms, characterised by autonomy and vulnerability, have intrinsic value	Nature has intrinsic value
Ethical-moral attitude towards nature	Nature only as resource to be exploited. No moral respect for nature	Respectful and responsible treatment of nature is man's duty towards himself or God	Moral respect for natural life-forms	Moral respect for nature

Source: Adapted from Achterberg (1986).

3) a participatory orientation, introduced by Achterberg (1986), who is also the author of this classification; and

4) a 'unity-with-nature' orientation, another extreme in the classification, represented by proponents of 'deep ecology'.

In the observed reality two approaches seem to predominate: the dominion-over-nature approach, especially in towns and urbanised areas, and the stewardship approach, which can be identified in the type of physical planning based on the sustainable development, or eco-development, model. The participatory approach can also be connected with sustainable development, as has been mentioned earlier, but in areas developed less intensively, while unity with nature is an approach we can talk about in the case of legally-protected areas.

At times when steps are taken to restore proper ecological relations, the dominion-over-nature approach is out of the question. On the other hand, so is unity with nature as a generally adopted attitude. Therefore, we are left with the choice of either the stewardship or the participatory approach.

CONCLUSIONS

When embarking on the process of physical planning, one should be fully aware of the fact that it involves the shaping of the organisation, structure and operation of the system of man's living environment. It is a system in which natural and man-made elements co-occur, and in which the latter develop at the cost of the former. Hence, there is competition for room between the natural and the artificial, but in reality the artificial tends to supplant the natural to an ever greater extent.

The way in which artificial elements compete with and supersede natural ones depends on how we understand the man-nature relation, what model of nature development we believe in, and what attitude towards nature we adopt. It also depends on whether we believe in integrating or separating the natural and the man-made elements. Our standpoint entails a specific level of interference with nature, from leaving it intact to replacing natural elements with man-made ones. The attitudes towards nature can also vary greatly, from one of dominion over it to one of unity with it.

The generally bad ecological relations in the environment and the necessity of using natural resources in socio-economic development make feasible only two approaches: the stewardship and participatory ones. They facilitate the implementation of the sustainable development model, which is in the vital interest of present and future generations, besides being necessary and promising for the disturbed ecological relations. These approaches will predominate in planning and spatial development, which does not preclude the 'deep ecology' attitude towards protected areas and the dominion-over-nature attitude towards degraded regions.

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MORTALITY IN WARSAW: IS THERE ANY CONNECTION WITH WEATHER AND AIR POLLUTION?

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ABSTRACT: City inhabitants are becoming more and more sensitive to weather changes and extreme atmospheric events. According to certain scientific reports mortality from cardiovascular and respiratory diseases is associated with oppressive weather conditions. In the years 1994–1995 a significant rise in mortality was found for Warsaw when particularly hot weather conditions, characteristic of a subtropical air mass, occurred. A synoptic approach in this type of research has been confirmed, and consideration of the influence of combined meteorological parameters on humans (via a biometeorological index) is seen to be much more fruitful and justified than using separate meteorological parameters in calculations.

KEY WORDS: mortality, weather, air pollution, Warsaw.

INTRODUCTION

The many factors determining death include the physiological, sociological, cultural, environmental, political and economic. The relationship between environmental conditions and mortality varies according to the types of disease directly responsible for death. The impact of the weather is greater in the case of suicides or cerebrovascular diseases than in the case of heart diseases (Okólski 1990). The number of people suffering from weather factors is still growing all over the world. Some researchers state that 50–70% of the populations of western countries show a sensitivity to weather changes which can be observed in mental discomfort at least (Machalek 1997).

Human beings have constantly to adapt to changing weather conditions, as well as to changes in the indoor microclimate. The maintenance of homeothermy is related to a few basic variables: the biological (metabolic rate, evaporation by vasodilatation and perspiration), the behavioral (clothing insulation) and the atmospheric (air temperature, thermal radiant temperature of surroundings, rate of air movement, atmospheric humidity). Physiological adaptation is easy for young

and healthy organisms, but the elderly or unwell cannot cope with extreme weather conditions (extreme heat, cold or a high level of air pollution), which can throw their organisms off balance and consequently lead to death.

In the 1960s, when thousands of deaths from acute respiratory diseases coincided with a smog episode in London, many authors started to consider and write about the effects of air pollution on human health (Jędrychowski 1995; Lipfert 1993). In turn the last two decades have seen numerous papers published on the changes in morbidity and mortality due to different air pollution levels and certain parameters of the atmosphere: air temperature, air humidity and wind velocity.

Several investigations have reported weather-related mortality during extreme heat or cold weather (Auliciems, Frost 1989; Kalkstein 1998). Extremely high temperatures not only trigger sunstroke, but also exacerbate many pre-existing health problems leading to a sizeable rise in mortality rates (Smoyer 1998). This means that stroke and heat exhaustion represent only a small part of heat-related mortality. Recent research suggests that one-third of the excess deaths that appear during heat waves occur in persons who would have died in the next few weeks (for other reasons). Many studies have shown that the number of cold-related deaths increases as daily winter temperature drops. However this rise is less steep than the accompanying rise in the summer. This relationship has been called "J-shaped" to indicate the steeper ascent at high temperatures. Many studies have established some threshold temperature above which a steep rise in mortality could be seen. There may be a critical load of heat stress above which the physiological adaptation mechanisms become inadequate (McMichael et al. 1996).

Recent papers have also confirmed the negative influence of some types of air masses on humans. In temperate climates this would especially be tropical or subtropical air masses. Some also report a negative impact of atmospheric fronts or pressure systems, though others do not.

There have been many investigations regarding changes in mortality rates in some Polish big cities, e.g. Poznań, Łódź and Kraków and their possible causes (Bogucki 1967; Wiecha 1952). They have revealed a connection between mortality and the inflow of subtropical air masses, and have pointed to a large number of cardiac infarctions on the days grouping extreme weather parameters (Skrobowski 1989).

Seasonal variation in general mortality has been noted in Poland, with a winter/early spring maximum and a summer minimum (Fig. 1). In Warsaw, as in many other Polish cities, the highest mortality is that recorded in March, the lowest that in June. This is related to variation in human biological activity, air temperature changes as well as weather activity. Respiratory deaths (hardly seen on the figure – because of the small number of cases) are subject to great seasonal variability with an obvious winter peak. Those of cardiovascular origin are in contrast the biggest group in the whole range of deaths and have seasonal changes very similar to those noted for the total number of deaths.
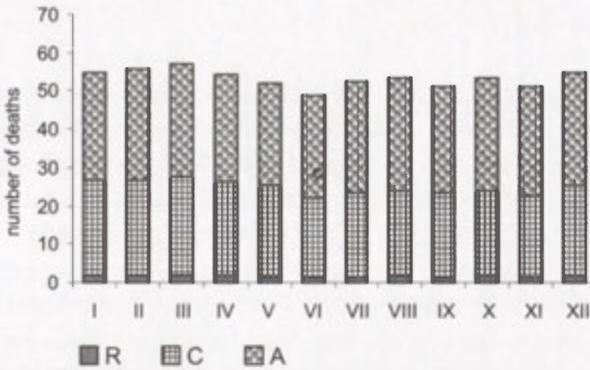
Deaths from: R – respiratory diseases, C – circulatory diseases, A – other

Figure 1. Mean daily number of deaths, Warsaw 1994–1995.

In Poland, as in most parts of the world, a general improvement in living standards (e.g. healthcare) in the 20th century has brought decreasing mortality and growing life – expectancy. That said, this process proceeds faster in towns than in rural areas, where the mortality rate is still high. In addition, the mortality among men is much higher than among women, especially in rural areas and in the 20–39 age group. Not only the number of deaths but also the structure of mortality has been changing. Fewer people die from infections, parasitic and respiratory diseases, but the incidence of cancer and circulatory diseases is still growing (Tab. 1). Circulatory diseases play a more important role in female mortality, while cancer and injury are more important in men.

Table 1. Structure to mortality in Poland.

Mortality structure	[%]					1995 [%]			
Deaths by causes	1960	1970	1980	1990	1995	urban areas	rural areas	men	wo-men
Circulatory disease	23	34	48	52	50	48	53	46	56
Cancer	12	17	17	19	20.5	22	18	22	19
Injury and poisoning	6	7	8	8	7.5	8	8	10	4
Respiratory disease	8	8	6	4	3	4	4	4	3
Infectious and parasitic disease	7	4	2	0.8	0.6	1	1	1	0.4

Source: *Demographic situation in Poland*, 1996, Report of the government commission on population policy.

The present paper describes the mortality in Warsaw and its potential dependence on the weather and air pollution. The number of weather-related deaths is considered to be the number of deaths occurring in excess of that expected for the given population in the absence of specific weather conditions (McMichael et al. 1996).

MATERIALS AND METHODS

The study has been conducted on the basis of deaths records obtained from the Central Statistical Office. The records refer only to the inhabitants of the city of Warsaw, and span a period of 2 years (1994, 1995), in which total number of deaths was 37,633. The average daily number of deaths in total is 51.7, while from circulatory diseases it is 23.2, and from respiratory diseases 1.7.

The main source of weather information has been synoptic map that helps to distinguish air masses, air pressure systems and atmospheric fronts over Poland. Weather in Warsaw has also been described by daily values for global solar radiation, sunshine duration, rainfall, air temperature (maximum, minimum, from 6 am and 12 am), air humidity, wind velocity and air pressure, as well as for day-to-day changes therein. The air pollution data, obtained from the Environmental Protection Institute, include mean daily figures for carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen monoxide (NO), nitrogen dioxide (NO_2), ozone (O_3) and particulate matter (PM) concentrations in the centre of Warsaw.

Calculation of one of the biometeorological indexes, the thermal human sense, is based on effective temperature (*TE*) after Missenard (Kozlowska-Szczęsna et al. 1997). This index compiles the influence of air temperature (*t*), air humidity (*f*) and wind velocity (*v*) on the human organism. These components together produce an "apparent temperature", that is perceived by the human body.

$$v \leq 0.2 \text{ m/s}$$

$$TE = t - 0.4 \cdot (t - 10.0) \cdot (1 - 0.01 \cdot f)$$

$$v > 0.2 \text{ m/s}$$

$$TE = 37.0 - \frac{37.0 - t}{0.68 - 0.0014 \cdot f + \dfrac{1.0}{1.76 + 1.40 \cdot v^{0.75}}} - 0.29 \cdot t \cdot (1 - 0.01 \cdot f)$$

At the same low air temperature an increase in air humidity intensifies the sense of coolness, in hot air a rise in water vapour pressure causes a negative sense of sultriness. The high air velocity on cold days enhances the sense of freeze but on hot days it becomes a real relief for overheated people. Human sensibility changes during the year. The same value of effective temperature in different months corresponds to different types of sensation. In the paper the Polish scale of thermal sensibility created for this index has been used (Baranowska et al. 1986).

The simplest estimation of weather impact on human health is the mean daily number of deaths under particular weather conditions, as well as the percentage deviation from the mean. In calculating this impact the following statistical methods were used: linear regression (Pearson simple and multiple regression coefficients) and non-linear regression. They consider the impact of one inde-

pendent variable on the dependent variable (number of deaths) and in the multiple regression, several weather variables and their combined influence on mortality rate (R), but also the impact of one chosen variable (the partial coefficient), after taking into consideration other factors. The significance of multiple regression coefficients was assessed by F-test, the Pearson linear coefficients by Student-t test. Several averaging periods were employed in using the moving mean method in these calculations. In all of them a 1 or 2-day time lag between an impulse and a response were taken into consideration.

There are many difficulties in drawing proper conclusions from the calculation e.g. the overlap between seasonal changes in mortality and weather or the high correlation among climatic variables. For this reason, all conclusions should be very cautious.

RESULTS

AIR POLLUTION

Daily and monthly fluctuations in air pollution are observed in Warsaw. The highest concentrations of the main air pollutants: SO_2, CO, NO_X, PM occur in winter (the season of highest mortality), with the exception of ozone which reaches its highest level in the summer (when daily numbers of deaths decrease). Thus seasonal variation in air pollution in general corresponds with the variation in mortality.

Table 2. The main characteristics of air pollution in Warsaw in the analysed period 1994–1995.

	Concentration				Daily norm in 1995 (norm in 2000)
pollutant	unit	minimum	maximum	mean	
SO_2	$\mu g \cdot m^{-3}$	1.84	144.09	27.85	200 (150)
CO	$mg\ m^{-3}$	0.10	3.83	0.92	1 (5)*
NO_2	$\mu g\ m^{-3}$	12.16	90.48	36.52	150 (150)
PM 10	$\mu g \cdot m^{-3}$	9.80	246.50	54.44	120 (125)
O_3	$\mu g\ m^{-3}$	3.33	108.50	33.85	39 (110)**

* – only for calculations; ** – average from 8 hours (10 am to 6 pm).

In comparison with other Polish cities, Warsaw has a lower level of SO_2 and a higher concentration of vehicle-derived pollutants (CO, NO_X and O_3) which are most hazardous for its residents (Tab. 2). There are many weather factors that influence the increase in air pollution (atmospheric calm, lack of ventilation, washing out by rainfall) but the most important are thermal inversion layers,

ground or free atmosphere layers. In 1994–1995 the highest air pollution values were measured on the days when a thermal inversion formed over the Warsaw Basin.

The concentrations of air pollutants in Warsaw, despite exceeding daily norms, do not yet reach the life-threatening levels. Nevertheless although they do not normally lead to death (except for the higher-risk group), their constant presence may stimulate certain symptoms of respiratory and circulatory diseases. SO_2 injures the respiratory system and causes a dangerous increase in airway resistance. The high affinity of CO for haemoglobin (depending on the ambient CO level) causes a decrease in oxygen-carrying capacity and may lead to cardiac infarction. Particulate matter damages lung vesicles, badly influences lung functioning and is responsible for lung pathology. Ozone intensifies pulmonary function response, causing edema and lung injury. Repeated exposure to all of the above may lead to asthma, bronchitis and allergy.

Combined air pollutants definitely affect the mortality rate, not directly by poisoning, but by the exacerbation of disease. Air pollution fluctuations explained 22% of the variance in circulatory-system mortality – 28% in the cold half-year, 21% in the warm half-year (Tab. 3). This has been confirmed via the distribution of 15-day moving means of mortality against SO_2 and ozone concentration (Fig. 2). The curve of the non-linear regression (6-degree polynomial) rises at higher levels of these gases. Some may argue that the mortality rise corresponding with the increase in SO_2 concentration in the air is random. It could be, because the highest mortality rate and the SO_2 concentration occur together in the cold season of the year. Although there is no doubt that the figure presents the dependence of general mortality on ozone stresses, the negative impact of this gas reaches the highest concentrations in summer, the season of low mortality. Also the number of deaths on days with air pollution concentrations exceeding by 50% the average in the warm half-year ($> \frac{3}{2}$ x) is much greater than in $< \frac{1}{2}$ x days (Tab. 4).

Table 3. The multiple regression coefficient (R) and coefficient of determination (R^2–%) between daily number of deaths and air pollution.

Death	Day-lag	Year		Cold half-year		Warm half-year	
		R	%	R	%	R	%
Total	0	0.31	9.5	0.22	4.7	0.41	16.9
	+1	0.41	16.5	0.39	15.4	0.48	22.7
Circulatory system	0	0.35	12.4	0.42	17.2	0.41	16.6
	+1	0.47	22.0	0.53	28.5	0.46	21.3
Respiratory system	0	0.15	2.2	0.15	2.2	0.26	6.6
	+1	0.20	4.1	0.23	5.1	0.14	2.1
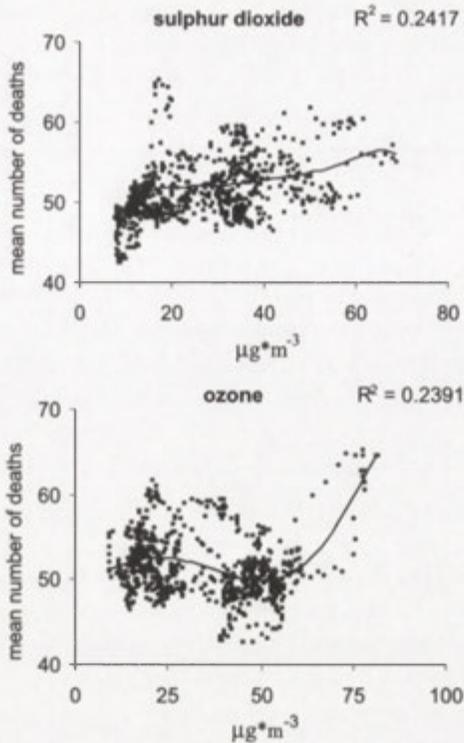
Figure 2. Distribution of 15-day means for deaths against sulphur dioxide and ozone concentrations, Warsaw 1994–1995.

In 1994–1995 the biggest increase in mortality coincided with the highest ozone concentration (Tab. 5). Its increase of 74% reflects a 49% increase in circulatory diseases and a 40% increase in the total number of deaths. The rise in particulate matter concentrations to 140% of the typical level for August coincided with a 30% excess of deaths from circulatory – system diseases.

Table 4. Mean mortality on days with air pollution differing by 50% plus or minus from the seasonal average.

Months VI–VIII	Total		Circulatory system	
	$> {}^3/_2 x$	$< {}^1/_2 x$	$> {}^3/_2 x$	$< {}^1/_2 x$
CO_2	59.5	43.0	26.4	15.0
SO_2	55.6	46.9	25.2	18.7
NO	52.8	47.5	23.5	20.5
O_3	66.6	48.9	29.7	19.9
PM 10	60.9	48.4	27.5	20.8
mean	50.0		21.8	

Table 5. The number of deaths and percentage deviations (Δ) from monthly mean
during episodes of high pollution levels.

Pollution					Mortality			
substan-ce	period	unit of measure	mean con-centr.	Δ %	total		circulatory system	
					number	Δ %	number	Δ %
SO$_2$	16–20.12.1995	μg·m^{-3}	94.95	+92	60.8	+15	26.0	+10
CO	24–27.10.1995	mg·m^{-3}	2.26	+54	47.8	–7	15.0	–32
O$_3$	30.07–07.08.1995	μg·m^{-3}	86.95	+74	72.0	+40	33.3	+49
PM	11–12.08.1994	μg m^{-3}	109.20	+144	59.0	+14	29.0	+30

WEATHER – SYNOPTIC SITUATION

In the search for mortality factors it is not only the analysis of meteorological parameters that is of great importance, but also qualification of the synoptic situation in which the excess mortality could occur. The synoptic situation (air masses in particular) can be expected to predict the total effects of weather on the human organism better than the components treated separately.

The most frequent air mass over Poland in 1994–1995 was the maritime polar fresh air (PPm) – on 33% of days and the maritime polar old air (PPms) – 26%. It should be pointed out that in the 90s inflows of hot subtropical (PZ – 6.5%) as well as fresh arctic (PA – 11%) air masses were more frequent than in previous times (in the years 1946–1956 – 2 and 3.7% respectively). Continental air (frequent in the 1950s and 1960s at about 30%, at a time when maritime polar air was rare), now appears over Poland quite seldom – 8% of the time (Tomaszewska 1964; Marsz and Styszyńska 1999).

During this 2-year period 328 atmospheric fronts moved over Warsaw and 275 frontal days have been recorded. 49% of the fronts were cold, 32% warm, and most of them (60%) were weak. Weather front classification takes the following form (Baranowska and Wojtach 1985):

	for three hours	in a day	front velocity
air temperature	< 1 > °C	< 5 > °C	warm fronts < 25 > km/h
air pressure	< 1 > hPa	< 5 > hPa	cold fronts < 45 > km/h
water vapour pressure	< 0.5 > hPa	< 3 > hPa	

In line with this classification, changes in the three meteorological parameters caused by the passing front and front speed were investigated. Values below the threshold classify an atmospheric front as weak, values equal to or above the threshold classify it as strong. A day on which two or more atmospheric fronts occurred is called a multifront day: strong where there was one strong front at least.

Low-pressure systems influenced the weather in Poland for 47% of days,

high-level systems for 43% and transitional systems for 10%. That said, of the 11 types of air pressure system, the most frequent was the anticyclonic one (high).

Generally, cyclonic weather (a trough of low pressure or weak-gradient low pressure system) leaves mortality higher than anticyclonic. In the analysed period, from within the group of 11 types of pressure system, the most hazardous was the weak-gradient low in which the highest daily number of deaths (87) occurred. In this type of pressure system a 7% mean increase in total mortality and a 13% increase in circulatory-system diseases (with a one-day lag) were noted.

These findings have been confirmed by investigation of air pressure values. It appeared that, on 27 January 1995, when the absolute minimum air pressure – 972.1 hPa – was noted, the number of circulatory-system deaths exceeded the average by 40% and all deaths by 11%. Equally, when the absolute maximum of air pressure – 1030.4 – was noted on 14.02.94, the elevation in circulatory-origin mortality was of 9% and in total mortality of 16%. This indicates the great role of extremely low air pressure in elevating mortality. In the present research no significant association has been found between mortality and day-to-day air pressure changes – despite several previously published postulations that there might be such a relationship. These big day-to-day changes play an important role in morbidity or car accidents, but in mortality the long duration of extreme high or low air pressure values seems to be more important.

Big, acute, synchronous changes in meteorological parameters on strong weather fronts burden the organism, leading to blood-pressure changes and an increase in the incidence of diseases of cardiovascular origin. In contrast, days of weak atmospheric fronts usually result in a drop in mortality.

Generally, there is a negative correlation between the daily number of deaths and cold-front frequencies, and a positive one between mortality and warm fronts. Behind a warm front, air pollution and water vapour pressure increase, in the warm sector of a cyclone. The amount of oxygen in the air being reduced, such that breathing intensifies, along with lung ventilation and pulse rate, while blood pressure drops and the heart is very burdened. Such circumstances can be the direct cause of death, from both respiratory and circulatory-system diseases.

Table 6. Mortality on days with selected types of front (percentage deviations from the mean).

Deaths	Day-lag	Days with atmospheric front		
		cold strong	warm strong	multifront strong
Total	0	+6	0	+2
	+1	–4	+5	+3
Circulatory diseases	0	+4	+1	+4
	+1	–5	+5	+4

The dangerous influence of a strong, cold front on the human body seems obvious – a narrowing of blood vessels occurs to protect the organism against overcooling, while there is a tendency for blood to clot at low temperature. Moreover, the cooling effect is enhanced by high air humidity, wind velocity and body exposure. The effect of warm fronts has been observed with a delay (on the day after and kept up on following days) and is connected with the weather in the cyclonic warm sector mentioned above (Tab. 6). Also, capable of causing stress is a multifront day with at least one strong atmospheric front. That said, the associations found here between mortality and weather fronts are not as strong as those reported in some previous papers.

The research reveals that, among synoptic factors, it is air masses that exert a particular impact on mortality in Poland. Formed over the Atlantic Ocean or Asian continent, they undergo partial transformations before they reach the Polish territory. During stagnation over Poland they take on features characteristic of our climate. Maritime polar fresh air (non-transformed) (PPm) is the most frequent air mass over Poland in the cold half-year; maritime polar old (PPms) – in the warm half-year. More frequent in summer are polar continental air (PPk) and subtropical air (PZ). Air masses are more stable than air pressure systems. The longest duration of one type of air mass was 12 days with arctic old air (PAs) and 10 days with subtropical air. Generally, the warmest and most polluted is subtropical air, while the coolest is arctic old air.

Table 7. Correlation coefficients between 10-day mean numbers of deaths and numbers of selected air masses.

Air mass ($n = 72$)	Day-lag	All deaths	Circulatory system	Respiratory system
Maritime polar old air (PPms)	0	–0.284	–0.154	–0.285
	+1	–0.271	–0.109	–0.289
	+2	–0.254	–0.118	–0.280
Arctic old air (PAs)	0	0.141	0.098	0.049
	+1	0.146	0.101	0.051
	+2	0.110	0.107	0.071
Subtropical air (PZ)	0	0.190	0.128	0.107
	+1	0.169	0.130	0.136
	+2	0.114	0.082	0.193

Mortality, especially from respiratory diseases, was shown to decrease with a rise in maritime polar old air advection (negative correlation) and to increase with the subtropical and arctic old ones (Tab. 7). The subtropical air (which remained in Poland for 48 days, from spring to autumn) gave a rise in the daily number of deaths (total by 6%, from circulatory diseases by 7% and from respiratory diseases even by 29%).

A particular increase in mortality was noted after the spring inflow of sub-
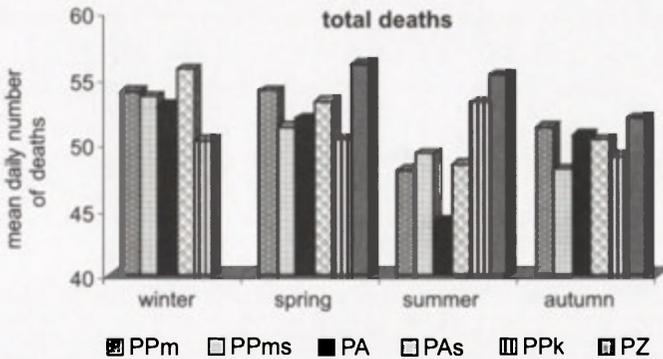
Figure 3. Mean daily number of deaths in particular air masses, Warsaw 1994–1995.
Types of air mass: PPm – polar maritime fresh, PPms – polar maritime old, PA – arctic,
PAs – arctic old, PPk – polar continental, PZ – subtropical.

tropical, dry and hot air (Fig. 3). People acclimated to winter conditions could not cope with the acute heat, with the result that a high mortality peak ensued.

HEAT WAVES

The analysed 2-year period included an extremely hot summer (1994), with the highest maximum temperature of 36.4°C being the extreme value over the 30 years 1966–1995 in Warsaw. The mean maximum temperature for 1994–1995 was only slightly higher (0.5 deg) than the 30-year climatic mean, although the mean minimum air temperature of 2.4 deg exceeds the average. The last decade of the 20th century was very hot, especially in 1992 and 1994 (Cebulak 1999). The analysed period includes the longest series of hot days, as described below.

Subtropical air creates heat waves that have not been precisely defined in Polish papers. For the purpose of the present research they have been defined as a sequence of days with the maximum air temperature exceeding 30°C. The prolonged heat wave which occurred in the spring was particularly dangerous because of the lack of acclimatisation to hot weather. Thus, the highest daily number of all deaths (87) was not recorded in spring, but in summer, on the fourth day of the presence of subtropical air, two days after the highest air temperature during the analysed period. Next day, in spite of the inflow of continental air, mortality was still much elevated, the number of deaths was 84, but the figure dropped successively in the following days. Also the number of deaths of cardiovascular origin was 84% over the summer average (Tab. 8).

On a single hot day total mortality (as well as that due to cardiovascular diseases) rises by 6–13% above the average. However, in a heat wave this immediate rise varies from 26% to 31% over the average. A hot environment burdens an organism significantly, causes acute diseases and intensifies chronic ones. Blood-vessel widening intensifies skin blood flow, skin temperature and sweat-

Table 8. Mortality during the last part of the longest (14-day) heat wave in the summer 1994.

Date	Air tempera-ture °C	Air mass	All deaths	Circulatory diseases	Respiratory diseases
30.07	34.4	subtropical	77	38	1
31.07	34.8	subtropical	77	33	2
01.08	36.4	subtropical	87	40	4
02.08	32.2	polar continental	84	42	4
03.08	30.2	polar maritime	74	33	1
summer – mean daily number of deaths			50.0	21.8	1.5

ing. The enhanced blood circulation causes an increase in blood volume and weakness. In the heat wave the drop in haemoglobin levels also leads to intensified lung ventilation. The large amount of direct solar radiation absorbed by an organism can also generate the rise in blood pressure. All these physiological reactions are responsible for excess mortality.

Mortality increase occurs not only in extremely hot weather, but in cold weather too, though the escalation is not as spectacular and dangerous as in the heat waves. On cold days, the number of deaths rises to 3–8% above the average, and with a prolonged freeze even up to 22% in the case of respiratory diseases.

The large, acute rises in air temperature seem to play a more important role in elevated mortality level than falls in air temperature (Tab. 9). In the light of the present research it seems that mortality is more associated with wave of heat or cold than with air temperature changes. This contrasts with the previously reported high association between the extreme day-to-day changes in meteorological parameters and morbidity.

The distribution of 15-day moving means for mortality as against air temperature (Fig. 4) denotes rising mortality at extreme high, as well as extreme low, air temperatures. The increase in mortality in high outdoor temperatures is acute and steep, while at low temperatures moderate growth is noted. The shape of mortality structure against water vapour pressure is very similar to the previous, an excess of mortality is noted on both very dry and very moist, sultry days.
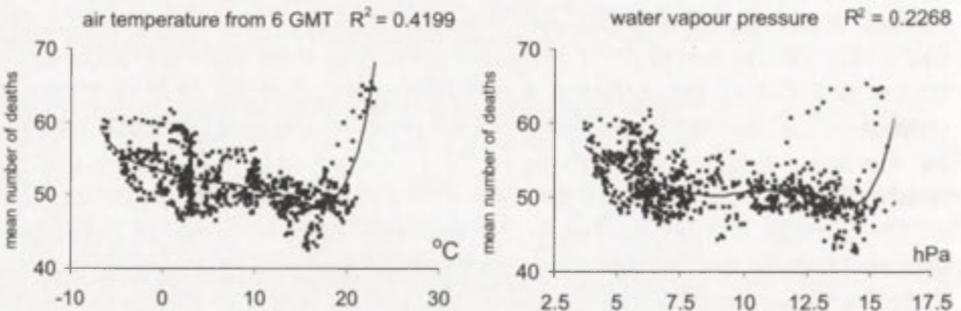

Figure 4. Distribution of 15-day means for deaths against air temperature and water vapour pressure, Warsaw 1994–1995.

Table 9. Extreme air temperature, its day-to-day changes and the number of deaths in Warsaw.

Number of deaths and deviation from mean		Air temperature				Day-to-day air temperature changes			
		t max = 36.4°C		t min = −17.3°C		drop of 10.1°deg		rise of 14.2°deg	
Date		01.08.1994		12.02.1994		03.06.1995		23.12.1995	
Deaths	day-lag	number	%	number	%	number	%	number	%
Total	0	87	+68	51	−12	43	−5	56	+2
	+1	84	+62	67	+16	49	+8	65	+19
Circulatory diseases	0	40	+72	21	−24	19	−3	29	+15
	+1	42	+81	30	+9	20	+2	32	+27

Table 10. Multiple regression between 5-day mean numbers of deaths and mean values for meteorological parameters.

Death	Day-lag	Correlation features $n = 145$		t max	t min	K	p	v	f	e
Total	0	R	.4744 beta	1.560	−2.085	−.671	−.125	−.278	−.323	.080
		R^2	.2250 r	.149	−.189	−.235	−.115	−.268	−.090	.020
		$p(F)$	<.0000 $p(t)$	.081	.027	.005	.180	.001	.294	.811
	+1	R	.4753 beta	1.576	−1.786	−.476	−.121	−.299	−.155	−.087
		R^2	.2259 r	.151	−.162	−.169	−.111	−.286	−.043	−.022
		$p(F)$	<.0000 $p(t)$	.078	.057	.047	.196	.001	.614	.794
Cardiovascular diseases	0	R	.3876 beta	.662	−.410	−.232	−.256	−.202	−.416	.303
		R^2	.1502 r	.061	−.036	−.079	−.220	−.190	−.111	.075
		$p(F)$	<.0039 $p(t)$	.478	.674	.354	.010	.026	.196	.385
	+1	R	.4212 beta	1.232	−.336	−.098	−.228	−.220	−.142	−.020
		R^2	.1774 r	.115	−.030	−.034	−.200	−.209	−.038	−.005
		$p(F)$	<.0007 $p(t)$	.180	.726	.688	.019	.014	.654	.954
	+2	R	.4180 beta	1.610	−.200	−.059	−.180	−.225	.079	−.244
		R^2	.1747 r	.149	−.018	−.020	−.159	−.213	.021	−.061
		$p(F)$	<.0008 $p(t)$	.081	.836	.811	.062	.012	.804	.477
Respiratory diseases	0	R	.3876 beta	1.387	−2.764	−.817	.077	−.013	−.216	−.085
		R^2	.1502 r	.127	−.236	−.271	.068	−.013	−.058	−.021
		$p(F)$	<.0039 $p(t)$	.138	.005	.001	.431	.883	.502	.808
	+1	R	.3826 beta	1.152	−2.406	−.713	.040	−.043	−.362	.265
		R^2	.1464 r	.106	−.207	−.238	.035	−.040	−.096	.065
		$p(F)$	<.0049 $p(t)$	.218	.015	.005	.682	.637	.262	.449

t – air temperature, p – atmospheric pressure, f – air humidity, K – global solar radiation, v – wind velocity, e – water vapour pressure; R – multiple regression coefficient, R^2 – determination coefficient, $p(F)$ – level of statistical significance assessed by F-test, beta-regression coefficient of standardised variables, r – partial correlation coefficient, $p(t)$ – level of statistical significance assessed by t-test.

Multiple regression results have shown that several of the meteorological parameters included in calculations explain 15% of mortality from respiratory disease, as well as 22% of total mortality changes annually (Tab. 10). Having taken into account the high correlation between the variables, the great impact of

air temperature (especially maximum temperature) on the human organism has been confirmed (beta). This calculation brings together all methods used in the paper to show that mortality increases with a drop in the global amount of solar radiation, air pressure or wind speed (negative r).

When several stressful factors occur together their negative effects cumulate (as in the case of very hot and sultry days, or extremely cold and dry ones with high air pressure). However in Poland such conditions occur only occasionally and do not threaten human health seriously.

THERMAL HUMAN SENSE

The values of effective temperature (defined in "Materials and Methods") indicate the highest association with daily numbers of deaths. In thermally-neutral, comfortable conditions, organisms can easily sustain their balance. Any disturbances in thermoregulation result in either a surplus or shortage of heat in an organism.

As the association between thermal conditions and the mortality rate has been demonstrated, the high correlation between effective temperature and numbers of deaths is not surprising. There is an apparent increase in mortality on "extreme hot" and "extreme cold" days. Table 11 shows the difference where in the

Table 11. Correlation coefficients between mean numbers of deaths and the number of the thermal sense; percentage deviation from yearly mean mortality in different thermal-sense types.

Correlation coefficients								
Deaths	mean	extreme hot	hot	warm	comfort	cool	cold	extreme cold
Total	10-day	0.29	−0.22	−0.21	−0.01	0.14	0.13	0.19
Circulatory	running mean	0.20	−0.19	−0.10	0.07	0.02	0.05	0.14
Respiratory	$n = 719$	−0.10	−0.11	−0.14	0.08	0.15	0.24	0.06
Total	10-day mean	−0.13	−0.16	−0.25	0.01	0.07	0.16	0.30
Circulatory	$n = 72$	−0.09	−0.14	−0.13	0.11	−0.05	0.05	0.29
Respiratory		−0.15	−0.07	−0.20	0.07	0.14	0.33	0.09
Percentage deviation from year mean [%]								
Deaths	day-lag	extreme hot	hot	warm	comfort	cool	cold and extreme cold	
Total	0	+13	−2	0	0	0	−3	
	+1	+13	−4	−1	+1	0	−1	
Circulatory	0	+11	−2	−1	+1	0	−5	
system	+1	+17	−6	−1	+2	−2	0	
Respiratory	0	−10	+5	−4	−1	+1	+22	
system	+1	+1	+3	−7	−4	+4	+33	

calculation makes use of two types of mean – a 10-day running mean or the mean from separate 10-day periods. Running means allow for the estimation of the influence of the sequences of some phenomena, and their cumulative effect on human beings. The separate periods divide these sequences e.g. heat waves and hinder the attempts to calculate their real effect on mortality rate. According to these wrong calculations, mortality only increases with decreasing temperature, and hence resembles only the seasonal variation of mortality.

Particularly hazardous are extremely hot days (Tab. 11). The rise in mortality is to 11–17% above average. "Extreme cold", because of the small number of cases, does not seriously threaten people. Mild types of thermal sense are thermoneutral and the percentage deviation from the mean number of deaths is negative or close to zero.

The reverse signs for the correlation between mortality and the "extreme hot" and "hot" thermal sense indicate a non-linear function. The thermal sense described as "hot" leads to negative human reactions in spring, but in summer, when this is the most frequent thermal feeling, some physiological acclimatisation to these stressful conditions could occur and be seen in a decrease in mortality (negative correlation).

CONCLUSIONS

The results of this research have confirmed the previous papers on the impact of weather on humans. It appeared that mortality in Warsaw is definitely dependent on weather. Excesses of mortality have been noted in unusual types of weather that contrast with average atmospheric conditions.

The very hot, dry, polluted subtropical air mass that occurs over Poland on 12.5% of summer days is always associated with a rise in mortality to 6–7% above the average. These results are very similar to those obtained in St Louis in the United States of America, where the tropical air mass has likewise been distinguished as the worst (Smoyer 1998).

In Poland, as in most temperate climate countries, the threshold temperature associated with excess mortality is observable for only 10–15% of the total number of summer days. The threshold temperature depends on both the average temperature and the frequency of extreme temperatures. It is for this reason that there is no universal value for the world, the climate zone or even the type of climate. The very existence of these thresholds shows that the human body cannot cope with thermally oppressive conditions. Fortunately, due to the big weather changes, characteristic of our climate, the unfavourable atmospheric conditions are not very stable or persistent.

As a reflection of inadequate thermoregulatory mechanisms, the greatest mortality among Warsaw residents occurs during heat waves and varies between 26 and 31% above the average. A particularly long and hazardous heat wave was

formed in a subtropical air mass during the extreme hot summer of 1994. An equally dangerous situation did not occur again in the analysed 2-year period. Other heat waves were much shorter and less intense, but they originated in subtropical or continental air mass.

Mortality also rises in an extremely cold environment, formed in an arctic air mass, although this excess is much lower than in the heat, an observation which may indicate that the human (biological, physiological and behavioural) capacity for adaptation is better in the lowest temperatures than in the highest.

Moreover the analyses show that daily mortality rises as the concentrations of carbon monoxide, ozone and particular matter increase.

On the other hand, under certain conditions, such as with a polar maritime old air mass or thermal conditions close to the seasonal average, there is an apparent decrease in the number of deaths.

The results of the research described may provide a basis for the future creation of a watch and warning health system to prevent excess mortality due to oppressive weather conditions. It could be very important in the face of global climate warming scenarios.

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PROBLEM AREAS IN POLAND'S AGRICULTURE

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ABSTRACT: In the author's opinion an agricultural problem area is characterized by an accumulation of negative socioeconomic and (or) natural phenomena handicapping it in comparison with agricultural areas of characteristics average for the country, and weakening its agricultural function. They are associated with disturbing demographic phenomena like the depopulation of villages, migration and the ageing of the owners of farms. Other equally unfavourable processes are the extensification of output, the laying fallow of large areas of land and a lack of interest in farm enlargement.
A division of agricultural problem areas into 4 types may be proposed: 1) areas backward in their development, 2) areas of productive reserves, 3) areas of unfavourable natural conditions, 4) conflict areas. These areas are concentrated in just a few regions of Poland – the south-east, the eastern part of Mazowsze and the north-east, the area of the Sudetic Mountains and part of the Silesian Lowland, small areas in Pomerania, the Świętokrzyskie Mountains and Upper Silesia.

KEY WORDS: agricultural problem areas, Poland's agriculture, backward areas.

Poland is among those countries with particularly marked regional disproportionalities between the development of agriculture and its productive potential. This results from both the diversity of natural conditions and the various economic situations that different parts of the country have found themselves in, in the course of history. For a long-lasting process of socioeconomic differentiation ensured the emergence of areas in which agriculture achieved only a relatively low level of development, not taking full advantage of its productive potential and losing out as compared with other economic functions. Such areas are termed agricultural problem areas.

THE THEORY AND CRITERIA BEHIND THE DELIMITATION OF PROBLEM AREAS

DIFFERENCE CONCEPTS OF THE PROBLEM AREA

What is a problem area? In the literature one encounters many and varied proposals as to the definition of this concept. Examples of these may be provided

by the works of Polish researchers in this field. For A. Zagozdzon (1988), these would be the parts of geographical space characterised by the occurrence of negative social and economic phenomena that induce defined internal anomalies. In turn, S. Ciok (1994, p. 11) understands by the term an area *"requiring special measures in the spheres of planning and regional policy if the problems existing within them are to be solved"*. For R. Domański (1987), however, a problem area would be characterised by the occurrence of problems that are particularly vexing and hard to solve.

A similar diversity is present when it comes to the criteria used in delimiting problem areas. One applied in Great Britain is a high figure for unemployment, while in the USA, E. M. Hoover (1971) identified problem areas with those in which there was dynamic deforestation, depopulation, or the exhaustion of mineral resources. In turn, EU Member States distinguish between areas that are lagging behind (with a low GDP per inhabitant), those with declining industry (where unemployment is high and employment in industry is declining) and backward agricultural areas (with excessive employment in agriculture).

Problem areas appear in many typologies of regions. All the concepts seek to identify regions with impaired opportunities for development. They may be sought in the core and periphery theory. J. Friedmann (Friedmann and Alonso 1964) identified four types of region, of which one was the "depressed region" exhibiting economic decline and an outflow of population. In turn, L. Davin (1968) used the theory of poles of growth as a basis upon which to divide problem regions into the backward, the weakly-developed and the declining. L. Klaassen (1965) also distinguished the distressed areas, of which J. Friedmann and C. Weaver (1979, p. 142) writes: *"no one quite knows what to do with them"*.

THE STUDY OF AGRICULTURAL PROBLEM AREAS

Agricultural problem areas are a basic type of problem area. I. Bowler (1992) termed them marginal peripheral regions, in which the natural environment limits the scope for the economic development of agriculture. K. Bis (1990) proceeded on the basis of a similar assumption, stating that agricultural production in particular regions is dependent on natural conditions that automatically bring about an underdevelopment of the whole agricultural infrastructure and culture. Such an approach to problem areas in agriculture that more or less confines its considerations to elements of the natural environment and omits historical and cultural conditioning is unacceptable.

Analysis of the subject literature points to a great diversity of criteria employed in the identification of agricultural problem areas (Tab. 1). Concepts for the distinguishing of these areas are presented, *i. a.* in a communique from the European Commission in Brussels entitled "The Future of Rural Society" (Cloke, Goodwin 1992). Three types of area are to be found here: **areas under pressure**

Table 1. Criteria in the identification of agricultural problem areas in selected countries (examples).

Country	Criteria
Austria	altitude a. s. l., location in a near-border zone
Finland	distance from markets, natural conditions
Spain	low level of income in agriculture
The Netherlands	out-migration of the population and loss of the agricultural function
Sweden	length of the growing season
Great Britain	a high level of rural unemployment

Source: devised after J. Heller (1989), E. Skawińska (1993), F. Thissen (1992).

from the modern style of life, where intensive agriculture is in competition with other economic functions, **areas of declining agriculture** with weak development in this sphere and a lack of alternative opportunities for employment, and **peripheral areas** with unfavourable natural and socioeconomic conditions and a high level of depopulation.

In Poland, the subject of agricultural problem areas is dealt with by only a small group of researchers. These are first and foremost geographers and agricultural economists (Bański 1999; Kulikowski 1995; Skawińska 1993).

THE AUTHOR'S CONCEPT OF AGRICULTURAL PROBLEM AREAS

In the author's opinion, an agricultural problem area is characterized by an accumulation of negative socioeconomic and/or natural phenomena which ensure its backwardness in relation to agricultural areas with features average for the country as a whole, as well as weakening the agricultural function. The following division of agricultural problem areas into 4 types may be proposed:

1) **areas backward in their development**, featuring a relatively low level of agricultural advancement,

2) **areas of productive reserves**, with inadequate use made of the natural and (or) socioeconomic productive potential,

3) **areas of unfavourable natural conditions** in which the quality of the natural environment hinders engagement in agricultural activity,

4) **conflict areas** with excessive development of non-agricultural functions and hence limitations on the proper serving of the agricultural function.

The spatial identification of these four kinds of area is achieved by applying a variety of methods. Areas backward in their development or with productive reserves can be identified using statistical methods, while those of unfavourable natural conditions or conflict require deductive reasoning, as well as study of the relevant literature and cartographic or statistical materials.

AGRICULTURAL PROBLEM AREAS IN POLAND

AREAS BACKWARD IN THEIR DEVELOPMENT

It is to these areas that the greatest attention has been paid. The first stage of their identification saw a search for the features most fully describing the agricultural situation in all spatial units. These served in the designating of an **index of the level of development of agriculture** in gminas, and have in turn provided a basis by which to identify the areas sought.

It was accepted that diagnostic features should characterise the issues of agrarian structure, the level of education of those living on farms, the degree of outfitting of agriculture in machines and technical infrastructure, and the productive results obtained. The following set of diagnostic features (measures) was adopted:

A. Level of education of those living on farms (% share of individuals with education above primary).
B. Provisioning of farms with technical infrastructure (% share of farms with mains or farm water supply, % share of farms with sewerage or septic tanks, % share of farms with a telephone, % share of farms with mains gas).
C. Size of farms (% share of all farms covering less than 5 ha).
D. Commercial farms (% share of farms engaged solely in agricultural activity, but mainly for the market, from among the total number of farms engaging solely in agricultural activity).
E. Outfitting of farms, in vehicles and machinery (number of private vehicles per 100 farms, number of cereal combines per 100 ha sown with cereals, number of tractors per 100 ha of agricultural land).
F. Yields of main crops (wheat, rye, barley, potatoes).

It was also assumed that all the measures of characteristics would be equal from the point of view of their influence on the perceived level of development of agriculture in communes. To make measures comparable they were subject to normalisation.

Distinguished for each of the features were five class intervals assigned appropriate values of between 1 and 5. In this way, a commune came to be described by a numerical code with several elements. The index (W_p) required was obtained by summing the numbers.

$$W_p = \sum_{j=1}^{i} a_{ij},$$

where: a_{ij} – standard value of measure j ($j = 1, 2... 6$) for commune i.

The next step was the adoption of limit values for the index below which a commune was included among problem areas. On the basis of tests it was accepted that this should be c. 80% of the mean values for the country as
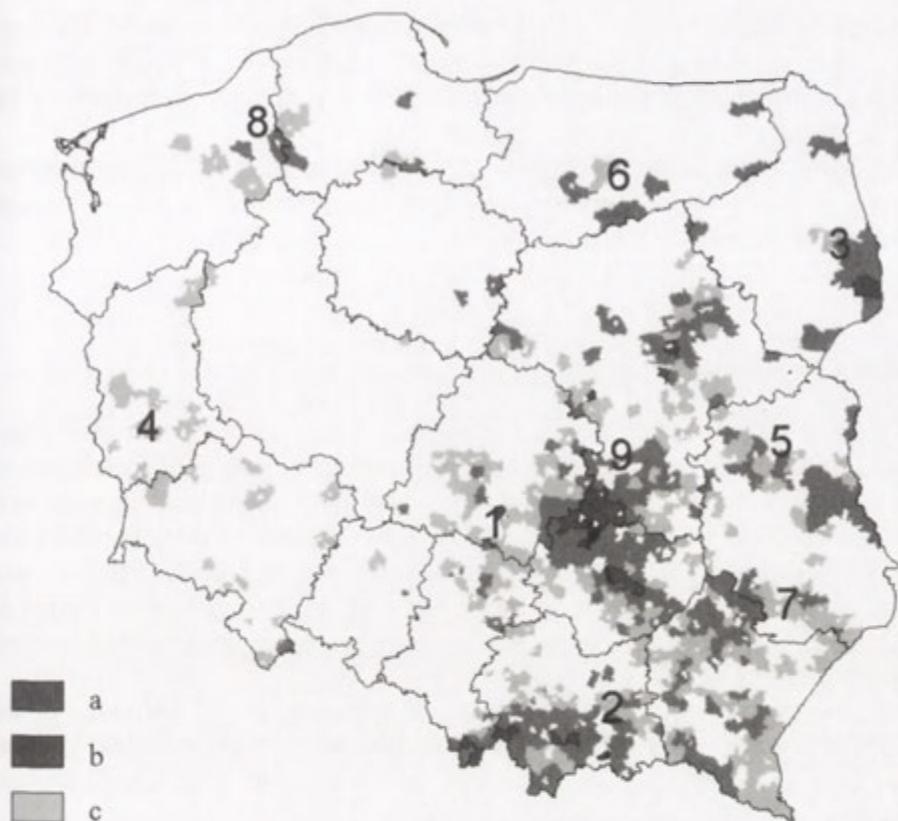
Figure 1. Backward agricultural areas.
1 – Kraków–Częstochowa, 2 – the Carpathians, 3 – Knyszyn–Białowieża, 4 – the Lubuski,
5 – Mazowsze–Polesie, 6 – Olsztyn, 7 – Sandomierz–Roztocze, 8 – Central Pomerania,
9 – the Świętokrzyskie.
a – critical areas, b – pathological areas, c – threshold areas.

a whole. The result was the acceptance of 13 points as the limit value for the index W_p denoting areas backward in terms of their development.

The picture (Fig. 1) obtained allowed 9 agricultural problem areas to be distinguished.

The areas identified were then divided up into three types of backward areas, according to the degree of concentration of unfavourable characteristics:

1. Critical areas – (code with 6 or 5 elements assigned 1 point) – distinguished by the lowest level of development of agriculture in the country. The backwardness of these areas is so extreme that farms deriving income solely from agriculture have no chance of development and are doomed to failure. A necessary condition for their development is thus the introduction into these areas of other economic functions, as well as the creation of new job opportunities.

2. Pathological areas – (code with 4 or 3 elements assigned 1 point). Without

outside assistance, the agriculture of these areas is doomed to failure. The only farms likely to remain on the market will be the few that are strongest economically. The development of other functions allowing for the re-employment of the excess workers in agriculture is indicated.

3. Threshold areas (other codes). These may be termed areas of opportunity, since a rationally-pursued restructuring may allow them to achieve an average level of development in the longer term.

AREAS OF PRODUCTIVE RESERVES

Theoretically an area of productive reserves is one able to achieve production results much better than it does at present. In the first method of identification, the measure of the use of natural conditions was the value of overall production per 1 ha of agricultural land, converted into 1 point of *qpas* (quality of productive agricultural space). The arbitrary value adopted as the limit below which a commune is included among problem areas was 1800 PLN from 1 ha as 1 point of *qpas*. Emerging in this way was a picture that allowed six complexes of productive reserves to be identified (Fig. 2).

The second method employed measures that assessed the use made of the quality of productive agricultural space from the point of view of yields obtained. The yields of the four cereals wheat, rye, barley and oats were taken into consideration.

The exact procedure for the identification of problem areas was in fact as follows. Theoretical yields were first calculated in accordance with the formula:

$$P_{tg} = \frac{W_{pg}}{W_{pk}} \times P_{rk},$$

where P_{tg} are theoretical yields of the 4 cereals in a *gmina*, W_{pg} the index for the quality of productive agricultural land (*qpas*) in the *gmina*, W_{pk} the index for *qpas* in the country as a whole and P_{rk} the real yields of the 4 cereals in the country. Differences were then calculated between real and theoretical yields of the 4 cereals in the given gmina, as ΔP:

$$\Delta P = P_{rg} - P_{tg}.$$

Finally, a coefficient was calculated in accordance with the formula:

$$S = \frac{\Delta P}{P_{rg}} \times 100,$$

where S is the ratio for the difference between real and theoretical yields of the 4 cereals and the real values for their yields, expressed in percentage terms.

The use of the natural environment in plant production was assumed inade-
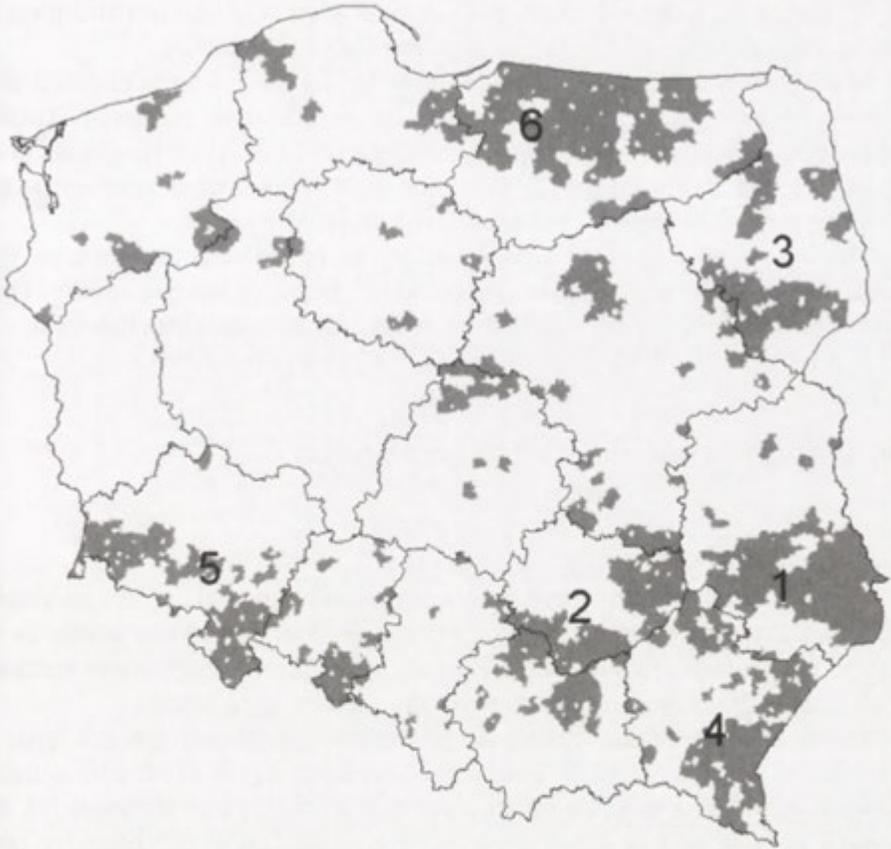
Figure 2. Areas of natural productive reserves (global production per ha per 1 point
of quality index of agricultural productive area – 1800 PLN, 1990).
1 – Lublin–Sandomierz, 2 – Małopolska, 3 – Podlasie, 4 – Przemyśl,
5 – Sudety, 6 – Żuławy–Warmia.

quate where the index ΔP attained a negative value, while S is greater than 20%.
A measure of this kind allowed for the identification of five problem areas,
namely those of Lower Silesia–Opole, Lublin–Sandomierz, Małopolska, Prze-
myśl and Żuławy–Warmia.

The correctness of the methods applied could be verified by reference to the
results in terms of the areas delimited. In both cases, the identified problem areas
were of similar extent.

The use made of soils in areas of productive reserves is generally appropriate
and in line with agricultural suitability. However, the yields obtained do not fully
reflect the quality of the productive agricultural space. The causes weakening the
productive potential include a flawed agrarian structure (high share of small
farms and high degree of fragmentation of cultivated fields), limited expenditure

on technical means of production, the low level of professional qualifications of farmers, and the ageing of the population engaged in agriculture.

Much greater difficulties are posed by the recognition of areas of productive reserves from the point of view of socio-economic conditions. Applying a similar delimitation procedure, and using a coefficient of the level of development of agriculture, it was possible to identify three areas of productive reserves: 1) the Kaszuby–Krajeński region, 2) Mazury and Kurpie, 3) Podlasie.

The identified areas are characterised by an agricultural development that would theoretically allow for the obtainment of better productive results. They are limited by relatively poor conditions as regards the natural environment.

AREAS OF UNFAVOURABLE NATURAL CONDITIONS

AREAS WITH A LOW-QUALITY NATURAL ENVIRONMENT

These areas will be characterised by natural conditions that hinder agriculture, including first and foremost by limiting possibilities for certain plants to be grown. The identification of such areas may be achieved using various methods which assess the natural environment for the needs of agriculture.

The coefficient of the quality of productive agricultural space – *qpas* – emerged as the most suitable indicator for designating areas of unfavourable natural conditions. A value of the *qpas* coefficient of less than 50 points (cf. the national average of 67) attests to severe limitations on possibilities for crop growing. Seven problem areas were identified on this basis (Fig. 3).

AREAS WITH A DEGRADED NATURAL ENVIRONMENT

Agricultural areas of this kind have experienced unfavourable changes in agroecological conditions under the influence of human activity. These conditions hinder, or in extreme conditions prevent, the production of food. Among the negative changes ongoing in the natural environment under the influence of human activity, those of significance for productive agricultural space are deforestation, the contamination of soils and waters by various chemical compounds and changes in water relations.

Agricultural areas with degraded environments include those with contaminated land, on which food produced may contain harmful chemical substances at levels which do not comply with standards, and others with natural attributes of a quality radically lowered by human activity. Agricultural activity should be curtailed or sometimes even forbidden in areas characterised by severe contamination of soil. Unfortunately, neither farmers nor local communities are aware of the threats posed by crop-growing and livestock breeding in these areas. Overall,
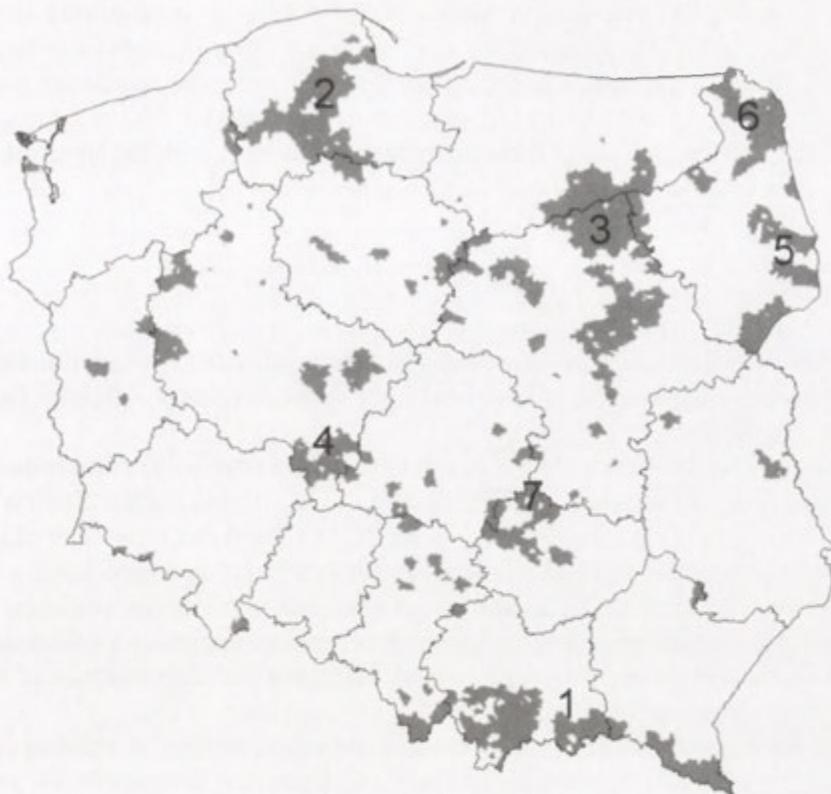
Figure 3. Areas of low quality of the natural environment.
1 – the Carpathians, 2 – Kaszuby, 3 – Mazury–Kurpie, 4 – Ostrzeszów, 5 – Knyszyn–Białowieża,
6 – Suwałki, 7 – the Świętokrzyskie region.

it is estimated that 4% of Poland's agricultural land shows elevated levels of heavy metals and is qualified as somewhat polluted.

The most marked contamination of soils is characteristic of Upper Silesia, where changes in reaction (pH) are accompanied by an accumulation of harmful trace elements, notably lead and cadmium. When the results of laboratory tests on vegetables are set against norms for weekly use, it is seen that the consumption of vegetables grown in the above areas leads to the introduction into the body of amounts of cadmium and lead several times higher than are permitted by the World Health Organisation. The same is true of results concerning fodder.

Agriculture itself contributes to degradation of the natural environment. A poor choice of agrotechnical measures leads to the erosion and impoverishment of soils, as well as to the biological and chemical pollution of large areas of agricultural land and ground-waters. For example, 66% of wells by farmhouses are excessively polluted by nitrogenous compounds.

To sum up, the greatest complexes of areas with a contaminated natural environment in which agriculture is carried on are those in Upper Silesia, the Lubin–Glogow Industrial District and the Kraków area. The remainder (zones around the largest industrial plants, waste dumps and busy roads) occupy small areas only. Food produced in these areas may not comply with the standards for permissible concentrations of certain chemical substances.

CONFLICT AREAS

Areas of conflict in agriculture are characterised by the excessive development of non-agricultural functions impacting negatively upon possibilities for the agricultural function to be served.

The severest conflicts are those generated between **agriculture and industry**. The main areas of such conflict are the zones around large industrial districts like Upper Silesia, the Legnica–Głogów Copper District, the Bełchatów Coalfield, the Tarnobrzeg Sulphur Field and the Wałbrzych Coalfield. Besides occupying land hitherto used in agriculture, industry also generates conflicts by polluting and degrading the natural environment in which agriculture operates. A consequence of these processes is the increased area of wasteland, the depopulation of rural areas, the extensification of production, etc.

The building of planned motorways and the modernisation of existing roads will sharpen conflicts between **agriculture and transport** in the next few years. The collision between agriculture and transport may also be assessed negatively because of the excessive drying-out of land and its pollution. Positive effects of the conflict in turn include the dynamic development of non-agricultural functions and intensified agricultural production to be observed for some time now along existing routes of supralocal significance like Warsaw–Katowice, Warsaw–Poznań, Gdańsk–Łódź and Kraków–Katowice. This is a particularly important phenomenon for backward areas seeking new stimuli to development.

Severe conflicts arise in areas around the larger cities with the **agricultural function having to compete with the residential**, and to a lesser extent the industrial and transport-related. Two processes standing in opposition to each other are involved. An absorbent market is a stimulus to agricultural intensification and an increase in the area used agriculturally, while the areal and populational expansion of cities leads to an ever-worsening shortage of the land required for this.

A further conflict is that arising where an area may be used in **agriculture and forestry**. Areas of intensive production are poorer in forests than anywhere else – here other functions are subordinated to the agricultural. The absence of forest and areas planted with trees in turn poses the threat of soil degradation, the steppification of land and a deterioration in water relations.

Yet another conflict is that in areas serving both **agricultural and touristic-recreational** functions. Tourism develops in culturally-attractive areas with high-

ly-valuable natural and landscape features. On account of these attributes, such areas are protected, thereby allowing for the appearance of conflicts. c. 26% of Poland enjoys such protection, and 45% of this area is used agriculturally (so accounting for 19% of the country's agricultural land). These figures attest to a strong linkage between protected areas that are attractive to tourists and the agriculture engaged in there.

Collisions emerge *inter alia* from agriculture's tendency to pollute areas of outstandingly valuable features and to destroy natural forms of landscape. As the technology of production in agriculture is not usually subordinated to the goals of environmental protection, there is a need to depart from the models in Western European countries, in which agriculture has played a major part in the ecological crisis in protected areas, including through the pollution of agricultural land by excessive fertiliser use, the destruction of landscape diversity and the non-rational application of plant protection agents.

THE GENESIS OF AGRICULTURAL PROBLEM AREAS

Agricultural problem areas, above all those that are backward in their development; areas with degraded environments and areas of productive reserves should all be conceived of dynamically, as units changing their spatial ranges over time. The process by which a problem area emerges is a long-lasting one, varying in intensity and dependent on a large number of factors which may be divided into: primary factors (historical and natural) and secondary factors (technical and organisational, sociocultural and production-related). This division is debatable in reality as there are usually interference phenomena, i.e. mutual overlaps between primary and secondary factors creating an inseparable whole.

Unfavourable conditions in the natural environment have been important factors in the process forming most of the developmentally-backward areas, and above all those of the Carpathians, Knyszyn–Białowieża and the Świętokrzyskie region. Serious soil-related and climatic limitations hindered progress in agriculture, *i.a.* by narrowing the range of possible strategies in crop production. For this reason, these areas are also among those in the category of a low-quality natural environment where agriculture is concerned.

Problem areas also arise as a result of degradation of the natural environment, through poorly thought-out economic activity. In this case, the areas referred to are those in which agriculture is liable to produce polluted food. These are mostly small in size, and thus require consideration on the microscale.

Economic polarisation, including the backwardness and impoverishment of agricultural areas against the background of history, results from inclusion within the areas then administered by the three partitioning powers of Germany, Austria-Hungary Monarchy and Russia; from wartime destruction and the major resettlements and border changes associated with it and from the economic policy

pursued after World War Two. Historical factors are reflected most fully in the north-east and north-west. The east of Poland has, in succession, been part of Old Russia, Lithuania, Poland, Prussia and Russia once again, and has been subject to a range of political, cultural and economic influences. The long period under the control of Russia, itself economically-backward, was reflected in the neglect shown for this area, especially in agriculture. In addition, the peripheral location did not favour development, but rather gave rise to economic backwardness.

The technical and organisational factors include neglect in the development of technical infrastructure (sewerage, mains gas, running water and electricity supply), limited accessibility (a low-density, poor-quality road system, a low level of communications services and large distances to services and markets), a low level of mechanisation and land melioration and a fragmented agrarian structure of farms.

Production-related factors result from all the aforementioned conditions. They include high costs of agricultural production, limited efficiency of work and output and a low level of commercial viability.

PROSPECTS FOR AGRICULTURE IN PROBLEM AREAS

The 1990s have seen an intensification of the processes underpinning the spatial differentiation of rural areas. Agriculture has undergone a particularly marked polarisation. Far from being evened out, the differences between highly- and poorly-developed areas are increasing. The greatest destructive influence in agriculture is to be seen in the problem areas, which require particular attention from local and central authorities at all levels. In a period of restructuring and adjustment prior to EU membership, problem areas are vulnerable to a host of social ills and will require the most assistance. This should at first entail predictive analysis and the drawing-up of development strategies, albeit with each of the areas identified requiring different solutions.

It would seem that agriculture has no chance of development in areas that are backward in their development and of low-quality productive agriculture space. It is thus bound to fail. In such a circumstance there is a justification for promoting other economic functions, including in particular forestry, tourism and recreation. The multifunctional development of agricultural problem areas may have the long-term effect of curtailing negative processes in agriculture and ensuring a better standard of living for those whose upkeep derives from it. However, it needs to be added that the development of non-agricultural functions in agricultural problem areas of northern Poland is hindered by the scattered rural settlement pattern and the low density of urban centres.

Areas of productive reserves require completely different approaches. These are the potential "food baskets" of Poland, where the agricultural function should be the leading one, protected by appropriate legal regulations. After a difficult

period of transition, the agriculture there will have gathered strength and be in a position to compete effectively with that in Western Europe.

In areas of unfavourable natural conditions, agriculture should link up with other economic functions without major collisions. Crop production should be subordinated to livestock rearing, which will be developed on large farms. In connection with this, there will probably be changes in land-use structure – an increase in the share of agricultural grasslands at the expense of arable land. Part of the latter – especially the poorest – should be afforested.

In areas with a degraded natural environment, efforts should be made to apply rational agrotechnical measures that should reduce the degree of contamination. In particular, there should be an optimisation of the use of mineral fertilisers and a significantly augmented utilisation of natural manures, an introduction of long--term cropping and mid-field areas of trees, as well as afforestation of land of the lowest quality.

CONCLUSIONS

Problem areas are an inseparable part of the geographical space of every country. The most important role among them is played by areas of ecological threat, as well as problem areas from the populational and agricultural points of view. These in general create problem complexes, in which there is a mutual overlapping of different kinds of problem area.

A characteristic feature of areas backward in development is a level of development of agriculture that is the lowest in the country and therefore hinders proper functioning. Areas of unfavourable natural conditions have been divided into categories – those of a low-quality natural environment which limits opportunities for managing land, and areas with an environment degraded by human economic activity. In turn, areas of productive reserves feature inadequate utilisation of the natural or productive potential. Finally, areas of conflict are characterised by an excessive development of non-agricultural functions that impacts negatively on opportunities for agriculture to function.

To generalise a little, the reconnaissance of problem areas in agriculture that has been carried out reveals these to be concentrated in just a few regions of Poland (Fig. 4).

1. The south-east, where the ranges of the various types of problem area overlap. The model of agriculture shaped here comprises small "two-profession" farms of limited commercial viability and inadequate technical infrastructure. A considerable part of the area nevertheless has good agroecological conditions, which need to be taken advantage of.

2. The eastern part of Mazowsze and the north-east. Here, agriculture is first and foremost hindered by unfavourable demographic processes, the limited activeness of farmers and poor outfitting of farms in agricultural machinery and

Table 2. Types of agricultural problem areas.

Types	Characteristic	Identification
1) backward areas: a) pathological b) critical c) threshold	lowest level of development of agriculture: a) no chance of development b) low chance of development c) able to develop	Diagnostic features: a) minimal value of measures (code with 5 or 6 elements assigned 1 point) b) in general minimal value of measures (4 or 3 elements assigned 1 point) c) low and minimal value of measures (other codes)
2) areas of productive reserves: a) natural b) socioeconomic	a) agriculture makes inadequate use of the natural productive potential b) agriculture makes inadequate use of the socioeconomic productive potential	a) value of overall production per ha of agricultural land, converted into 1 point of index of quality of productive agricultural space. b) yields of the four cereals converted into 1 point of index of the level of development of agriculture (with out measures – yield of main crops)
3) conflict areas	excessive development of non-agricultural functions impacting negatively upon possibilities for the agricultural function	field investigation and study of literature
4) areas of unfavourable natural conditions: a) areas with a low-quality natural environment b) areas with a degraded natural environment	a) natural conditions that hinder agriculture b) unfavourable changes in agroecological conditions under the influence of human activity	a) lowest index of the quality of productive agricultural space b) various coefficients of pollution, deforestation and others

technical infrastructure. It is also necessary to add to this relatively less-favourable natural conditions that hinder the cultivation of some crops.

3. The area of the Sudetic Mountains and part of the Silesian Lowland, in which various kinds of agricultural problem concentrate. These range from backwardness in development to limited use of the natural environment in crop production.

4. Small areas in Pomerania on which the fall of the State Farms led to an extensification of land use and crop structure, as well as an abrupt increase in unemployment. The economic collapse in these areas manifests itself *inter alia* in the limited use made of socioeconomic production reserves.

5. The Świętokrzyskie area taking in the zone between the Vistula and Pilica
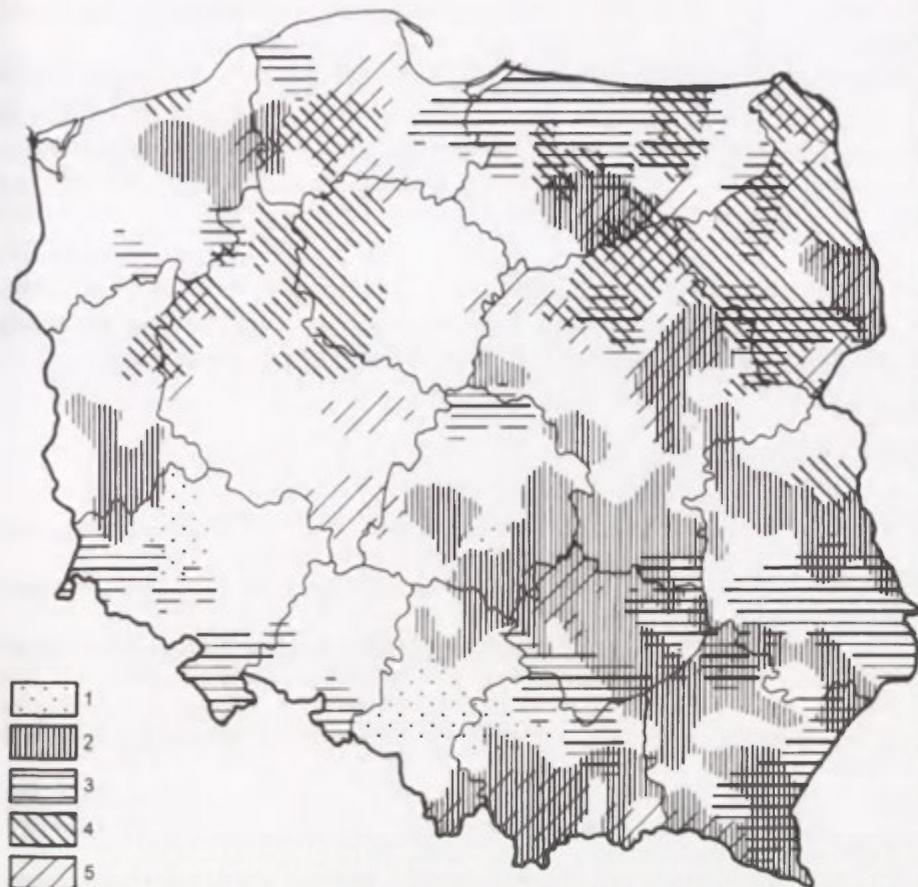
Figure 4. Agricultural problem areas in Poland.
1 – agricultural areas characterized by degradation of natural environment, 2 – backward agricultural areas, 3 – areas of natural productive reserves, 4 – areas of economic productive reserves, 5 – areas of low quality of the natural environment.

rivers. The research done shows this to be the largest and most complex agricultural problem area. Much of it is backward in terms of development and has productive reserves, while the Świętokrzyskie Mountains themselves may be regarded as an area of low-quality productive agricultural space.

6. Upper Silesia and the zones around the large industrial plants and agglomerations characterised by degradation of the natural environment in which agriculture takes place. The food produced there does not always meet standards for its purity.

Problem areas are units of geographical space which have developed over decades through an interweaving of diverse factors. Some of these are primary (historical and natural conditioning), others secondary (technical and organisational, socio-cultural and production-related). Each of the problem areas recog-

nised has emerged through the action of different, specifically-interconnected causes.

The dynamic to these "problem-generating" processes has strengthened in certain periods. This was the case after 1989, when inter-regional polarisation in rural areas gathered pace, especially as regards agricultural development. There appeared areas in which agriculture was condemned to failure or – in the best case – to remain in the vicious circle of poverty.

Problem areas are associated with disturbing demographic phenomena like the depopulation of villages, migration and the ageing of the owners of farms. Other equally unfavourable processes are the extensification of output, the laying fallow of large areas of land and a lack of interest in farm enlargement.

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UNSUSTAINABLE FORESTRY CAUSES FOREST FIRES.
A CASE STUDY FROM GALICIA (NORTH-WEST SPAIN)

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ABSTRACT: Galicia's forestry holds a special position within Spain due to the relatively great cover of woodlands and an increasing concentration on fast-growing tree species, i.e. eucalyptus trees. Its earning capacity is rather low because of a lack of industrial potential. Development funds allocated by the EU and altered by national and regional legislatures do not improve the disadvantagous structure of Galician forestry and its economically and ecologically poor situation. The high incidence of forest fires is a result of a misguided forestry policy and structural problems. The especially-formed fire brigades are only of short-term assistance. In future, long-term support can be expected via EU-funded eductional campaigns and structural reforms.

KEY WORDS: Spain, Galicia, forestry, forestry policy, EU structural policy, eucalyptus trees, forest fire.

INTRODUCTION

Forests form a substantial part of the cultural landscape and serve multiple functions (see Tab. 1). On the one hand, the ecological, social and cultural demands on forests are rising considerably; due to industrialisation and post-industrialisation respectively and the correlated population growth. On the other hand, wood use as fuel or building timber is being substituted for more and more by other materials (Kuusela 1994; Pérez Moreira 1991). Contrary to the manifold demands is the vulnerability of woodlands to natural and human stress. Silvicultural forests are especially prone to any kind of stress.

While Europe's potential woodland area can be estimated at some 80% of the total area, only 27% of the continent is tree-covered at present. Cover in different EU countries varies, however, between 68% in Finland and less than 8% in The Netherlands (Tab. 2).

Table 1. Functions of European forests (after UN-ECE/FAO 1986).

Production	wood:	tree trunks, sawn wood, building timber, fuel, pitwood, cellulose
	further products:	food (berries, honey, herbs, mushrooms, sweet chest-nuts, meat...), medicinal herbs, grazed woodland, litter production, tanning agents, tar production, potash, re-sin, cork, Christmas trees, lichens, moss and other decorative material
"Services"	environmental protection:	erosion control, Water reservoir and -filter, windscreen, noise abatement, air filter, avalanche protection, preservation of biodiversity
	social function:	recreation (strolls etc., hunting, berry-picking), landscape element, cultural asset

Table 2. Wooded area in selected EU countries (after: Wirtschaftskommission der Vereinten Nationen für Europa/Europäische Kommission 1999; and Anuario 1994).

Countries	Total area [in 1000 ha]	Woodland/ total area [%]
Germany	35,562	30
Spain	50,471	25
Galicia	2,900	62
Netherlands	3,482	8
Finland	30,460	68

As demonstrated in Table 2, Galicia is a disproportionally wooded region for Spain and Europe, and this reflects its climatic and pedological conditions and its historical background. The rest of Spain is only sparsely covered with trees. Traditionally, Galicia's silviculture is closely connected to a specific topographic feature of the "montes". Basically, all areas of spontaneous and cultivated vegetation not in agricultural use are embraced by this term. Due to the originally--strong relationship between relief and landcover the term "montes" is widely used as a synonym for forested areas. As a result of intensive degradation problems less than 50% of the montes are at present still covered with trees. The region of Galicia is amongst those within Spain with many forest fires leading to the creation of extensive degraded sites. Thus investments are inhibited and afforestation costs rise (Fernández Leiceaga 1990; European Commission 1996). With the aid of the available statistical data relationships between forestry policy under special recognition of EU funds and structural features on the one hand and forest fires on the other can be established for this region.

AREA UNDER INVESTIGATION

Covering about 29,000 km^2 and with an almost square shape, Galicia is located north of Portugal between the Atlantic Ocean in the West and the Bay of

Biscay in the North. It comprises the four provinces of La Coruña, Lugo, Ourense and Pontevedra. The region belongs to the more autonomous parts of the country with legislative rights ("comunidades autonomas", C. A.) (García Alvarez-Coque & Möhlendick 1992; Romero García 1992).

Map 1. Galicia's Location in Spain.

Generally speaking Galicia can be characterized by its structural richness concerning different landscapes based on immense relief energy, numerous rivers, many remote and dispersed villages and the widespread practice of traditional cultivation techniques on small allotments (Lois González & Santos Solla 1993). There is a lack of urban centres to render the development and improvement of infrastructural features. Moreover, the rural exodus continues and low fertility rates help to intensify the depopulation process (Comisión Europea 1994). High development potentials are supposed to be found in the forestry sector with above-average yields of timber per hectare and large areal reserves (Raviña Ruvira 1985; Pérez Moreira 1991).

Despite the deeply-carved coastal inlets (Rias) and the river valleys, the mean elevation of the coastal plain lies at about 200 m above sea level (a.s.l.). The interior lies on a niveau of nearly 600 m a.s.l., hence it can be classified as a highland area with its eastern parts peaking at nearly 2000 m a.s.l. The slopes of about 50% of the area are steeply declined from 20 to 35%. A siliceous bedrock material, high precipitation rates of 1500 to 2000 mm/a in the north-west and about 1000 mm/a in the south-east combine with the anthropogenic soil degradation mentioned above to result in generally poor soils. The average temperature ranges between 12 and 14° C (Pérez Albertí 1982).

Natural woodlands occur specifically in the eastern parts of Galicia. The potential vegetation includes oak communities of *Quercus ilex*, *Q. suber*, *Q. robur* and *Q. petraea* with mainly scrubby growth. A few beech woods are found in the boundary region of Asturias and Castilia. The Romans were prob-

ably responsible for the introduction of chestnut trees (*Castanea sativa*) to the country. Stands with *Betula alba* at an elevation of 400 to 500 m compensate for other plant communities and build the climax vegetion to the east of Lugo. The main economically-exploited stands are those with pines (*Pinus pinaster*, *P. radiata, P. silvestris*) and eucalyptus trees (*Eucalyptus globulus*). The not half-hardy eucalyptus species originates from the Australian mainland and dominates along the coast at elevations lower than 500 m asl (Rigueiro Rodríguez 1997; Pérez Albertí 1982). Its growth period is considerably shorter than that of the autochthonous species, as is shown in Table 3.

Table 3. Growth period of Galician timber (after: Fernández Leiceaga 1990).

Species	Growth period
Eucalyptus	12
Conifers	30
Deciduous trees	60

GALICIAN FORESTRY AND THE EU

The Galician administration can be subdivided into different counsels ("Consellería"), all of which can be differentiated into a couple of general departments ("Dirección Xeral"). The "Consellería de Agricultura Ganderia e Montes" is the head of the department "Dirección Xeral de Montes e Medio Ambiente Natural", which is responsible for the woodlands. The latter can be subdivided into three sub-divisions for forestry and natural environments, forest fire combat as well as hunting and river fishery. The responsibility for the reform of private property, for companies in the timber processing industry and research and education belongs to other departments. Galicia's forestry is promoted by its natural conditions and large areal reserves for afforestation. A minor decline in the total forest area of about 22,000 ha can be stated statistically between 1986 and 1995 (Anuario). This development is partly due to infrastructural improvements of the montes.

Within the European forest industry, Galicia is a major supplier of raw material with a low value for the paper industry. Conflicts with environmental protectionists, recreation requirements as well as continued improvements in rural infrastructure are therefore inevitable.

The recent development of timber is shown in Table 4. The growth of the gross production value of the agricultural sector including forestry has declined since 1989 (López Iglesias 1996). To but a small degree might this be attributed to the shrinking forest area. Rather more important factors concerning proceeds include a lack of care for the sites with ageing stands, short-term profit interests, forest fires and political preconditions to addressing structural problems of the EU.

Table 4. Development of the annual timber yield 1991–1998 in m including bark (after: Conselleria de medio ambiente, 2000).

Species	1991	1992	1993	1994	1995	1996	1997	1998	Δ91–98 [%]
P. silvestris	74,640	51,353	35,430	60,386	98,577	104,627	100,669	26,625	−64.3
P. pinaster	3,038,945	2,760,565	2,554,389	1,949,799	2,443,887	2,581,017	2,729,105	2,278,671	−25.0
P. radiata	498,947	393,346	377,284	508,769	575,366	607,654	786,350	645,278	29.3
Others conifers	5,088	4,560	29	61	342	359	207	85	−98.3
Σ conifers	3,617,620	3,209,824	2,967,132	2,519,015	3,118,172	3,293,657	3,616,331	2,950,659	−18.4
Betula spec.	12,475	11,633	8,593	10,843	16,954	20,382	24,352	22,280	78.8
Chestnut	19,675	17,788	15,765	15,143	15,646	18,808	12,220	10,116	−48.6
Q. robur	70,158	25,802	29,825	69,525	63,802	76,702	70,786	69,563	−0.9
Eucalyptus	2,029,100	1,808,223	2,081,664	1,707,175	2,343,384	2,393,384	2,730,002	2,764,858	36.3
Other deciduous trees	58,493	101,499	89,215	34,544	27,164	32,751	26,581	20,812	−64.4
Σ deciduous trees	2,189,901	1,964,945	2,225,062	1,837,230	2,466,950	2,542,027	2,863,941	2,887,629	31.9
Σ timber	5,807,521	5,174,796	5,192,194	4,356,245	5,585,122	5,835,684	6,480,272	5,838,288	0.5

According to Fernández Leiceaga (1990), the actual yield per hectare is 6.42 m³/ha. This differs slightly from the mean yield of German forests, but still lies considerably above the value for the following country, Ireland, with only 5.27 m³/ha. Though the yields per hectare show almost identical figures to those of Germany, the value for logged wood is at only one third of the German. The monetary yield remains at lower levels since most of the timber is of low quality and is used as raw material for the production of paper. Despite the high forest potential in the natural respect most high-quality timber for furniture and other needs must be imported from overseas. Equally related to the promotion of fast-growing species in monocultures are negative alterations of the landscape.

Galicia's forestry policy targets are (after Xunta de Galicia 1992):

* Implementation of a network of natural sites that meet society's requirements for recreation and nature conservation;
* Allotment consolidation in the montes and the establishment of landowner federations to promote modern forestry;
* Investment incentives in the forestry sector sponsored by private initiatives and the forest industry;
* Creation of a long-term development plan for the forestry sector which enables and facilitates the highest possible levels of assistance from the EU;
* Improvement of the collaboration between timber production, the paper industry and the administration;
* Establishment of advisory services on a local scale;
* Reform of Galicia's forestry administration to allow it to deal with more complex tasks in future;
* Setting up a forestry research centre and improvement of general knowledge about forestry-related subjects.

Since 1993 Galicia has belonged to those target areas for EU assistance with the "development and structural adjustment of regions with development deficits". The enterprises of less than two hectares which are common in Galicia are excluded from subsidy applications on the strength of Directive 2328/91, article 14. This applied to 54% of all enterprises in 1982 and to 41% in 1993. EU funds concentrating on infrastructural projects did not manage to change the situation in the montes significantly. Parallel to an afforestation program between 1993 and 1997 about 462 new forest enterprises were established.

The effect of this scheme on the vast number of tiny enterprises with scattered, dispersed allotments is limited. Previous consolidation programs gave counterproductive results. Without the old paths and ways losing their rights and the building of new ones more area is lost and split up. Furthermore, older consolidation programs showed the well-known negative outcomes for nature and the landscape, i. e. a loss of biodiversity, habitat loss (especially of wetlands) and complete deforestation (Vixande and Garrido Couceiro 1994).

REFORESTATION AND TREE SPECIES

The afforestation program in Galicia is based on EU Directives 2080/92 and 1610/89. It includes the afforestation of fallow land in order to restructure rural agriculture and the development and improvement of remaining forests (Ferández Espinar 1994). A concentration on eucalyptus trees can generally be noticed, although these species claim only limited funds in accordance with Directive 2080/92. Highly subsidized deciduous trees can almost be neglected considering the reforested area, as can be seen in Table 5 (Xunta de Galicia 1997).

Table 5. Timber species used in reforestation from 1993 to1997 (after: Xunta de Galicia 1997).

Timber species	[ha]
Conifers	29,938
Eucalyptus	10,325
Deciduous trees	5,008
Total	45,272

The assigned EU subsidies can easily be converted by national or regional laws. Hence, funds for afforestation costs are almost as high for eucalyptus as for coniferous trees. In 1996 Galicia managed to obtain care and afforestation grants for eucalyptus trees. In sum the monetary advantages of this species cannot be compensated for by other trees. In 1996 eucalyptus afforestation in Galicia was subsidized by an amount comparable to that for coniferous species in the rest of Spain (Prada et al 1996). Having been altered by national and regional legislatures, the EU afforestation program is supporting an immense spread of allochthonous tree species (Tab. 6).

Table 6. Differences in subsidies [in ptas] for various timber species
(after: Prada Blanco & Gonzalez Gomez 1993, modified).

Timber species	EC	Galicia	
	1992	1993	1996
Deciduous trees – Eucalyptus	387,600	215,000	242,500
Conifers – Eucalyptus	232,700	35,000	0,0
Deciduous trees – Conifers	154,900	180,000	242,500

The number of granted applications reaches more than 14,600 as part of a steadily upward trend (Xunta de Galicia 1997). One half of all request deal with afforestation costs, the remainder with conservation costs and even less with subsidies. Possible reasons for these few applications must be considered. Firstly, expenditures on these are very high. Secondly, they do involve an aversion to long commitments towards the administration, and, last but not least, only a small amount of money will be granted. These conditions seems to be most important,

since at least 25% of the annual income must be derived from agricultural pro-
ducts – something which does not apply to Galician forestry enterprises (Fernán-
dez Espinar 1994).

Taking into account the currently differing afforestation costs, eucalyptus
trees become the most profitable species. The loss due to forest fires of highly
valuable species with slow growth rates is enormous since stands of these need
a long period to recover (Prada Blanco & González Gomez 1993).

The regional forestry policy aims to reforest the best soils on degraded loca-
tions with predominantly (70%) eucalyptus and coniferous forests. Although the
net production of pinewood remains highest in absolute terms, conifers are sub-
sequently replaced by the even faster-growing eucalyptus tree. Between 1972 and
1986 the potential yield per year of deciduous and coniferous trees declined
steadily. In contrast eucalyptus loggings manage to compensate for the losses of
deciduous trees, and the area covered with this foreign species is already larger
than that of the autochthonous species (Prada et al. 1996; see also Table 4).

Whereas Germany's forestry concentrates on stands with slowly-growing
trees for the production of timber, Galicia focuses on fast-growing genera that
yield short-term profits (Prada Blanco 1991; Xunta de Galicia 1997). On a re-
gional scale, afforestation subsidies are preferably awarded to eucalyptus tree
plantations. In this respect forestry policy appears to affect the economic devel-
opment of the sector negatively.

Eucalyptus trees are capable of coping with very poor soils, have the property
of growing very fast and are superior to conifers in biomass production (Alamo
Jiménez 1993; Uña Alvarez 1992). During forest fires, pine trees burn down
easily, whereas eucalyptus trees are favoured because of their pyrophytic proper-
ties. Thanks to the lack of a timber-processing industry the total production value
remains low. The substitution of indigenous species by monocultures of fast-
-growing allochthonous trees impairs biodiversity substantially (Pérez Moreira
1991). Consequently the landscape is affected negatively as, ultimately, is the
touristic potential of the region. Whether eucalyptus is ecologically detrimental
to groundwater and soil resources in the long run is something that still needs to
be discussed.

CAUSES OF FOREST FIRES

Statistical investigations of forest fires commenced in 1968 (Ros 1994). In
terms of the number and size of affected areas, Galicia accounts for one third of
the forest fires throughout Spain (Serrano 1990; Velez 1990). Annually an aver-
age of 3% of Galicia's forests are set on fire. Degraded broom and heather
patches are affected to a similar extent. The coastal lowlands, as well as the
southern part of Ourense, are most particularly damaged (Fernández Leiceaga
1990). Table 7 shows the development of forest fires and affected areas.

Table 7. Development of the number and size of forests between 1989 and 1998
(Conselleria de medio ambiente, 2000).

Year	Number of fires	Woodland	Scrubland	Total areas	Area per fire
1989	8,380	91,758	104,036	195,794	10.95
1990	7,058	16,598	32,945	49,543	2.35
1991	5,307	3,893	9,485	13,378	0.73
1992	8,197	2,769	9,558	12,325	0.34
1993	7,197	1,529	6,427	7,956	0.21
1994	8,397	1,743	11,059	12,802	0.21
1995	15,121	12,130	32,088	44,218	0.80
1996	9,885	3,322	17,479	20,801	0.34
1997	14,388	5,749	21,841	27,590	0.40
1998	12,935	11,190	36,985	48,175	0.87

The causes of these extremely numerous and large forest fires are various. Forest clearing for agricultural purposes are of minor importance. Some damage is derived from careless burning of agricultural and forest wastes. More than 90% of all fires are deliberatly ignited (Carbajo 1998). The main reason can be found in the hampered reform of the socio-economic structures of the montes. The forest fire danger is increased by conflicts amongst rural inhabitants about unsolved property and land-use rights on the former commons. Serrano (1990) found a correlation between frequent forest fires and the dissatisfaction of the people in the montes regarding the administration. Profits tend to be made by a few major landowners with the majority being left out. During Franco's dictatorship federations of landowners were not tolerated and plot consolidation was not carried out properly, leading to monocultures for the paper industry. Forest fires therefore indicate that the interests of inhabitants need to be taken into account in order to improve the acceptability of forestry in society. The dwindling identification of the local people can be linked to the general rural exodus and land-use change. The desorientation caused by the lost traditional significance has made farmers abandon their former tasks. As a result, conservation measures to prevent forest fires cannot be carried through. The vast patches of fallow land in the agricultural sector can be explained this way (Fernández, Prada 1996; Ros 1994).

Neighbourhood conflicts and land speculation in coastal areas or in the urban centres deliver further reasons for the increase in forest fires (Ros 1994; Fernánadez Leiceaga 1990). Lumber merchants are in part suspected because slightly-damaged wood can be purchased cheaply (Fernández Leiceaga 1990; Redacction y liberia lineo 1996). Some fires might be caused by members of the fire brigades who fear losing their jobs (Anonymous 1997). Besides significant damage for forestry, prospective ecological aspects must be considered. The structure of soils and the edaphone are destroyed and bare soil can irreversibly be eroded by the

denudative effect of high precipitation rates. Thus, regeneration under these prevailing regional climatological and morphological conditions tends to be difficult.

THE FIGHTING OF FOREST FIRES

The combating of forest fires is a national task of the department of nature conservation ("Dirección General de Conservación de la Naturaleza") within the Ministry of Environmental Protection ("Ministerio de Medio Ambiente") (Prada et al. 1996). The regional administration of the montes installed a sub-division called the forest fire brigade that deals with the active combating of the forest fires (Xunta de Galicia 1992). Hence, the regional administration focuses on the technical fire combat.

In contrast, EU program 3529/86 for the protection of forests in the community against fires supports investigations into causes and tries to overcome structural problems. Information campaigns, fire watches, education and research lead to increased attention and motivation among people to inhibit forest fires.

Since the establishment and extension of the fire fighting infrastructure a smaller area has been burnt, though the number of fires has grown (Tab. 4). The foundation of "Servicio de Defensa contra Lumes forestais" in 1989 became necessary after a huge area was set on fire. The fire brigade with its budget of 6.8 billion Pesetas has 4000 members – after an unexpected devastating fire in 1997 almost 6000 – and can rely on modern equipment. To generate a more sustainable situation acute fire combat measures and fire prevention need to be coordinated properly. In this respect the EU measure to promote certain structures including careful afforestation schemes might play a key role. Great expectations exist towards forest federations which can work on plots of comparatively larger size than single landowners. Their increased economic power can result in less-susceptible stands of native species with slow-growing species and a better monetary yield. Moreover, federations differ from individual proprietors in being capable of financing external specialist support, a trained workforce and career development schemes. This rather sustainable forestry guarantees stable yields per hectare and prevents losses from fires. In effect the regional economy profits as well as the landscape due to reduced erosion and thus more sustainable habitats of greater biodiversity.

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CHANGES IN THE ROLE AND PERMEABILITY
OF POLISH BORDERS

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ABSTRACT: The degree of openness, and thus the permeability and the functions, of Poland's borders has changed fundamentally in the last seven years, as has the intensity of the traffic crossing them. The aim of this study was to define the degree of advancement of the process of functional change on Poland's borders as a whole, and in reference to the sections of border with particular neighbours. As element in this was the description of trends to the changes in the intensity and structure of border traffic in the years 1990–1999. In summing up the analysis carried out in this study a ranking of the permeability of borders waś prepared. It has been found that – in both of the studied time intervals (1990 and 1996) – the highest places were mostly taken by the German border, while the border with the Kalingrad District was consistently the worst on average. Between 1990 and 1996, the border improving its position as regards permeability to the greatest degree was that with Lithuania.

KEY WORDS: borders, permeability, barriers, border functions.

The degree of openness, and thus the permeability and the functions, of Poland's borders has changed fundamentally in the last seven years, as has the intensity of the traffic crossing them. This has been a result of: 1) the fall of the communist system, as the main and most fundamental factor; 2) geopolitical changes manifesting themselves in the fall of the state organisms of all three countries bordering onto the former People's Republic of Poland, and the emergence of 7 new sovereign states; 3) changes in the economic and visa policies towards Poland in Western Europe; and 4) a different level of economic development and different rates to the systemic transformations in the different countries bordering onto Poland.

The aim of this study is to define the degree of advancement of the process of functional changes of Poland's borders as a whole, and in reference to the sections of border with particular neighbours. An element in this is the description of trends to the changes in the intensity and structure of border traffic in the years 1990–1999. An additional aim has been to indicate which of the spatial barriers occurring along the borders have had and continue to have the greatest impact on the aforementioned permeability.

CHANGES IN THE FUNCTIONS OF BORDERS IN EUROPE

It may be accepted that borders in Europe were (and are) to serve three fundamental and broadly-conceived functions (beside their basic role as the boundaries of state sovereignty) that are: military (providing a barrier to military aggression from abroad), economic (constituting a barrier to the free flow of goods) and social (as a barrier to the free movement of people). As recently as in the 19th century it was still the first of these functions – the military – which predominated, albeit augmented by the economic role. The system of restrictions on the movement of individuals was still limited in scope. However, with the onset of the 20th century, the significance of all three of these fundamental functions began to change rapidly. The military functions gradually became concentrated along the borders between alliances. After the Second World War, this concentration took on the extreme form of the "Iron Curtain", which at the same time implied a significant enhancement of the economic and social functions of the borders along which it ran. In this same period, the economic functions were a derivative of the economic policy of the different countries at the time. After the Second World War, processes of economic integration were set in train in Western Europe. This bore fruit in a steady lifting of customs barriers and a consequent limitation of the border controls over goods and the vehicles carrying them. In turn, the progressive strengthening of the social functions of political boundaries was a result of two basic factors. In the case of totalitarian countries, the factor took the form of fears that citizens would make contact with the outside world, and that they would emigrate en masse to it. Equally, the democratic countries were afraid of mass immigration from poorer states.

It is possible to attempt the identification of several basic phases to the functional changes along Europe's state borders – based on our own studies and the literature, among other things on the Doliwa-Klepacki phases of European Integration (Doliwa-Klepacki 1996) and S. Ciok's analysis of Polish-German border functional changes (Ciok 1996):

Phase I. Maintenance of the significance of the military function, with simultaneous development of the economic and social functions, of borders – a situation which currently applies once more in the area of the former Yugoslavia.

Phase II. The decline of the military function with the maintenance of well--developed economic functions (customs) and social functions (restrictions on exits via passports and on entries via visas) – a situation which now hardly occurs along any European border.

Phase III. With this phase, the economic and social functions of borders are steadily limited. There is a liberalization of foreign trade and passport policy, with simultaneous retention of visa-mediated movements of people, and full border controls over individuals and goods (e.g. to this day at the Norwegian-Russian border). The transition to phase III may (though does not have to) be associated with the onset of economic integration.

Phase IV. The trade in goods undergoes further liberalization (usually as a consequence of initiated or advanced economic integration). Non-visa travel is introduced, though border controls over people and goods are retained (as along the Polish-German border at present).

Phase V. There is a full liberalization of the trade in goods (lifting of the majority of customs duties and fees at borders). Visa-free travel gives way to full freedom of movement, the taking-up of work and changes in place of residence. Border controls over people and goods are simplified and limited to a minimum (as at present along the French-Swiss border).

Phase VI. The elimination of all border controls, thereby permitting the crossing of borders at any point (as in the case of the Schengen group of countries).

In the last 40 years, there has been a gradual change in the spatial extent of areas with borders at the different stages of the above functional changes. An ever greater part of Europe has come to be embraced by ever more advanced phases, with an associated increase in the permeability of more and more borders (Fig. 1).

POLAND'S BORDERS AS SPATIAL BARRIERS

Like any state boundary, the ones dividing Poland from its neighbours function in the definite geographic, historical-political and economic environments. These kinds of environment find their reflection in the existence of various sorts of barriers which together make up the nature of the given boundary as the formalized spatial barrier (Boggs 1940). In many cases the existence of a barrier of one kind implies the emergence of barriers of other types (e.g. increased formal and legal difficulties cause the transboundary infrastructure in place to become insufficient). In some relations this dependence takes the form of a feedback. The analysis of mutual interactions of various kinds of barriers confirms the particular significance of the infrastructural barrier, as the one which focuses other constraints to border permeability (Fig. 2).

The role of the **physico-geographic factor as the spatial barrier** has drastically diminished over the last century. Still, the basic dependence between the spatial setting of some elements of the environment and the costs of implementation of infrastructural investments persists. Along the land boundaries of Poland we deal with orographic, hydrographic and ecological barriers. The orographic barriers concentrate along the southern border, and to some extent also the eastern one. The traditional trade route from Poland southwards crossed Cieszyn Silesia and the Moravian Gate. The persisting role of the physico-geographical factor is confirmed by the fact that in 1996 as much as 51% of all Polish-Czech border traffic still took place across the Moravian Gate. The hydrographic barriers include – in Polish conditions – border rivers and lakes. We deal with them

1960s 1970s

	Phase IV		Phase V		Phase VI
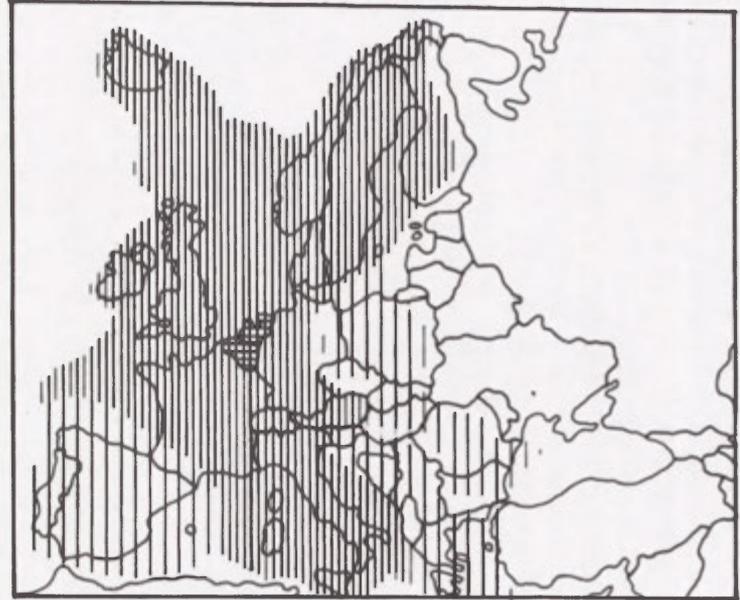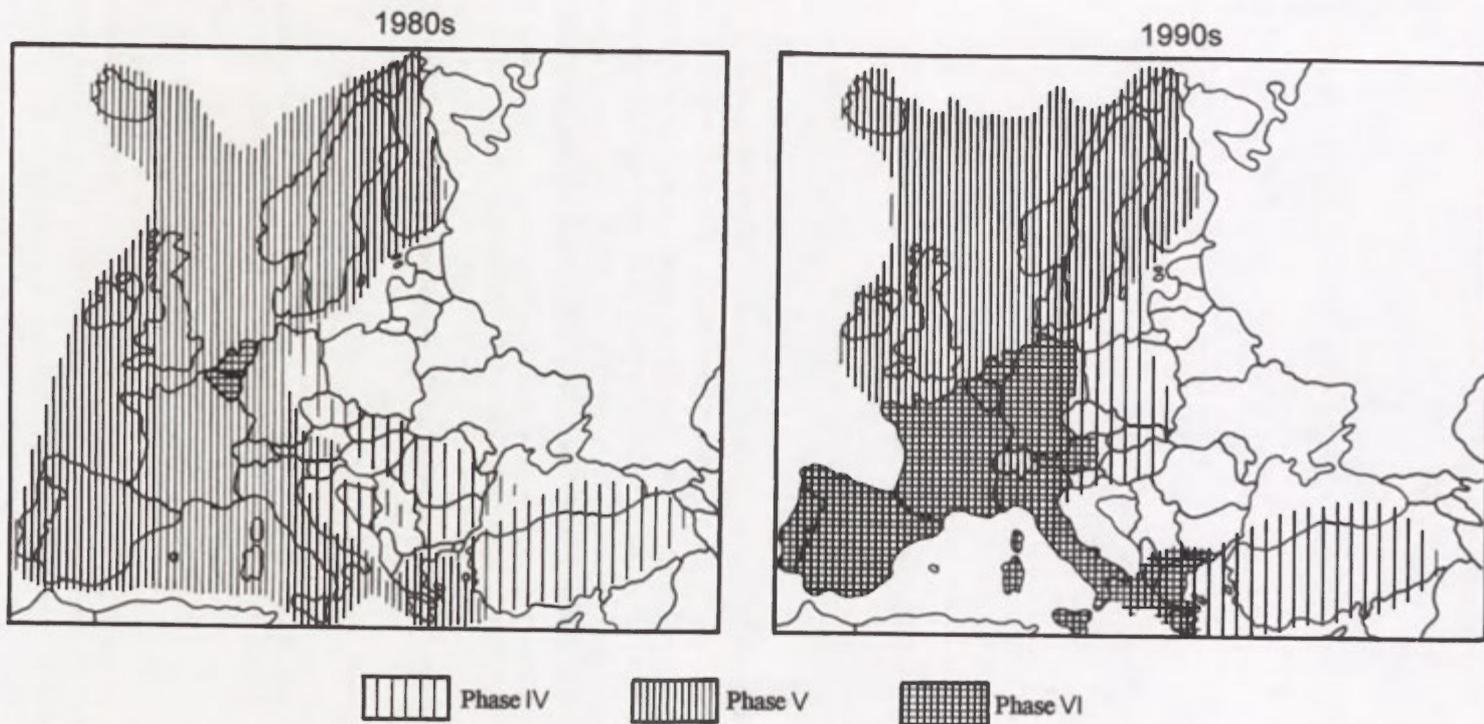
Figure 1. Changes in the functions of borders in Europe.
Source: author's own elaboration based on literature.
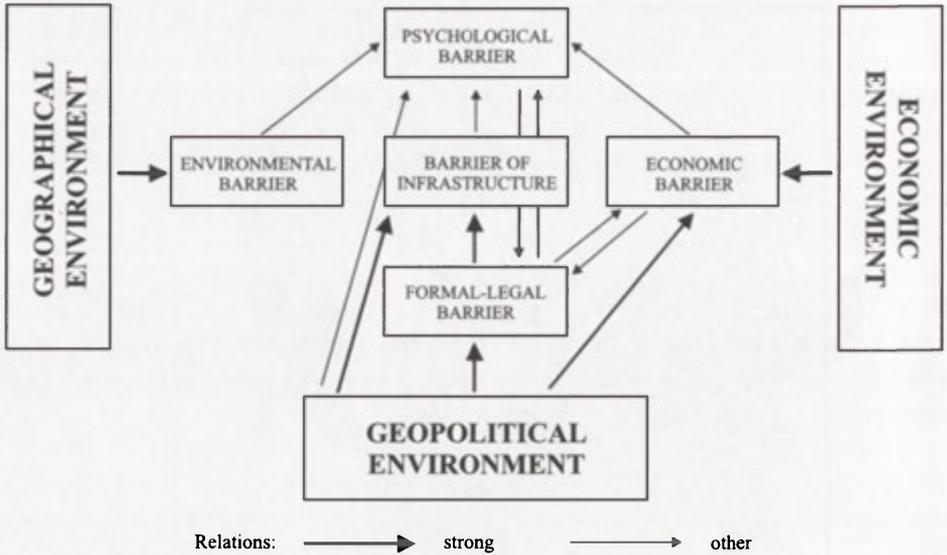
Figure 2. Borders of Poland as spatial barriers.
Source: author's own elaboration.

first and foremost along the Oder–Lusitanian Neisse rivers and along the Bug. In the case of large border rivers a lack of bridges constitutes a significant factor delaying the development of transboundary transport links. A new kind of barrier, closely connected with the natural environment, is constituted by the ecological barrier. We can speak of their existence when crossing of a border is not possible over a certain segment due to the natural value of the given area and to the protection policy implemented there. In practice this reduces to a blocking of infrastructural investment undertakings, to a limiting of the scope of admissible traffic over the already existing border crossings, and to a countering of the agreements on free tourist movement. In Polish conditions the agents setting up the ecological barriers are most frequently constituted by the boards of near-border National Parks. A classical situation of this type exists within the area of Bieszczady National Park, where there are still no border crossings to Ukraine or to Slovakia.

The **legal barriers** existing in cargo traffic result from the existence of: 1) export and import custom tariffs, 2) various kinds of fees similar in nature to customs tariffs (border taxes, excise taxes, compensation fees), 3) interdictions on the import or export of certain goods, 4) concession or licensing systems for the import of some goods, 5) phyto-sanitary and veterinary limitations, 6) transit guarantee procedures, 7) licensing systems for the carrying out of international cargo transport activities, 8) road traffic regulations applying to truck transport. The above limitations result in the functioning of border procedures expressed through the necessity of: preparing appropriate documents, starting with the

certificates of origin and ending with SAD (Single Administrative Document) forms; being subject to customs clearance (possibly inside the country); being subject to border control; and being subject to transit procedures.

Polish customs tariffs list more than 14,000 items. Along with the abandonment of the centrally-planned economy, tariff policy also underwent a change. It now concentrates on import limitations and its main tasks comprise the protection of Poland's own market and the securing of budgetary revenues. In addition, the tariffs themselves and the existence of (customs-free) import quotas result partly from the international agreements signed by Polish authorities. Particularly essential are: the association agreement with the European Union of December 1991, the CEFTA agreement and the free trade agreements signed with some other countries (e.g. with Lithuania).

On the other hand, barriers to the movement of persons result from: 1) limitations on citizens' rights to leave their own territory (issuance of passports, border passes etc.); 2) limitations on the right to enter the territory of a given country (visas, vouchers, financial guarantees, etc.); 3) the functioning of the previously-mentioned limitations on cargo traffic (customs and possibly also sanitary controls of persons); 4) limitations on the forms of traffic admitted at particular border crossings; 5) principles for the road traffic of passenger cars and buses; and also 6) insurance regulations. These limitations entail: passport control of persons; customs clearance of persons; vehicle control; in some cases also sanitary control of persons.

Since 1989 the agreements relative to the minor border traffic signed with Germany, Slovakia and the Czech Republic have guaranteed the right of border crossing on the basis of the domestic ID documents of persons residing in near--border communes. The 1990s also brought a breakthrough in visa policies with respect to the citizens of Poland. Agreements abolishing the need to have visas were signed with almost all countries of Europe, with some countries having emerged from the former Soviet Union, as well as with some non-European countries (*Wykaz państw...* 1997). In the case of remaining countries of the former USSR the old agreement concluded between the Polish People's Republic and the Soviet Union of December 1979 is still valid. This agreement guarantees visa-free entry for the participants of group excursions, for the bearers of certified personal invitations, accommodation vouchers for the stay, or appropriate stamps in the passport. The possibility of crossing the border on the basis of vouchers became a gate for practically-unlimited traffic between Poland and its eastern neighbours. Availing oneself of dud vouchers at 2–10 USD a piece became possible, with the trade frequently being conducted even at the border crossing. The situation changed as of January 1998 when the Polish authorities began to require, in accordance with the new Act on Aliens (*Ustawa o cudzoziemcach* 1997) that persons coming from Belarus and Russia had invitations confirmed by Voivodship Offices, or vouchers constituting authentic evidence of having paid accommodation in hotels.

The degree of **infrastructure-related penetrability** of particular borders is the resultant of two basic elements (Komornicki 1995) 1) existence of infrastructure of a purely transport character (roads and railroads crossing the border, seaports and airports), 2) the degree of use of this infrastructure reflected in the functioning of generally-accessible road border crossings, as well as regular railroad, ferry and air connections. The first element derives, on the one hand, from the course of the border as set against the natural conditions, and on the other hand – from the historical past (the time for which a given border has existed). The second element is connected with the political and economic constraints prevailing before 1989, the stipulations of international agreements, and the speed of realization of current investment projects.

The measure of the availability of direct transport infrastructure (element 1) is constituted by the length of the border (in km) per one hard-surface road (Tab. 1), and per one railroad line crossing the border. In Poland as a whole one hard-surface road crosses the state border every 23 km on average. The densest network of transboundary roads occurs along the boundary with the Kaliningrad District of the Russian Federation. There is one hard-surface road per 12 km of this particular border. The boundary with the Kaliningrad District, established in 1945, cut through the economic organism of Eastern Prussia, which had existed for several centuries. The situation along the border with the Czech Republic is also good (one road per 14 km of border), and is not so bad along the border with Germany either (24 km). The poorest border accessibility by road is observed along the border with Slovakia (one road per 40 km of boundary line), something which is primarily due to the border's running along the Carpathian mountains, and along the border with Ukraine (one road per 47 km).

The degree of use of the infrastructure described above is measured by the percentages of roads on which there exist any – or only the generally-accessible – border crossings, and by the percentages of railroads on which such border crossings are located – or perhaps of the railways on which passenger trains routinely run. In contradistinction to the level of equipping of borders in transport infrastructure, the degree of use of this infrastructure increased considerably in the period 1989–1997. For all the land borders of Poland the percentage of transboundary hard-surface roads passing through the generally accessible border crossings increased from 30% to 48% in the period 1993–1997 alone. Decidedly the highest level of use of the transboundary road network is that observed on the Polish-German border. Border crossings are there found on 90% of the existing relevant hard surface roads (only 68% as recently as in 1993). Along the border with Slovakia 69% of existing routes are used as generally-accessible border crossings (or as much as 92% if border crossings only for minor border traffic are accounted for). On the other hand, though, in spite of the signing of a new agreement on the minor border traffic with the Czech Republic the latter percentage share for this border is only 73%, and with respect to the generally-accessible crossings – a mere 42%. The degree of use of the existing road infrastructure is

Table 1. Transboundary road infrastructure in 1997.

Border with:	Length of border in km	Number of hard surface roads crossing the border	Length of border per 1 hard surface road in km	Number of road border crossings					Length of border per 1 generally-accessible border crossing in km	Degree of use of hard surface roads by border crossing in %	
				total	with hard surface roads	generally accessible				all border crossings	generally-accessible crossings
						total for persons	with hard surface roads				
Russia	210	17	12.3	4	4	3	3		69.9	23.5	17.6
Lithuania	102	3	34.1	2	2	2	2		51.2	66.7	66.7
Belarus	407	14	29.1	9	9	4	4		101.9	64.3	28.6
Ukraine	526	11	47.8	8	8	5	5		105.2	72.7	45.5
Slovakia	518	13	39.8	24	12	10	9		51.8	92.3	69.2
Czech Rep.	786	55	14.3	75	40	42	23		18.7	72.7	41.8
Germany	462	20	23.1	21	18	18	18		25.6	90.0	90.0
Total/Averages	3011	133	22.6	143	93	84	64		36.3	69.9	48.1

Sources: Author's own calculations on the basis of materials from the Border Guard.

Table 2. Passenger border traffic in the years 1980, and 1990–1999 inclusive, by type

Kinds of traffic:	1980		1990		1993		1996		1999	
	thousand	%	thousand	%	thousand	%	thousand	%	thousand	%
railway*	7636.4	19.9	15645.3	18.6	13506.2	7.3	8045.7	3.1	6766.1	2.38
road**	21800.7	56.9	60579.3	71.9	166315.1	89.6	247554.9	94.4	265795.2	93.3
air	1572.4	4.1	2378.9	2.8	2111.3	1.1	2949.6	1.1	4334.7	1.5
sea	431.3	1.1	703.9	0.8	1245.0	0.7	1564.2	0.6	4400.8	1.5
river	18.7	0.0	0.4	0.0	6.1	0.0	10.9	0.0	987.2	0.3
non-passport	6877.5	17.9	4942.5	5.9	2552.3	1.4	2228.8	0.8	2561.7	0.9
Total for Poland	38336.9	100.0	84250.3	100.0	185551.5	100.0	262354.1	100.0	284845.8	100.0

* in 1993 together with the Polish-German minor border traffic, in 1996 together with Polish-German, Polish-Czech and Polish-Slovak minor border traffic.

** among others planes, ferry and train crews; military traffic.

Sources: Author's own calculations on the basis of materials from the Border Guard.

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decidedly the lowest along the border with the Kaliningrad District (only 24% for the border crossings and 18% for the generally-accessible ones). The level of use of infrastructure is somewhat higher for the rail network (the average for all the boundaries being equal to 75%). The vast majority of this is used in cargo transport. Passenger trains run across the border over exactly half of the transboundary lines (22 out of 44) (Lijewski 1994, *Przejścia graniczne* –... 1998).

The Economic barriers concentrated along state boundaries are most frequently the result of the legal barriers which exist there and of the economic functions fulfilled at the given time instant by the given border. They appear whenever the cost of travel becomes higher just because of the fact that the state boundary is crossed. In Polish conditions we can observe the existence of the following five kinds of economic barriers – side by side with the customs system described previously:

- The barrier caused by the costs of issuing passports and visas. This barrier has relatively low significance currently. This category of costs, though, should also encompass the costs of vouchers required in the case of travel to Russia and Belarus.
- The barrier caused by higher fares in transboundary train traffic. It appears on virtually all boundaries. And so, for instance, the price of a train ticket from Warsaw to Berlin is some 20 PLN (5 USD) higher than the sum of domestic tickets purchased separately on both sides of the border.
- The barrier related to the obligatory insurance of vehicles. Cars insured in the countries of the European Union, as well as – in particular – in the Czech Republic and Hungary are automatically given the so called "green card", being the evidence of civil liability insurance within the whole of Europe. Since January 1st, 1997, relatively high fees again began to be charged in Poland for this kind of insurance.
- The payment of fees for the use of roads within a country (e.g., the motorway and expressway fees in the Czech Republic).
- Fees related to the very fact of crossing the border. This kind of fee exists currently at the border with Belarus.

Various kinds of **psychological factors** do undoubtedly have a bearing on the magnitude of the cross-border traffic. The nature of the factors may be positive (motivating travel abroad and economic co-operation with neighbours) or negative (causing apprehension with respect to travelling and co-operation – and forming psychological barriers). It seems that in Poland, a country whose eastern and western borders shifted several hundred kilometres in the not-too-distant past, the existence of psychological barriers is still distinct.

QUEUES AT THE BORDERS

The most pronounced sign that Polish boundaries are spatial barriers is constituted by the queues at border crossings. They are due primarily to two types of

barriers: the legal and the infrastructural, with the former apparently playing the dominating role in this case. With the assistance of officers of the Headquarters of the Border Guard, information was gathered in 1992 on the queues of vehicles at Poland's borders (Komornicki 1994). In 1992, the phenomenon of queues appeared on 22 border crossings altogether. In reality, though, the problem concerns a smaller number of crossing points. The annual average waiting time exceeded 1 hour (for at least one category of vehicles) at 14 border crossings, including 8 on the German border, 2 on the Belarussian, 2 on the Ukrainian, and 1 each on Czech and Lithuanian borders. Queues were seldom observed on the border with Slovakia. The longest waiting time for trucks entering Poland was noted on December 18th at Kuźnica Białostocka (160 hours). The worst situation which arose on the western border was at Świecko on November 4th (60 hours wait to leave the country). A waiting times of 26 hours for entry was noted on the southern border at Cieszyn and Kudowa.

The infrastructural investment projects implemented in the years 1992–1997 brought a very limited improvement of the situation in terms of the occurrence of queues at borders. These efforts can be supposed to have been countered by the further increase in traffic. It is not without significance that the investment projects mentioned were not accompanied by improved functioning of border services (especially those in the CIS countries). The situation with respect to the queues of trucks at the German border has hardly changed in spite of what is apparently the biggest concentration of various kinds of projects on both side of this border. On the other hand, waiting times for cargo traffic increased quite distinctly on the southern border.

Just a couple of years ago queues of lorries would occur at borders within the European Union as well. According to a study carried out in 1988 within the framework of the programme The "Cost of Non-Europe" (encompassing Belgium, France, The Netherlands, the then Western Germany, the United Kingdom and Italy), the average delay in transport relating to the existence of internal boundaries ranged between 1.44 hours in case of trips from Belgium to The Netherlands and 7.6 hours in the case of transport from France to Italy (The "Cost of Non-Europe –"... 1988). As part of the same study it was estimated that the total cost of delays caused by clearance (in traffic between the six countries mentioned) amounted to 780 million ECU. These calculations were based upon the rates of compensation of drivers and the costs of the idle time of trucks. It is difficult to develop analogous estimates in Polish conditions due to the differentiated costs of driver wages in particular. Still, if we make a simplification entailing the adoption of costs of labour and equipment at similar levels to those in the European Union in 1988 then we obtain 27.6 ECU per hour of waiting at the border. Further, assuming average waiting times calculated within the framework of the 1992 study and the intensity of the truck traffic observed during that year, we obtain an estimate of the bottleneck costs borne by forwarders at just the single border crossings in Świecko (Western border) at 263 million ECU, and in

Terespol–Kukuryki (Eastern border) – at 229 million ECU. These two points alone incurred losses equal to almost half of all those borne in an analogous manner in 1988 between the six aforementioned countries. Currently the truck traffic is twice as heavy and the waiting queues similar.

CROSS-BORDER TRAFFIC

As mentioned already, the increase in the level of border passenger traffic in the 1990s was without precedence in the history of Poland up to that time (see Fig. 3). While there were a total of 59 million individual crossings of all the borders taken together in 1989, the figure a year later was already up to 84 million, while that for 1992 was as high as 157 million (thus 2.5 times the level three years previously). In subsequent years, the rate of increase in traffic slowed gradually, while still exceeding 10% each year. By 1996, the number of individual crossings of the border in the two directions exceeded 262 million, of which Poles were involved in 33%. Later on the increase was slower, mainly because of the Russian crisis, price balancing between Poland and Germany and lesser intensity of the bazaar trade on the Eastern and Western borders the connected with the previous factors. In 1999, Polish borders were crossed by 285 million people.

There was also a major change in the structure of cross-border traffic in the period (see Tab. 2). In 1980, only just over half of all crossings took place by road (including on foot). One-fifth of those crossing at that time made use of railways and just over 4% went by air. At the same time, as many as 18% of all crossings were without passports (local cross border traffic, army traffic etc.). From the late 1980s onwards, there was a steady rise in the role of road traffic at the expense of rail, air or non-passport traffic. By 1996, the share taken by road
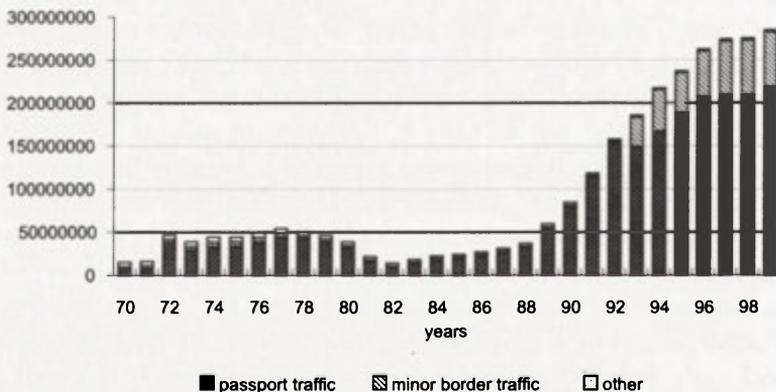

Figure 3. Passenger traffic at Poland's borders in the years 1970–1999.
Source: author's own elaboration based on Border Guard materials.

traffic had exceeded 94%, while those taken by air and rail were of only 1.1% and 3.1% respectively (the only part of the border along which rail crossings remained of greater significance was that between Poland and Belarus). At the end of the 90s, the role of sea and air crossings was higher again (mainly because of Polish citizens, ferry and charter flight holiday departures), however the significance of rail passenger border traffic was still decreasing (representing only 2.4% of total border traffic in 1999).

The directional structure to the traffic also changed markedly (see Tab. 3). In the years 1990–1991, it was along the German and eastern borders that the greatest increase in traffic occurred. In the years 1993–1994, the German border was again predominant (Komornicki 1996), followed by those with the Czech Republic and Russia. In contrast, the years 1995–1996 saw the biggest increase along the Czech, Slovak, Ukrainian and Russian borders. At present (1999), the greatest streams of cross-border passenger traffic are focused on the borders with Germany and the Czech Republic (with the two together accounting for 80% (1999) of the traffic in terms of numbers of people and 86% in terms of numbers of cars). In the 1997–1999 period the share of trans-border passenger traffic with all Eastern neighbours (except Lithuania) decreased, mainly as a result of the Russian crisis, a new Ukrainian customs policy and a new Polish immigration policy (in accordance with Ustawa o cudzoziemcach – the Aliens Act – 1997). The number of people crossing the Polish-Czech border was also lower than in the middle of the decade. On the other hand, the shares taken by the German border in these terms was higher again (at 54% in 1999), and the number of people crossing the border at seaports and airports increased.

The period up to 1995 saw a decline in the proportion of Polish citizens among those crossing the Polish border (from 55% in 1990 down to 30% in 1995), as well as in the share of private passenger vehicles with Polish registration that crossed over. The trend was reversed in the years 1995–1996. The dynamic to the increase in the number of departures abroad by Polish citizens was smaller up to 1995 than that for all border traffic taken together. However, in 1996, the level of increase was almost twice as great, mainly as a result of a greater number of tourist journeys across the southern border, and an increase in the number of flights. Along the borders with Ukraine and Russia, the border traffic is two-directional. In contrast, the border with Belarus has a large share of transit traffic (heading for Russia), as do those with Lithuania (for the other Baltic States) and the Czech Republic (for southern and south-western Europe). For German, Czech, Slovak, Ukrainian and Belarussian citizens entering Poland, this country is most often the target destination. In contrast, for most Lithuanians and a large part of the Russians entering the country it is merely a transit state.

A separate issue is the increase in the level of border traffic involving heavy goods vehicles (HGV). Proof of the increasing vitality of economic contacts is provided by a dynamic to the growth in this kind of border traffic that is even greater than in the case of individuals and private passenger vehicles. While

Table 3. Passenger border traffic in the years 1980 and 1990–1999 inclusive, by direction.

Border with:	1980		1990		1993		1996		1999	
	thousand	%	thousand	%	thousand	%	thousand	%	thousand	%
Russia	5.1	0.0	82.9	0.1	1124.8	0.6	4199.0	1.6	4238.3	1.5
Lithuania	4.6	0.0	995.5	1.2	3548.9	1.9	2939.0	1.1	3079.1	1.1
Belarus	1715.0	4.5	5567.2	6.6	8926.2	4.8	10878.6	4.1	10084.6	3.5
Ukraine	998.6	2.6	4272.3	5.1	5563.2	3.0	10629.4	4.1	9889.6	3.5
Slovakia**	2763.9	7.2	6225.7	7.4	8055.8	4.3	16749.8	6.4	19185.0	6.7
Czech Republic**	8180.8	21.3	16716.8	19.8	33909.5	18.3	82452.0	31.4	73966.2	26.0
Germany*	15787.9	41.2	42364.6	50.3	118514.4	63.9	127763.7	48.7	153105.7	53.8
sea border	431.3	1.1	703.9	0.8	1245.0	0.7	1564.2	0.6	4400.8	1.5
air border	1572.4	4.1	2378.9	2.8	2111.3	1.1	2949.6	1.1	4334.7	1.5
non-passport traffic	6877.5	17.9	4942.5	5.9	2552.3	1.4	2228.8	0.8	2561.7	0.9
Total for Poland	38336.9	100.0	84250.3	100.0	185551.5	100.0	262354.1	100.0	284845.8	100.0

* in 1993, 1996 and 1999 together with minor border traffic; ** in 1996 and 1999 together with minor border traffic.
Sources: Author's own calculations on the basis of materials from the Border Guard.

Table 4. Movement of heavy goods vehicles across Poland's borders in the years 1980 and 1990–1999.

Border with:	1980		1990		1993		1996		1999	
	thousand	%	thousand	%	thousand	%	thousand	%	thousand	%
Russia	1.7	0.6	1.9	0.2	20.1	0.9	46.6	1.3	52.6	1.2
Lithuania	0.0	0.0	12.5	1.2	86.8	4.0	305.9	8.8	426.1	9.9
Belarus	49.9	16.9	136.3	12.6	268.2	12.3	555.1	15.9	398.2	9.2
Ukraine	8.2	2.8	34.1	3.2	75.3	3.4	179.2	5.1	161.9	3.8
Slovakia	2.2	0.8	14.5	1.3	44.2	2.0	167.2	4.8	228.6	5.3
Czech Republic	56.2	19.0	145.0	13.5	208.7	9.5	407.1	11.7	510.9	11.9
Germany	149.9	50.7	686.5	63.7	1427.3	65.3	1752.9	50.4	2426.1	56.3
Sea border	27.2	9.2	46.7	4.3	55.1	2.5	67.5	1.9	105.6	2.4
Poland total	295.4	100.0	1077.5	100.0	2185.7	100.0	3481.4	100.0	4310.0	100.0

Sources: Author's own calculations on the basis of materials from the Border Guard.

295,000 HGVs crossed all Poland's borders taken together in 1980, the figure for 1990 was 1.1 million, that for 1993 – 2.2 million, that for 1996 nearly 3.5 million and that for 1999 4.3 million. This growth in HGV traffic took place virtually uninterrupted along all borders (see Tab. 4) up to 1997 and in general is still doing so.

Here, as well, the traffic via the Polish-German border dominates (at currently more than 56%). This share decreased to 1997, though in comparison with the year 1993 by almost 15 percentage points, mainly to the advantage of the Polish--Belarusian, Polish-Lithuanian and Polish-Russian borders. This was evidence for the increasing significance of transit transport between Western Europe on the one hand and Russia and the Baltic States on the other. In comparison with 1980, the greatest decrease in the share of this category of traffic occurred at the Polish-Czech border (a decrease from 19% to 12%), in what is a reflection of a distinct decline in economic contacts between the two countries, as well as a more limited role of transit cargo traffic along the North-South axis. At the end of 90. HGV border traffic growth was still ongoing on the western and southern borders, on the sea border and on the border with Lithuania, though it had stopped on the border with Russia and Ukraine. The traffic with Belarus decreased significantly in this period. The main Polish-Belarussian customs post at Kukuryki (on the Berlin–Moscow transport corridor) is no longer the Eastern border crossing most overcrowded by HGV traffic. This position was taken by the Polish-Lithuanian customs post at Budzisko on the "Via Baltica" transport corridor (426,000 HGVs in 1999).

THE RANKING OF BORDER PERMEABILITY

In proceeding to sum up the analysis carried out, an attempt was made at even a simplified systematic arrangement of Poland's borders. Efforts were confined to the preparation of a ranking of border permeability. Even so, the complexity of the issue required a more penetrating and cautious interpretation of the material obtained using these methods. Nine variables – on the basis of statistical data and 9 descriptive measures – based on the author's own detailed studies of each border situation (Komornicki 1999) depicting the permeability of borders were chosen (see Tab. 5).

In analyzing the ranking for the nine variables, it has been found that – in both of the studied time instances (1990 and 1996) – the highest places were mostly taken by the German border, while the border with Kaliningrad District was consistently the worst on average. Between 1990 and 1996, the border improving its position to the greatest degree was that with Lithuania. An additional interpretation proved possible for the results obtained from the analysis of descriptive measures. In 1990, whole sections of the border with the different countries then in existence (Germany, Czechoslovakia and the USSR) obtained similar numbers

Table 5. Classification of border permeability in 1990 and 1996.

Measures	1990 - border with:							1996 - border with:						
	Russia	Lithuania	Belarus	Ukraine	Slovakia	Czech Rep.	Germany	Russia	Lithuania	Belarus	Ukraine	Slovakia	Czech Rep.	Germany
Statistical measures:														
Number of hard surfaced roads per 100 km of the border	8.1	2.9	3.4	2.1	2.5	6.6	4.1	8.1	2.9	3.4	2.1	2.5	7.0	4.3
rank	1	5	4	7	6	2	3	1	5	4	7	6	2	3
Number of railways per 100 km of the border	1.4	1.0	1.5	1.3	0.6	1.5	2.8	1.4	1.0	1.5	1.3	0.6	1.5	2.8
rank	4	6	3	5	7	2	1	4	6	3	5	7	2	1
Degree of use of transborder roads by border crossings in %	0.0	33.3	14.3	18.2	30.8	17.0	55.5	17,6	66,7	28,6	36,4	69,2	40.0	90.0
rank	7	2	6	4	3	5	1	7	3	6	5	2	4	1
Degree of use of transborder railways by border crossings in %	0.0	0.0	33.3	42.9	33.3	16.7	30.8	33,3	100.0	50.0	57,1	66,7	41,7	46,2
rank	7	7	2	1	2	5	4	7	1	4	3	2	6	5
Passenger border traffic in thousand per border crossing	20.8	996.0	927.8	712.0	1245.2	1393.1	2824.3	1049.8	979.7	1208.8	1181.0	2093.8	2576.6	5807.4
rank	7	4	5	6	3	2	1	6	7	4	5	3	2	1
Passenger car border traffic in thousand per border crossing	2.5	195.0	247.0	238.5	197.4	325.9	651.9	549.7	438.5	599.8	614.5	428.6	857.3	2826.2
rank	7	6	3	4	5	2	1	5	6	4	3	7	2	1
HGV border traffic in thousand per border crossing	1.0	13.0	34.0	17.0	4.7	14.5	76.3	15.7	306.0	185.0	59.7	41.8	31.3	219.1
rank	7	5	2	3	6	4	1	7	1	3	4	5	6	2
Reciprocal of passenger border traffic concentration level indicator	2.0	10.0	2.2	1.8	3.5	2.5	3.1	2.3	3.3	2.8	2.3	2.4	2.1	3.2
rank	6	1	5	7	2	4	3	5	1	3	6	4	7	2

|														
Reciprocal of HGV border traffic concentration level indicator	6.7	10.0	1.9	2.1	3.3	1.6	1.9	1.6	10.0	2.9	8.7	2.2	1.6	2.8
rank	2	1	5	4	3	7	6	7	1	3	2	5	6	4
Descriptive measures (points from 1 to 5)														
Permeability from the points of view of:														
Environmental barrier	5	5	4	3	2	2	3	5	5	4	3	2	2	3
Formal travel barrier (visas, vouchers etc.)	1	1	1	1	2	2	3	2	3	2	3	5	5	5
Role of the minor border traffic	1	1	2	2	2	2	1	1	1	2	2	4	5	5
Level of custom tax reduction in bilateral exchange	1	1	1	1	1	1	1	1	2	1	2	3	3	3
Level of border control precision	1	1	1	1	3	3	3	2	2	2	2	4	4	4
Economic barrier	3	3	3	3	5	5	5	4	4	2	4	4	4	4
Psychological barrier	2	2	2	2	4	4	3	2	3	2	3	5	5	4
Length of border queues for passenger car	3	1	1	1	5	5	4	2	2	1	2	4	5	4
Length of HGV border queues	1	1	1	1	4	3	2	1	2	1	1	3	3	2
Average rank	5.33	4.11	3.89	4.56	4.11	3.67	2.33	5.44	3.44	3.78	4.44	4.56	4.11	2.22
Total points	18	16	16	15	28	27	25	20	24	17	22	34	36	34
Average points note	2.00	1.78	1.78	1.67	3.11	3.00	2.78	2.22	2.67	1.89	2.44	3.78	4.00	3.78

* only border crossings with more than 0.1% of bilateral traffic in each category.

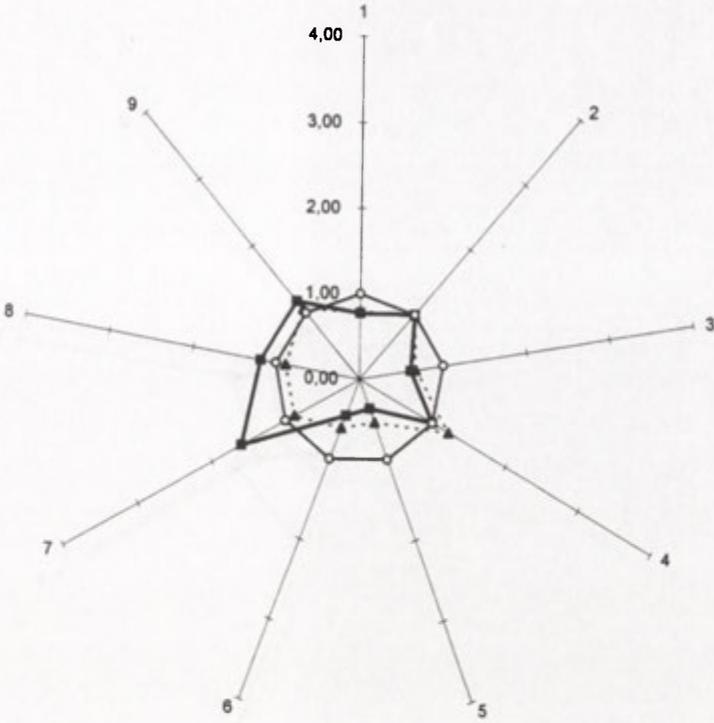Sources: Author's own calculations on the basis of materials from the Border Guard, topographic map and literature.

Russia
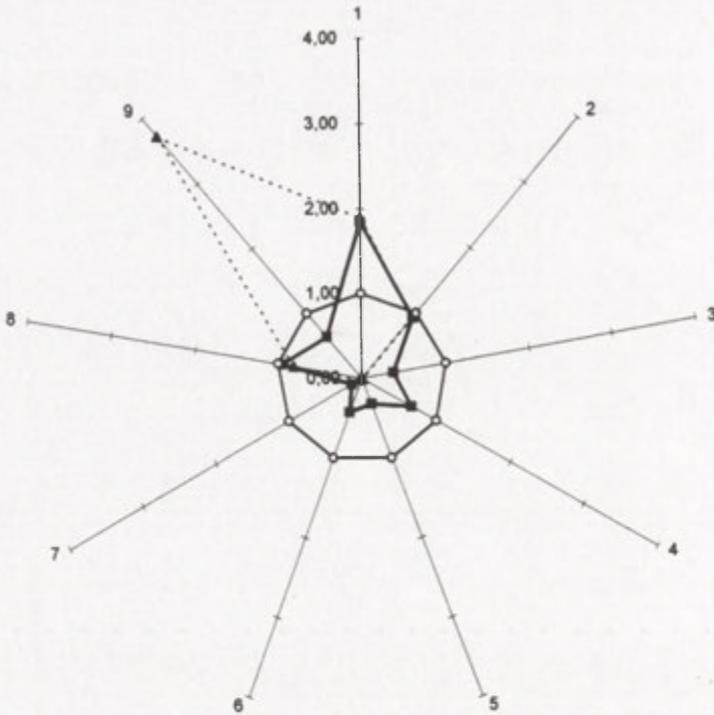
Lithuania
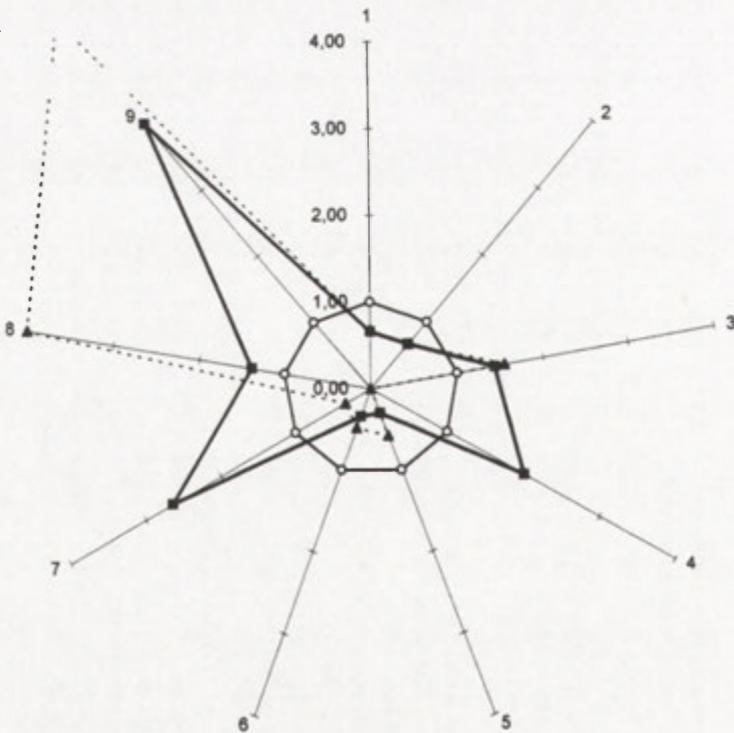
Belarus

Ukraine
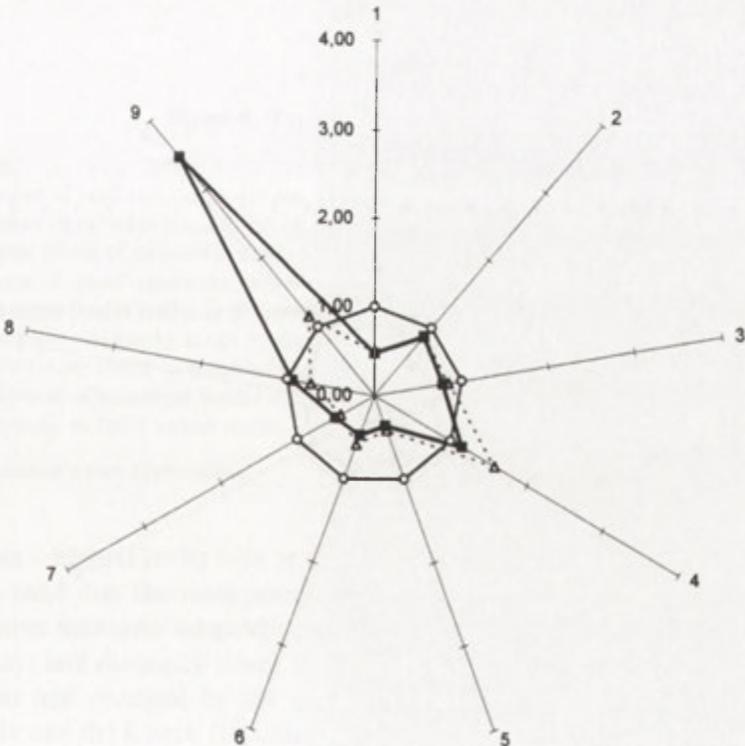
Slovakia
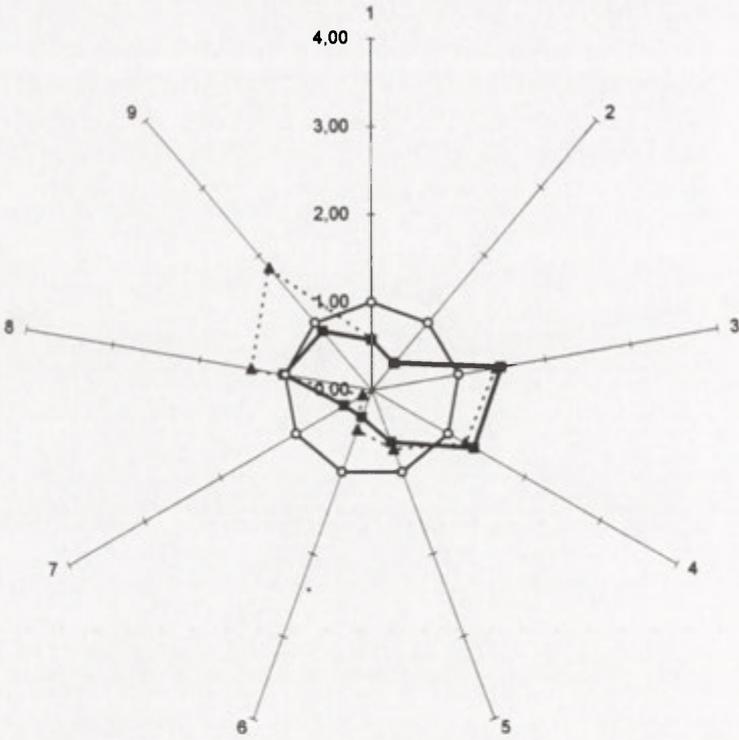
Czech
Republic
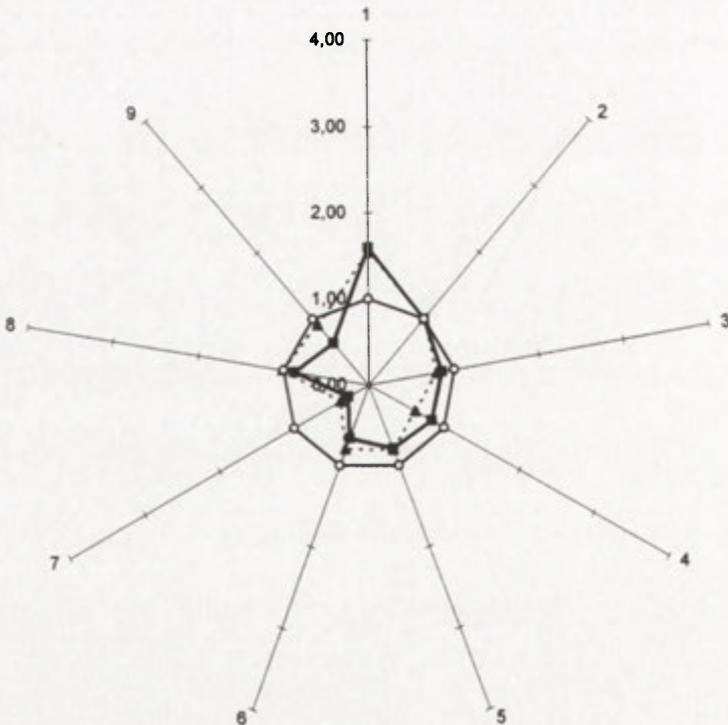
Germany
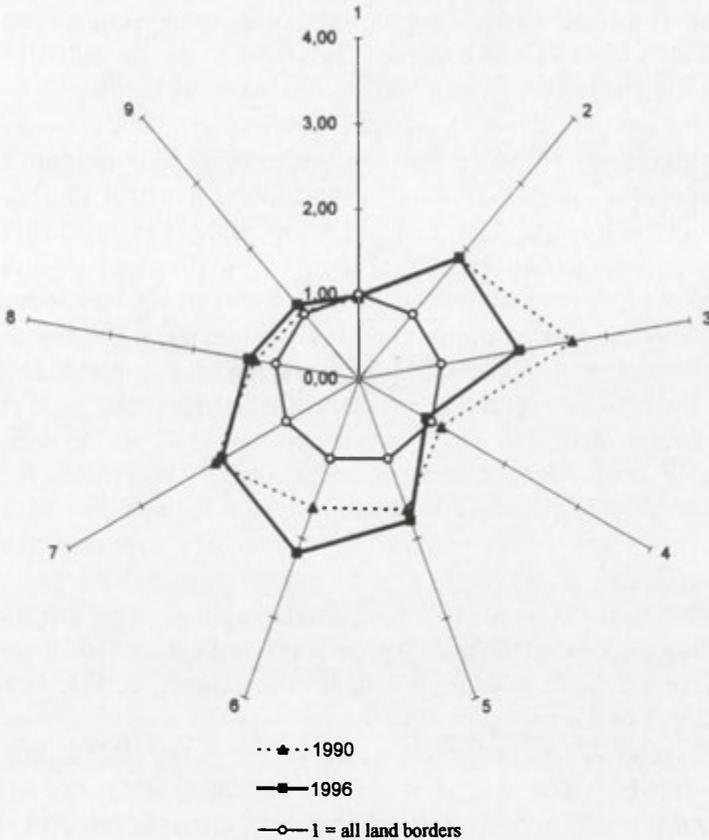
Figure 4. Typograms of border permeability.

Variables:
1 – number of hard surfaced roads per 100 km of the border,
2 – number of railways per 100 km of the border,
3 – degree of use of transboder roads by border crossings in %,
4 – degree of use of transboder railways by border crossings in %,
5 – passenger border traffic in thausand per one border crossing,
6 – passenger cars border traffic in thausand per one border crossing,
7 – HGV border traffic in thausand per one border crossing,
8 – reciprocal of passenger border traffic concentration level indicator,
9 – reciprocal of HGV border traffic concentration level indicator.

Source: author's own elaboration.

of points – highest in the case of the borders with the Czech and Slovak Republic (which were thus the most permeable from the point of view of analysis of the descriptive measures adopted); only a little lower in the case of the border with Germany; and distinctly lower in the case of that with the USSR. However, the situation had changed by the end of 1996, with the borders with Germany, Slovakia and the Czech Republic all gaining similar numbers of points (though

the last obtained the most); while the eastern borders had become differentiated into those with Lithuania (most points), followed by those with Ukraine and Russia, with the Polish-Belarussian border clearly further behind.

The ranking gave relatively unambiguous indications that the German border is at present the most permeable; that the permeability of those with Lithuania and Ukraine (so far limited) is improving steadily; and that the border with Russia remains the least permeable. If it is accepted that the statistical measures are a reflection of the real infrastructural situation and the existing border traffic; and that the descriptive measures give a general idea of the conditioning under which traffic moves; then particular interest should be taken in those sections of the border where assessments based on the two types of indicator differ from one another. On the borders with the Czech Republic and Slovakia, good conditions (capable of being referred to as "potential permeability") are accompanied by relatively more weakly-developed infrastructure and by more limited, and concentrated, border traffic. The reverse situation applies to the border with Belarus, along which the unfavourable conditions do not prevent a huge traffic (especially in goods) from taking place.

Efforts were made to supplement the picture obtained with a graphic presentation. To this end, a radial diagram (typogram) (Pietkiewicz 1971) was devised for each border, on the basis of the 9 statistical measures (see Fig. 4). Comparison of the shapes of the nonagons obtained showed which of the sections are (or were in 1990) more or less permeable than the average for all Poland's borders. This in turn allowed it to be judged which sections are similar to one another and which have been characterized by the most marked changes in recent years.

CONCLUSIONS

In relating the results obtained to the question posed at the outset regarding the advancement of the change in permeability and comparisons with the phases distinguished for functional transformations along borders in Europe as a whole, the research was found to confirm that the Polish-German, Polish-Czech and Polish-Slovak borders are already in phase IV of the transformation. They also indicate that differences in the degree of advancement of these transformations along the three borders are more limited than has been widely-recognized. While it is true that the greatest border traffic is still concentrated along the German border, its role is slowly declining – mainly in favour of the Czech border, while these southern borders have simultaneously (after 1995) become the most permeable from the formal, economic and psychological points of view. At the same time, the analysis of permeability confirms that all the eastern borders remain in phase III, while the differences between them in this regard are again rather smaller than has been assumed. It should thus also be noted that the functional

transformations and improvements in permeability along the western and southern borders have been achieved by evolutionary means, without more major holdups. In contrast, changes along the eastern border have been abrupt in character.

Analysis seeking to identify the kind of spatial barriers along the Polish border that have the greatest impact on permeability has confirmed the particular role played by legal and infrastructural barriers. However, as of the late 1990s, it is possible – with a certain caution – to consider the infrastructural barrier as being of more limited significance than had been assumed. It was decisive in the first period of the transformation (before the attainment of a certain necessary minimum in this sphere), but has with time given way to the role of the legal, and above all organizational, factor (on the eastern border). Thus, it is not possible to look solely to infrastructural developments (including the construction of modern border crossings) as antidotes by which to improve the permeability of borders.

Particularly noteworthy is the slowing, after 1995, in the rate of growth of passenger traffic, and of the considerable associated structural changes. This confirms the huge role played in the increased traffic by so-called "bazaar-based economic relations". A slow contraction in this kind of exchange is resulting in a reduced dynamic, and even in a slight fall in the level of traffic along the western border. 1999 is likely to be the last year showing an increase in the level of border traffic. In consecutive years, the steadily-increasing number of crossings of the Polish border by authentic tourists, and by those travelling on business, was not sufficient to make up for the declining numbers of crossings by those coming here to shop. Unlike passenger traffic, goods traffic by road may be expected to increase further, though the possibilities for its further deconcentration are limited.

In the context of the negotiations over Poland's accession to the European Union, it is particularly important that the principles for traffic between Poland and all her eastern neighbours are normalized prior to their conclusion. The period leading up to Poland's membership is some kind of "last chance" for its own policy in this sphere, towards the countries of the former Soviet Union, to be devised. One of the priorities in Poland's accession negotiations should thus be to obtain immediate full (phase VI) permeability of the western and southern (Czech) borders to passenger traffic. However, it must also be a priority for Poland to stand against the creation of too many new legal barriers along the eastern border (retention of permeability at the phase IV level or that of phase III in particular cases) (Rościszewski 1997), and particularly along that with Slovakia (at the phase IV or even phase V levels).

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Wykaz państw z którymi Polska zawarła porozumienia o zniesieniu obowiązku wizowego lub które jednostronnie zniosły obowiązek wizowy dla obywateli RP (stan na 1 sierpnia 1999) (List of the countries with visa-free traffic for Polish citizens, situation as of 1 August 1999), 1997, Ministerstwo Spraw Zagranicznych, [http://www.msz.gov.pl/infokonsul/polakzagr/wykazruchubezwiz.html]

EVAPORATION IN WROCŁAW AND ITS VARIABILITY IN THE YEARS 1946–1995

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ABSTRACT: The Authors present the results of a statistical–climatological study of evaporation from the water surface in Wrocław and its variability in the years 1946–1995. The evaporation was characterized by year-to-year variability in the annual, half-year and monthly sums and the multi-year trends were determined mathematically with the help of linear and polynomial trends of the 3rd and 6th degrees. The trends were compared with the long-interval tendencies for the basic factors controlling evaporation, i.e. with saturation deficit, solar global radiation and wind velocity. The "variability of variability" was taken into consideration and multi-year periods of relative stabilization and extinction of amplitude fluctuations separated and contrasted with intervals of increased fluctuational dynamics. The analysis points to the occurrence of 8, 10–11, 16 and 21–23-year evaporation rhythms. The overall findings were investigated in the context of solar activity (Wolf's number) and of multi-year circulation changes in Poland.

KEY WORDS: evaporation from water surface, Wild's balance-evaporimeter, factors controlling evaporation, multi-year variability, solar activity, atmospheric circulation.

INTRODUCTION

Issues connected with multi-year changes in evaporation in Wroclaw were investigated by Schmuck (1956) in the mid-50s. His elaboration concerned the period 1891–1953 covering 50 years of data collection excluding the periods of the two World Wars. It relied mainly on evaporation values from a water surface (E), calculated using an empirical formula of Schmuck's devising: $E = k*d\sqrt{v}$, where: d is the mean saturation deficit in a month, v the mean wind velocity in a month and, k the empirical coefficient (11.2–15.5) determined for particular months.

In his work Schmuck only established that there were considerable fluctuations in annual E sums, without any directional tendency. The material he used was significantly heterogeneous due to repeated changes of measuring stations and a lack of uniform procedures. The accuracy of Schmuck's formula was challenged several years later by field studies at Swojec conducted by Bac (1968, 1970), who educed the two empirical equations:

1) for "decades"[1]: $E = d\sqrt{v} + 4* G$

and

2) for months: $E = 3*d\sqrt{v} + 4*G,$

where: G – is global radiation [kcal/cm^2] (one should multiply by 0.344 when G is to be in: [kWh/m^2]).

Recently Bryś (1997, 2000), used 35-year data collected at Swojec to propose a new formula for the calculation of evaporation, i.e.:

$$E_p = d\,(0.43 + 1.65\sqrt{v}) + 0.0676\,G + 1.52,$$

where: E_p [mm] is the "decade" sum of potential evaporation, d [hPa], v [m/s], G [kWh/m^2] (one should divide by 3.6 when G is to be in: [MJ/m^2]).

METHODOLOGY

The study is an amplified version of the work published earlier in Polish (Bryś, Bryś 2000). The current work goes further in presenting the proof-related aspects and the results of the investigations carried out.

The paper is a statistical–climatological analysis of evaporation from a water surface (Wild's evaporimeter-balance at 0.5 m under a rooflet screen) at the Agro- and Hydro-meteorological Observatory of the Agricultural University at Wroclaw–Swojec. The station is representative of the agricultural areas of low-land Lower Silesia. The work presents the global results (Tab. 1) of evaporation measurements (1961–1995) and calculations of E sums (1946–1960). The 50-year data obtained this way, were used to characterize the main features of the variability to multi-year evaporation in Wroclaw in the years 1946–1995.

The conditions for the years 1946–1960 were determined on the basis of instrumental measurements and the observation of elementary meteorological parameters (*Prace Obserwatorium...* 1947–1988) in the nearby (5.5 km) Meteor-ological Observatory of the Wroclaw University.

The basis for calculations were "decade" data (sums or means). The years 1961–1965 as well as 1971–1974 (i.e. the whole available period in which com-parison of materials from the two observatories was possible) were used to obtain very accurate formulae for multiple regressions (R^2 from 0.985 to 0.995), com-bining University measurement results with those obtained at Swojec (Bryś, Bryś 2000). "Decade" values for the factors controlling evaporation (d, v, G) obtained in this way, helped calculate, with the use of the formulae from Bac (1968) and Bryś (1997), "decade" evaporation sums (E). Finally, after comparisons of those

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[1] In the work we employed, beside the normal sense of the word decade, a special meaning signified by "decade". The so-called "decades" are periods of 10 days (or 11 days at the ends of the 31-day months and as appropriate 8 or 9 days in the case of February); the denotation links to the old Greek, French, German (and also to many other European) languages.

Table 1. The values of monthly and I–XII, IV–IX evaporation sums [mm] at the Observatory Wroclaw–Swojec in the years 1946–1995.

Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I–XII	IV–IX
1946	19.0	25.5	31.0	63.6	85.0	78.4	90.5	63.2	51.8	27.0	16.0	13.8	564.8	432.5
1947	15.0	14.3	32.7	70.6	97.5	92.0	90.8	75.9	74.8	41.3	27.3	18.0	650.2	501.6
1948	23.5	24.2	43.8	84.5	74.9	84.8	83.9	78.1	76.8	45.5	24.5	21.7	666.2	483.0
1949	22.3	27.6	32.4	70.0	76.7	70.6	84.0	73.4	53.4	54.1	21.2	25.3	611.0	428.1
1950	17.4	35.7	41.4	53.5	88.5	109.7	109.8	79.8	56.0	35.0	25.2	16.5	668.5	497.3
1951	21.9	22.6	30.6	66.1	56.4	89.5	83.2	74.2	56.6	39.7	24.9	25.4	591.1	426.0
1952	23.0	18.1	31.6	56.3	64.4	76.1	103.6	80.1	43.2	26.9	19.5	14.8	557.6	423.7
1953	14.9	24.8	45.9	79.9	69.9	92.1	101.0	78.9	70.0	44.7	31.5	17.1	670.7	491.8
1954	18.5	19.1	27.0	37.0	68.6	82.0	67.0	80.2	59.7	46.7	21.3	22.1	549.2	394.5
1955	19.7	22.1	31.4	42.5	76.1	77.2	61.8	55.3	46.1	28.6	21.8	24.1	506.7	359.0
1956	24.9	12.5	36.0	41.2	74.0	73.2	84.9	67.3	63.5	30.4	18.3	18.8	545.0	404.1
1957	17.5	22.9	39.8	51.8	69.9	101.3	76.7	61.3	44.2	35.2	28.5	16.5	565.6	405.2
1958	17.6	26.1	**20.4**	36.0	73.7	70.1	81.6	68.2	50.0	29.7	15.6	19.1	508.1	379.6
1959	25.6	21.1	38.3	61.6	78.5	97.8	81.8	77.0	59.4	49.2	21.9	16.7	628.9	456.1
1960	15.2	25.3	35.8	49.3	80.4	77.4	66.7	57.2	49.9	32.1	24.4	18.7	532.4	380.9
1961	18.0	15.0	55.0	69.8	50.7	73.7	62.2	51.7	56.3	34.0	12.0	12.0	510.4	364.4
1962	18.0	12.0	24.0	63.7	**39.2**	65.8	59.4	62.6	50.3	**22.0**	20.0	9.0	446.0	341.0
1963	**4.5**	4.6	34.5	63.7	53.7	84.1	88.1	92.2	40.9	29.0	36.7	10.2	542.2	422.7
1964	13.8	23.8	22.1	65.8	74.8	89.9	109.9	75.4	80.7	41.5	20.3	15.7	633.7	496.5
1965	17.0	15.6	34.3	54.9	54.3	65.7	76.6	95.8	72.3	39.7	23.3	24.8	574.3	419.6
1966	8.9	16.7	42.2	54.7	78.3	90.0	68.7	65.2	64.1	38.0	23.1	28.8	578.7	421.0
1967	20.2	34.4	58.8	65.9	90.4	88.4	87.4	72.8	55.3	48.1	20.2	22.3	664.2	460.2
1968	15.5	16.9	62.9	69.8	64.4	93.8	95.3	82.7	43.1	29.2	18.3	8.9	600.8	449.1
1969	13.3	17.2	30.2	58.4	80.1	82.4	101.4	86.1	60.0	38.2	**38.3**	4.6	610.2	468.4
1970	8.1	14.7	25.1	50.7	71.1	88.2	99.7	60.7	64.2	26.7	24.3	12.6	546.1	434.6
1971	9.9	12.5	27.7	51.7	74.6	**55.7**	87.9	110.0	48.5	46.8	23.3	17.5	566.1	428.4
1972	11.4	15.1	68.7	49.6	63.3	73.0	75.7	62.5	**34.6**	25.1	31.6	14.1	524.7	358.7
1973	6.7	18.7	39.6	57.6	64.7	73.7	72.0	101.0	72.4	28.8	36.2	18.2	589.6	441.4
1974	15.9	19.5	57.1	82.0	58.2	60.7	67.3	64.3	54.6	25.9	19.8	20.8	546.1	387.1
1975	24.0	17.4	36.2	56.2	65.7	74.4	75.1	89.5	63.8	25.2	18.9	26.2	572.6	424.7
1976	22.5	13.2	31.1	63.8	84.5	92.3	96.5	64.7	37.6	23.4	14.9	10.7	555.2	439.4
1977	8.3	11.4	33.7	41.2	62.2	65.0	62.9	**37.4**	38.9	24.3	27.8	13.3	**426.4**	307.6
1978	14.3	14.2	44.0	48.2	58.2	72.4	71.0	58.1	52.4	22.1	17.3	10.5	482.7	360.3
1979	6.1	12.1	37.5	47.0	99.9	87.8	78.1	85.0	57.3	38.5	17.3	22.6	589.2	455.1
1980	7.6	11.3	36.2	42.5	67.3	77.9	**56.6**	63.5	45.4	41.1	22.5	20.8	492.7	353.2
1981	16.5	21.3	40.0	59.4	78.6	79.1	64.5	70.0	40.2	30.7	27.2	10.1	537.6	391.8
1982	11.5	12.9	45.2	54.6	65.5	74.7	79.4	113.8	77.7	48.9	25.7	18.2	628.1	465.7
1983	35.5	15.3	44.1	71.6	72.8	90.1	141.9	106.5	90.9	**59.0**	22.3	21.3	771.3	573.8
1984	34.1	24.1	49.3	59.7	61.4	75.7	73.3	91.2	50.7	53.1	29.3	12.6	614.5	412.0
1985	9.4	15.6	35.7	54.2	79.1	58.1	84.0	67.9	56.6	28.9	22.0	20.5	532.0	399.9
1986	22.0	7.1	41.3	52.4	83.2	83.1	80.7	50.2	41.5	40.4	22.9	17.9	542.7	391.1
1987	6.2	14.6	32.9	56.1	60.3	57.2	82.0	72.0	50.8	42.0	17.2	17.4	508.7	378.4
1988	19.2	24.4	32.1	80.6	**119.7**	68.6	95.2	83.9	48.6	43.4	22.9	30.2	668.8	496.6
1989	25.0	30.3	65.8	62.7	91.2	68.2	84.5	99.5	58.5	52.3	14.2	24.9	677.1	464.6
1990	29.9	**53.5**	81.9	63.0	119.2	79.1	139.4	111.7	50.8	53.2	22.1	15.4	819.2	563.2

Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I–XII	IV–IX
1991	26.4	14.7	45.0	65.6	68.3	78.8	106.7	106.8	**94.9**	45.5	23.9	16.9	693.5	521.1
1992	20.6	27.3	52.5	76.6	118.3	**139.0**	140.2	**147.0**	82.9	44.0	31.9	10.7	**891.0**	704.0
1993	**44.2**	13.2	40.0	87.6	104.2	94.0	90.2	96.4	60.1	40.7	**10.7**	33.5	714.8	532.5
1994	30.3	17.6	53.6	69.0	79.4	108.7	**187.5**	131.3	58.3	38.2	33.7	23.9	831.5	634.2
1995	24.5	36.5	59.7	**91.7**	88.1	69.7	139.1	106.6	42.2	31.8	14.0	6.1	710.0	537.4
Mean	*18.3*	*19.7*	*40.8*	*60.5*	*75.6*	*81.0*	*89.0*	*80.1*	*57.1*	*37.3*	*23.0*	*17.8*	*600.2*	*443.3*

formulae (Bryś 2000), the results with Brys's formula were adopted as the basis for determining monthly, half-year and annual sums for the years 1946–1960, as better estimating the values measured in the years 1961–2000.

The basic statistics for the analysed parameters were determined (arithmetic mean, min., max., range, standard deviation, variability coefficient, skewness and kurtosis). Graphs were used to present year-to-year variability in the annual, half-year and monthly E sums and the way they were conditioned (here, only in the case of annual sums) by the factors controlling evaporation (d, v, G). Multi-year trends were determined mathematically with the aid of linear and polynomial trends of the 3rd and 6th orders, and mutual comparisons, both of trends and of styles of variability (i.e. analyses of geometrical forms and the character of their variability in graphical, linear records of time series runs) of the studied parameters, were carried out. The "variability of variability"[2] was taken into consideration and multi-year intervals of relative stabilization and extinction of amplitude fluctuations were distinguished and contrasted with the periods of increased fluctuational dynamics. Along with year-to-year value analysis there were also appropriate studies carried out on the courses and trends for 2- to 40-year consecutive values, (for the needs of the new, so-called R^2 method of intermediate research into periodicity – description in the next chapter), revealing the consecutive 11-year mean as the basic one for E, d, v, and G as well as for the macro-type (Osuchowska-Klein 1978, 1991) of summer (V–VIII) cyclonic circulation (CC). In order to examine periodicity, spectral analysis employing the WFT (Windowed Fourier Transform), was used. The whole was considered in the context of multi-year circulatory changes in Poland (Boryczka et al. 1992, Kożuchowski 1995; Kożuchowski, Marciniak 1986; Osuchowska-Klein 1987; Trepińska 1992, 1996) and in their regional depiction (Dubicka 1994; Pyka 1991).

Last, the obtained trends and rhythms were subjected to verification on the material of 3 calculated, alternative series of E sums for the years 1946–1995 from Wrocław–Swojec: 1) with the Bac formula (the years 1946–1960) and measurement data (1961–1995) – together, as one series; 2) only with the Bac formula (1946–1995); 3) only with the Bryś formula (1946–1995).

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[2] The "variability of variability" is the rate $|\Delta|/|\overline{\Delta}|$, where $|\Delta|$ is the absolute value of year-to-year variations and $|\overline{\Delta}|$ the mean value of absolute values of year-to-year variations.

INVESTIGATION OF PERIODICITY

The best authoritative, mathematically-reliable analyses of rhythmic fluctuations are based on the Fourier transform (Box, Jenkins 1970; Ghil, Yiou 1997; Lau, Weng 1995). Spectral methods demand long time series according with the period of a searched rhythm. The series should represent a multiple of the period. The longer the time series, the greater the chance of finding or excepting the presence of a climatic rhythm.

The 50-year evaporation series investigated by the authors, gives the possibility of detecting by means of spectral analysis climatic rhythms of several years at most. Other methods used in the work were not based on harmonic analysis, giving only an approximate, initial recognition of the possibility of periodicity occurring. Therefore the results of their application in the relatively short time series 1946–1995 can only give less or more probable hypotheses as to the existence of revealed rhythms.

Non-harmonic methods of approximate research into periodicity applied in the paper make use of the effect of geometric repetition and some regularity in temporal-spatial replications of the macroforms of graphical notation (on linear graphs) of time series and also the importance of the differentiation of the extreme levels for several-year means (the most frequent of 3–5-year for cycles from 7-year to interdecadal) in succeeding, regular (or quasi-regular), characteristic portions of the investigated period, which are identified with a considered cycle (Brys 1998b). The comparison (by T- and F-test) of those extreme mean values with appropriate values for their linear trend, determines the answer to a question as to whether the means are significantly rhythmical. In a instance in which the trend is weakly oblique it is possible to compare the series for max with that for min from succeeding cycles of an analysed rhythm. It is imperative for those series of comparisons to have at least 3 values (for strong rhythms with a high amplitude) or appropriately more (for fainter ones) but this limits the possibility to investigate longer or feebler rhythms in the event of time series being relatively short.

In the intermediate research the best issue entails the employing of a combination of several methods. For this reason, above-mentioned method is preceded by the analyses of consecutive means and graphical records of polynomial smoothings that are optimally fitted to the investigated time series runs. For the polynomial fitting, consideration was given to two criteria: 1) R^2, i.e. the value of the determination coefficient for a smoothing function (the nearer to 1 the better the fit); 2) the demanded order of the polynomial.

It was accepted that the use of a polynomial of order n needs a time series of at least $2(n+1)$ years to adhere to the requirement of minimal multiplicity for the length of a time series in relation to the minimal number of points which are needed for a polynomial description. The option of 6th-order polynomials (with orders 3 to 5 used sometimes for comparison) was dictated by a compromise

between the needs to use the best fitting function and to take account of the length of the investigated time series and separated sub-periods within them (Fig. 2). Next, the necessity to retain a synthesis as regards directions of changes was the reason for all polynomial trends to be seen in relation to linear trends that were global (of the 50th years) and partial (for analysed sub-periods).

The new method for the detection of periodicity, as proposed by the authors of this paper, employs R^2 values from a polynomial smoothing of consecutive runs of means (Figs 8, 9a). Paradoxical use is made of the fact that a smoothing of the time series by means of consecutive means makes it impossible detect to rhythms with a cycle that is equal to the period being the base of a consecutive mean (Gregory 1967). Consequently, advantage is taken of an initial principle that polynomial curves of higher orders (from the 4th to the 6th), which smooth consecutive mean runs, should give relatively the best (in a local area of the sequence of succeeding consecutive means) (Fig. 8) or relatively the worst (Fig. 9a) fit in the case in which a sought cycle is equal to the period that is the base of a consecutive mean. Local concordance (max) or lack of conformity (min) in the phase of a smoothing function determines the appearance of such a local, distinct maximum or minimum of fit. The effect has a local character and its credibility is limited in respect of time, because the using of succeeding, higher basic periods of consecutive means, by their nature brings a better and better fit (as means tend towards equality) with the results that the information value inevitably approaches a "white noise". The best results (information range and evidential force) bring here a comparison of smoothing by means of all the 3 aforementioned functions (Fig. 9a). Therefore the R^2 of the curves becomes a key allowing for the intermediate, initial detecting or rather well-founded signalling of symptoms of "latent" periodicity. Of course, both of the similarly useful methods mentioned and used in the work only allow for the finding of more arguments to hypotheses which must be established over a properly-long time series by means of more precise modern methods of harmonic analyses (compare: Fortuniak 1999).

DISCUSSION

In the years 1946–1995 (Tab. 1) evaporation in Wroclaw reached a mean value of 600.2 mm for annual sums and 443.3 mm for the vegetation period (IV–IX). On average, E sums for the summer half-year are 73.9% of annual sums. A scatter graph with histograms (Fig. 1) shows a very strong linear trend of that mutual, basic statistical relation and some similarity to the structures for those sums (relatively stronger scattering of evaporation totals only in the range of the several highest ones). Extreme values were recorded in 1977 (min – 426.4 mm for annual sums and 307.6 mm for summer period) and in 1992 (max – 891.0 mm

Tab.2. The basic statistics for E [mm], d [hPa], v [m/s], G [MJ/m^2] in the years 1946–1995 and tests F for variances I (1946–1964), II (1965–1976), III (1977–1995) and tests T for mean values I (1946–1964), II (1965–1976), III (1977–1995).

Function	E I–XII	$|\Delta|$	E IV–IX	$|\Delta|$	d I–XII	$|\Delta|$	v I–XII	$|\Delta|$	G I–XII	$|\Delta|$
Mean	600.2	75.7	443.3	61.1	3.8	0.5	3.8	0.3	3756.4	194.9
Min	426.4	4.4	307.6	1.1	2.9	0.0	2.7	0.0	3257.7	3.5
Max	891.0	197.5	704.0	182.9	6.1	1.5	5.3	1.2	4212.2	582.6
Range	464.6	193.1	396.4	181.8	3.2	1.5	2.6	1.2	954.5	579.1
St dev	95.1	48.6	74.7	44.9	0.8	0.4	0.8	0.3	219.3	156.0
Var coeff	0.2	0.6	0.2	0.7	0.2	0.7	0.2	1.0	0.1	0.8
Skewness	1.0	0.5	1.2	0.8	1.1	0.8	0.1	1.5	0.0	0.9
Kurtosis	1.3	−0.5	2.3	0.4	0.7	0.3	−1.3	2.1	−0.5	0.0
Var 46–95	9046.1	2359.6	5577.2	2018.3	0.6	0.1	0.6	0.1	48088.9	24335.9
Var 46–64	4147.6	1200.6	2550.8	882.1	0.1	0.1	0.5	0.1	37278.0	35852.9
Var 65–76	1336.2	679.4	915.7	796.5	0.1	0.0	0.0	0.1	26767.6	15267.9
Var 77–95	17157.9	2980.2	10792.6	2892.1	0.7	0.2	0.1	0.1	63552.9	19294.3
F I/II	0.060	0.339	0.087	0.886	0.599	0.131	**0.000**	0.606	0.584	0.153
F II/III	**0.000**	0.016	**0.000**	0.034	0.003	0.003	0.055	0.884	0.146	0.707
F I/III	**0.004**	0.067	**0.004**	0.018	0.002	0.044	**0.000**	0.665	0.267	0.202
T I/II	0.475	**0.015**	0.445	0.118	0.437	0.261	0.276	0.156	**0.005**	0.181
T II/III	**0.034**	0.000	0.052	**0.001**	0.000	0.045	**0.000**	0.360	**0.038**	0.396
T I/III	**0.037**	0.008	0.051	**0.008**	0.000	0.022	**0.000**	0.072	0.283	0.120

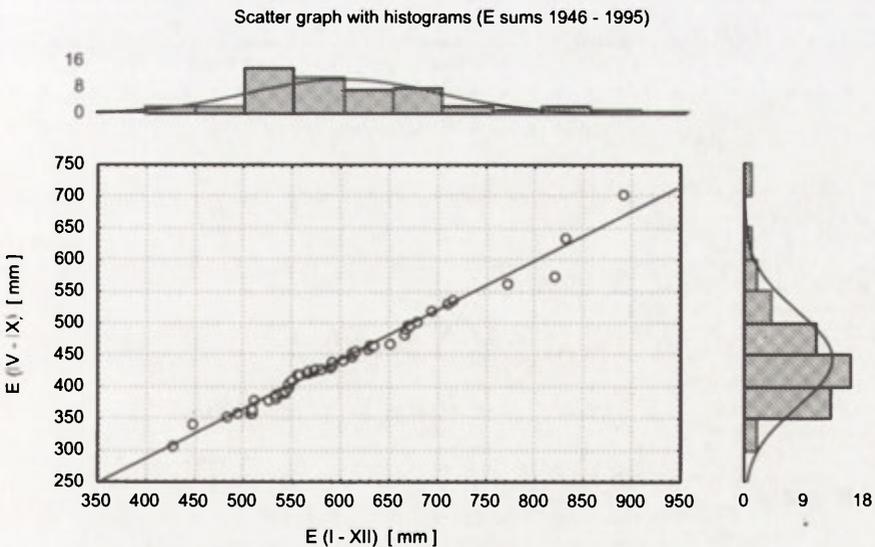The absolute value of year-to-year variations = $|\Delta|$.

Figure 1. Scatter graph with histograms of E sums for period IV–IX (across) and I–XII (along) at Wrocław–Swojec Observatory in the years 1946–1995.
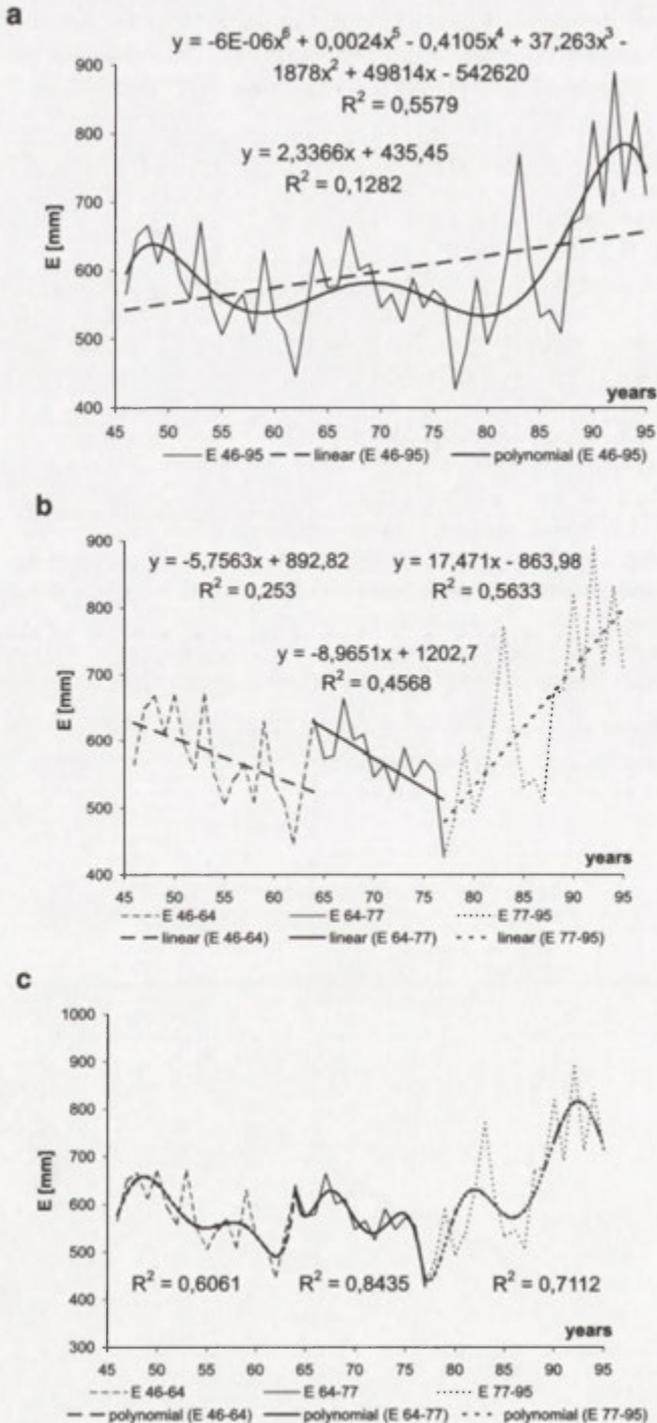
Figure 2. The courses of annual sums of evaporation (*E*) at Wroclaw–Swojec Observatory
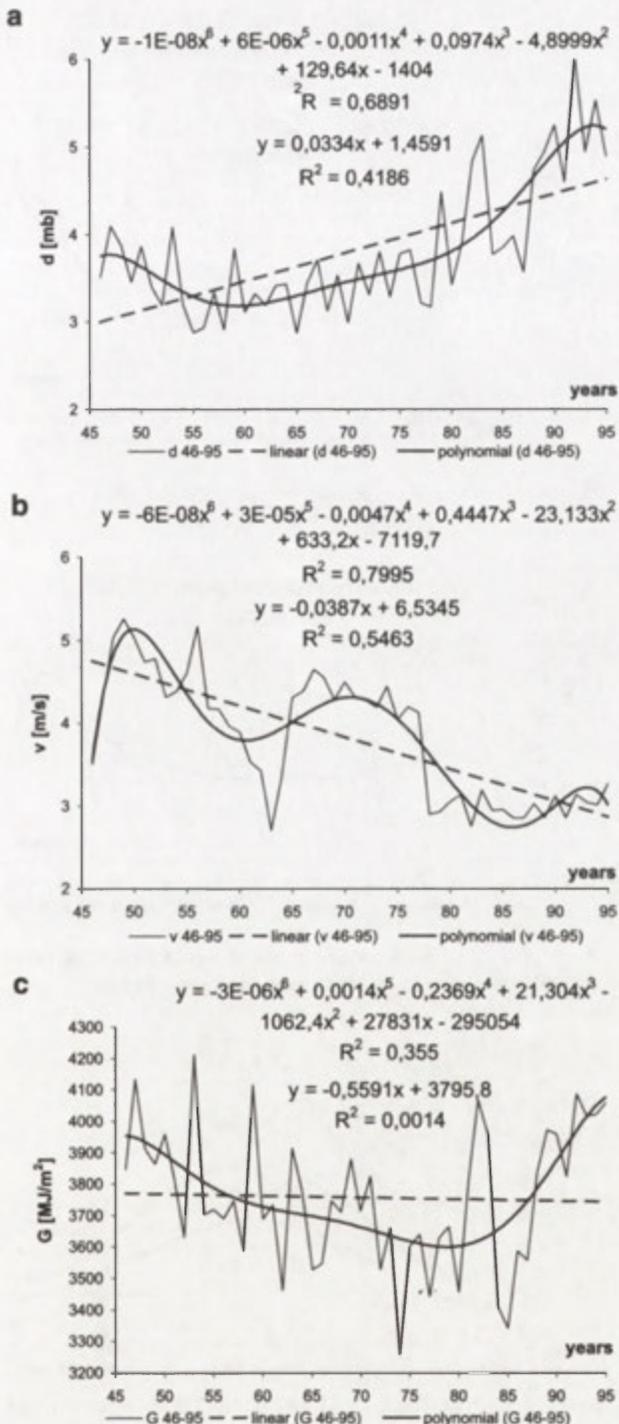in the years 1946–1995 and their trends (polynomial of 6th order).

a

$$y = -1E\text{-}08x^6 + 6E\text{-}06x^5 - 0{,}0011x^4 + 0{,}0974x^3 - 4{,}8999x^2 + 129{,}64x - 1404$$
$$R^2 = 0{,}6891$$
$$y = 0{,}0334x + 1{,}4591$$
$$R^2 = 0{,}4186$$

d [mb]

years

45 50 55 60 65 70 75 80 85 90 95

—— d 46-95 — — linear (d 46-95) —— polynomial (d 46-95)

b

$$y = -6E\text{-}08x^6 + 3E\text{-}05x^5 - 0{,}0047x^4 + 0{,}4447x^3 - 23{,}133x^2 + 633{,}2x - 7119{,}7$$
$$R^2 = 0{,}7995$$
$$y = -0{,}0387x + 6{,}5345$$
$$R^2 = 0{,}5463$$

v [m/s]

years

45 50 55 60 65 70 75 80 85 90 95

—— v 46-95 — — linear (v 46-95) —— polynomial (v 46-95)

c

$$y = -3E\text{-}06x^6 + 0{,}0014x^5 - 0{,}2369x^4 + 21{,}304x^3 - 1062{,}4x^2 + 27831x - 295054$$
$$R^2 = 0{,}355$$
$$y = -0{,}5591x + 3795{,}8$$
$$R^2 = 0{,}0014$$

G [MJ/m²]

4300
4200
4100
4000
3900
3800
3700
3600
3500
3400
3300
3200

years

45 50 55 60 65 70 75 80 85 90 95

—— G 46-95 — — linear (G 46-95) —— polynomial (G 46-95)

Figure 3. The courses of annual sums (or mean values) of *d*, *v*, *G* at Wrocław–Swojec Observatory in the years 1946–1995 and their trends (polynomial of 6th order).
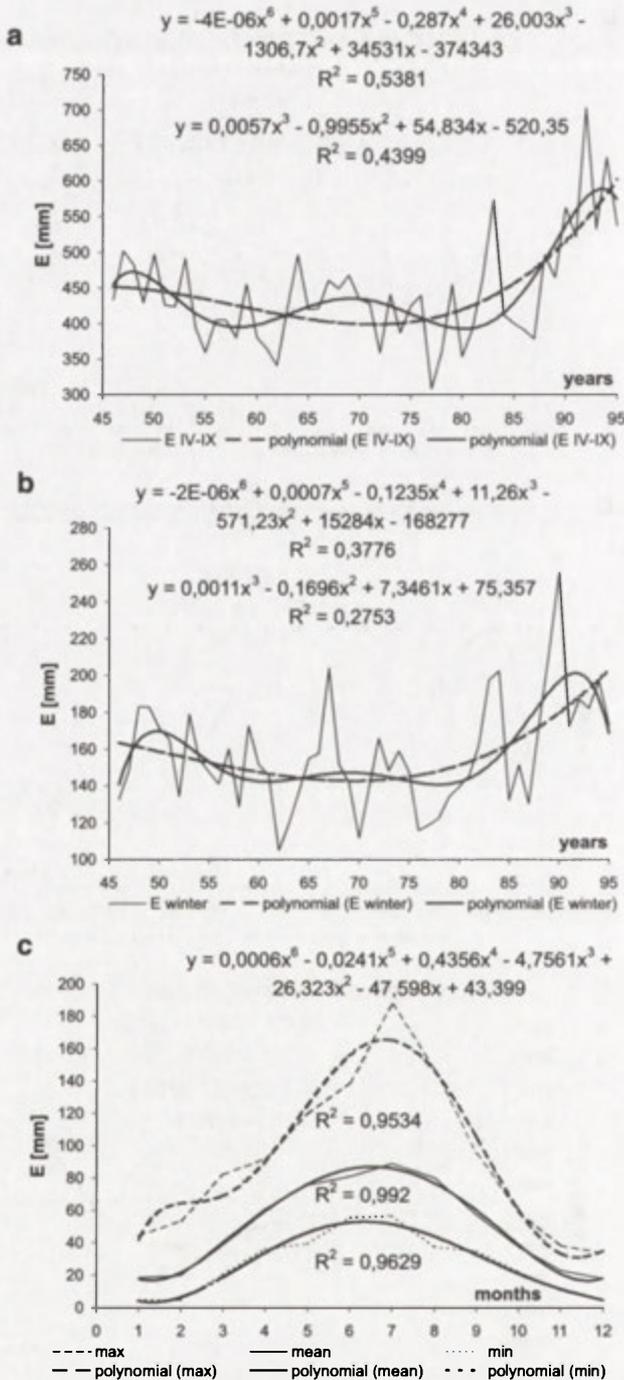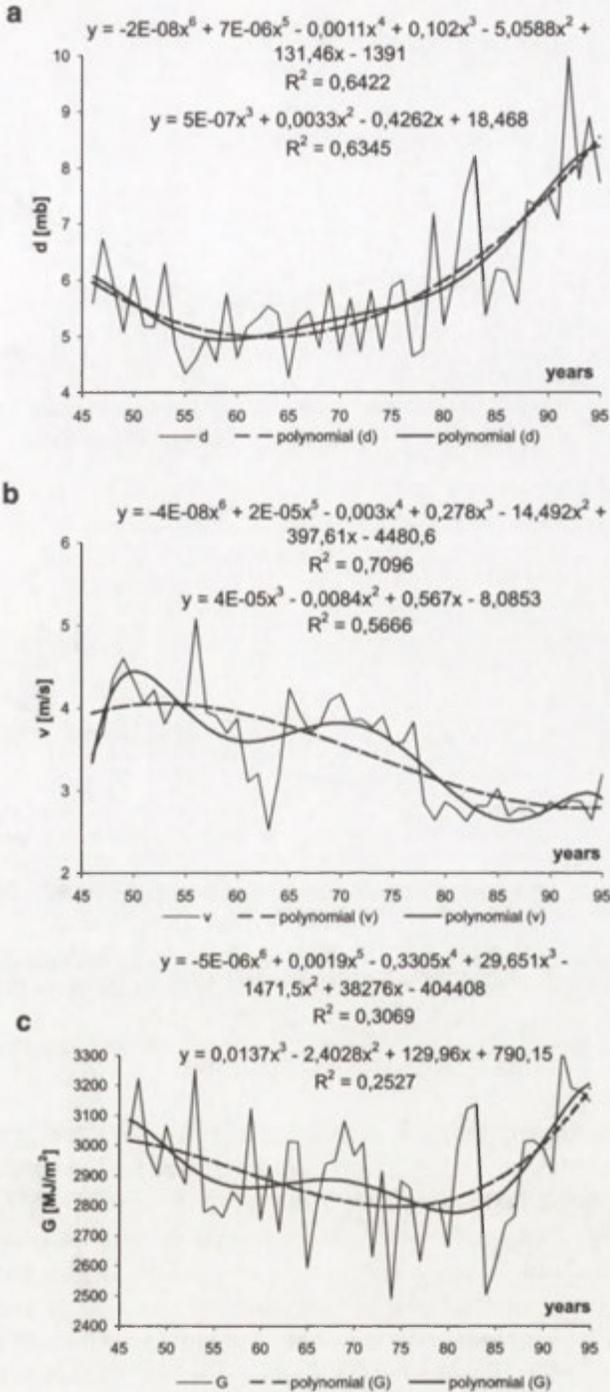
a

$$y = -4E-06x^6 + 0,0017x^5 - 0,287x^4 + 26,003x^3 -$$
$$1306,7x^2 + 34531x - 374343$$
$$R^2 = 0,5381$$

$$y = 0,0057x^3 - 0,9955x^2 + 54,834x - 520,35$$
$$R^2 = 0,4399$$

—— E IV-IX — — polynomial (E IV-IX) —— polynomial (E IV-IX)

b

$$y = -2E-06x^6 + 0,0007x^5 - 0,1235x^4 + 11,26x^3 -$$
$$571,23x^2 + 15284x - 168277$$
$$R^2 = 0,3776$$

$$y = 0,0011x^3 - 0,1696x^2 + 7,3461x + 75,357$$
$$R^2 = 0,2753$$

—— E winter — — polynomial (E winter) —— polynomial (E winter)

c

$$y = 0,0006x^6 - 0,0241x^5 + 0,4356x^4 - 4,7561x^3 +$$
$$26,323x^2 - 47,598x + 43,399$$

$R^2 = 0,9534$

$R^2 = 0,992$

$R^2 = 0,9629$

- - - - max   —— mean   ⋯⋯ min
— — polynomial (max) —— polynomial (mean) · · · polynomial (min)

Figure 4. The courses of half-year sums (IV–IX, winter) and extreme (max, min) and mean monthly sums of evaporation (*E*) at Wrocław–Swojec Observatory in the years 1946–1995 and their trends (polynomial: dashed line = of 3-rd order, solid line = of 6-th order. Only in lower graph all polynomials of 6th order). Equation in lower graph refers to mean values run.

a

$$y = -2E{-}08x^6 + 7E{-}06x^5 - 0{,}0011x^4 + 0{,}102x^3 - 5{,}0588x^2 + 131{,}46x - 1391$$
$$R^2 = 0{,}6422$$

$$y = 5E{-}07x^3 + 0{,}0033x^2 - 0{,}4262x + 18{,}468$$
$$R^2 = 0{,}6345$$

b

$$y = -4E{-}08x^6 + 2E{-}05x^5 - 0{,}003x^4 + 0{,}278x^3 - 14{,}492x^2 + 397{,}61x - 4480{,}6$$
$$R^2 = 0{,}7096$$

$$y = 4E{-}05x^3 - 0{,}0084x^2 + 0{,}567x - 8{,}0853$$
$$R^2 = 0{,}5666$$

$$y = -5E{-}06x^6 + 0{,}0019x^5 - 0{,}3305x^4 + 29{,}651x^3 - 1471{,}5x^2 + 38276x - 404408$$
$$R^2 = 0{,}3069$$

c

$$y = 0{,}0137x^3 - 2{,}4028x^2 + 129{,}96x + 790{,}15$$
$$R^2 = 0{,}2527$$

Figure 5. The courses of half-year (IV–IX) sums (or mean values) of *d*, *v* and *G* at Wrocław–Swojec Observatory in the years 1946–1995 and their trends (polynomial: dashed line = of 3rd order, solid line = of 6th order).

a

b
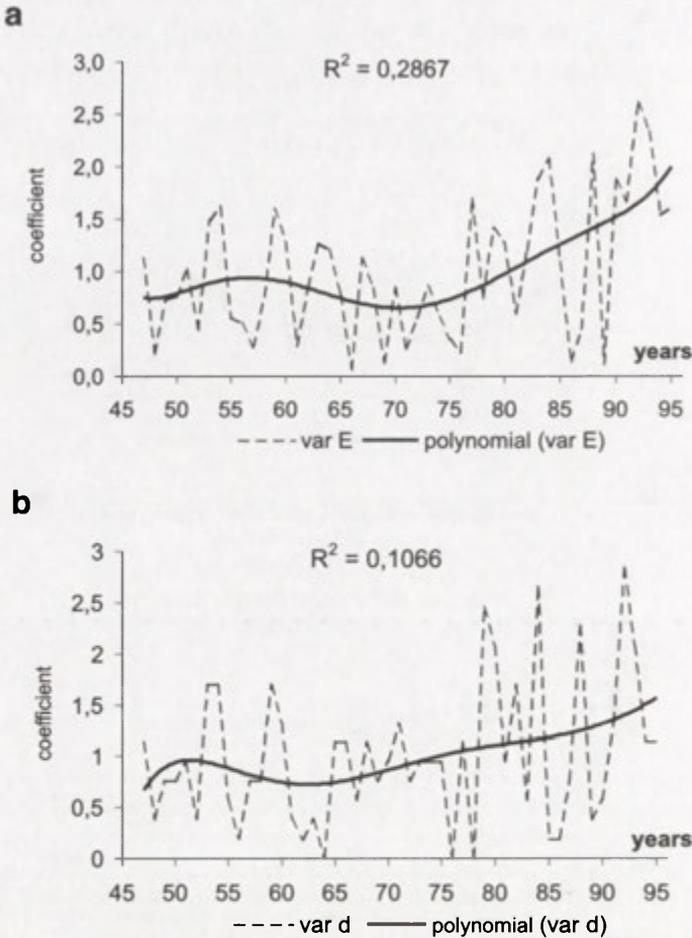
Figure 6. The runs and the trends (polynomial of 6th order) for the year-to-year variation
indicators (var = coefficient = $|\Delta|/|\overline{\Delta}|$)) of E, d, v, G in the years 1946–1995
at Wroclaw–Swojec Observatory

and 704.0 mm, respectively). Remaining basic statistics are given in Table 2
(compare: Bac 1968, 1970; Brys 1997, 1998a; Szczepankiewicz-Szmyrka 1981).

Figure 2 shows a distinct upward linear trend ($R^2 = 0.13$) for E and its rhyth-
mic, partial (Fig. 2b, c) and overall, linear and polynomial projections. A fluctu-
ation rhythm of about 21–23-years smoothed by the 6th degree curve (Fig. 2a) is
forced by the main culminations and decreases of multi-years annual E sums to
the location of which, with some time shift (smoothing effect), it corresponds.

The three deepest decreases of the E value were characteristic of 1962 (446.0
mm), 1977 and the not included in this study 1996 (481.9 mm), followed by
a sudden increase in annual E sums. These constitute marked caesuras dividing
the analysed 50 years into 3 different, characteristic periods of type of variability

c

d
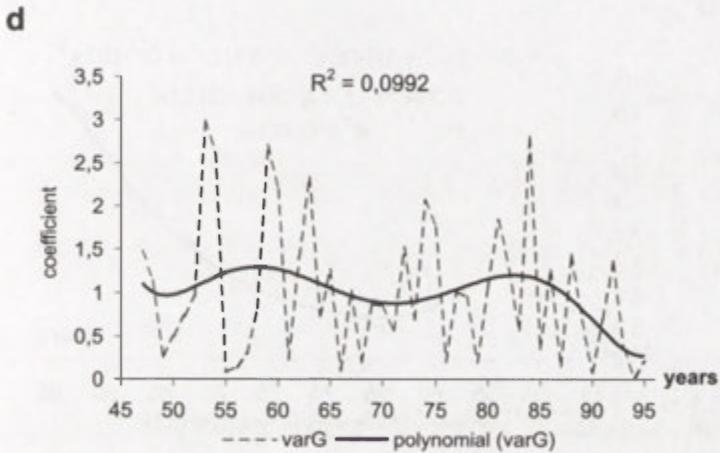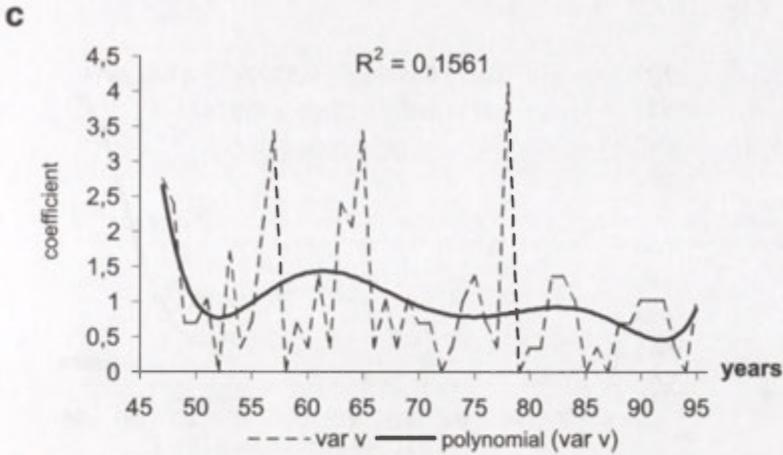
to the multi-year course of evaporation in Wroclaw. The years 1964–1976 – 1963 is transitional in character – (period II) are characterized by a decided extinction of fluctuations, with episodes of "inactivation" and the appearance of mean E values which gradually go down ($R^2 = 0.46$ for the linear trend). The opposed periods – the preceding period I (covering 1946–1962(63)) and the following period III (1977–1995), are also different from each other. The intensification of fluctuations, so characteristic for these two, is strongest in period III, where it occurs by turns among the lowest and the highest values (1989–1995), according to a decidedly upward trend ($R^2 = 0.56$ for the linear trend). Within period III there is also a 3-year episode of amplitude extinction (years 1985–1987) identi-fied (Fig. 9b) with the border years of successive periods (1976–1986 and 1986–1996) of Wolf's number manifestations, i.e. 11-year solar activity. It is worth recalling earlier ranges of this periodicity here (1944–1954, 1954–1964, 1964–

a

$$y = -7E\text{-}06x^6 + 0{,}0029x^5 - 0{,}5322x^4 + 51{,}472x^3 - 2774{,}6x^2 + 79035x - 928742$$
$$R^2 = 0{,}956$$

E [mm]

700, 680, 660, 640, 620, 600, 580, 560, 540, 520

years

45 50 55 60 65 70 75 80 85 90 .95

- - - - E11 ——— polynomial (E11)

b

$$y = -3E\text{-}09x^6 + 1E\text{-}06x^5 - 0{,}0002x^4 + 0{,}0197x^3 - 0{,}9373x^2 + 22{,}759x - 211{,}64$$
$$R^2 = 0{,}9896$$

d[hPa]

5, 4,8, 4,6, 4,4, 4,2, 4, 3,8, 3,6, 3,4, 3,2, 3

years

45 50 55 60 65 70 75 80 85 90 95

- - - - d11 ——— polynomial (d11)
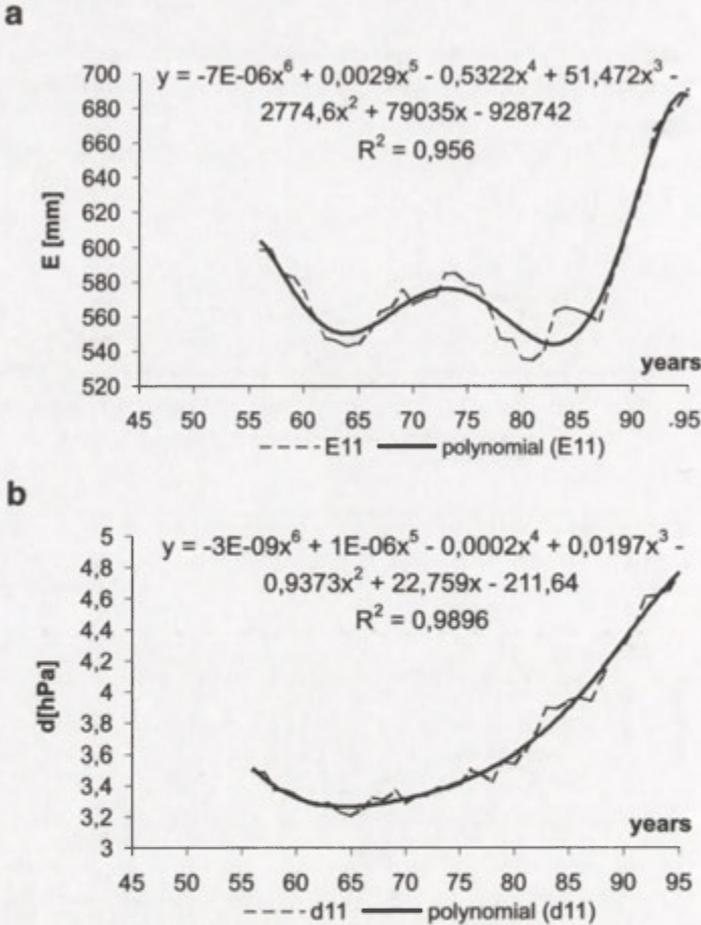
Figure 7. The runs and the trends (polynomial of 6th order) for 11-year consecutive mean annual values of E, d, v and G in the years 1946–1995 at Wrocław–Swojec Observatory.

1976) and comparing them with the 11- and 21–23 year rhythms in consecutive mean values of E (Fig. 9a, b) detected by the authors of the paper and also with the very distinct horizontal trend of so-called balance points (in Fig. 9b – the circular signs of Rh 11) for the 11-year rhythms in order to see a strong link in the different years screened to various degrees by circulation factors linking multi-year evaporation fluctuations with the Sun's cyclical activity.

The rightness of dividing evaporation variability into the three above men-, tioned periods is confirmed by statistical tests (Tab. 2): F – to establish the significance of variation differences for these periods, and the T test – to compare the significance of differences in arithmetic means of E, at the 95 % confidence level. A similar testing carried out for the basic factors controlling evaporation – d, v, G reveals a considerable conformity of results except in the case of G, an

c

$$y = -1E-07x^6 + 5E-05x^5 - 0,009x^4 + 0,8974x^3 - 50,174x^2 + 1483,4x - 18112$$

$$R^2 = 0,9932$$

V [m/s]

years

45 50 55 60 65 70 75 80 85 90 95

- - - - V11 ——— polynomial (V11)

d

$$y = -4E-06x^6 + 0,0015x^5 - 0,2679x^4 + 25,025x^3 - 1299,6x^2 + 35554x - 395998$$

$$R^2 = 0,9481$$

G [MJ/m²]

years

45 50 55 60 65 70 75 80 85 90 95

- - - - G11 ——— polynomial (G11)
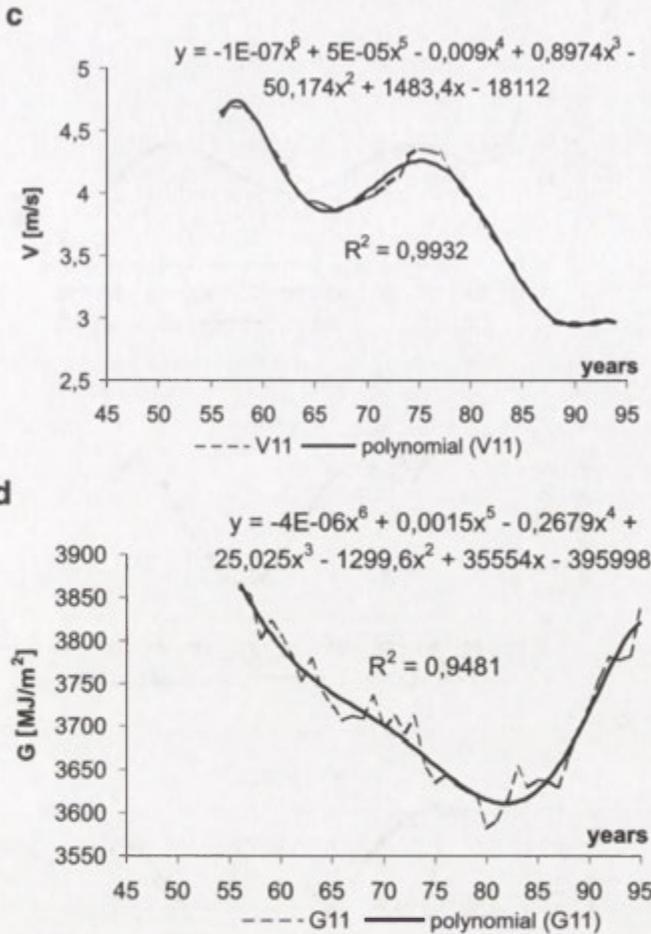
observation which probably results from a certain inadequacy of the distinguished ranges to *G*. These ranges are related to the sensitivity which is different with different meteorological factors (as reflected in the types of fluctuation) and to a phase shift of consequences in the reception of initial climatic signals – solar and circulatory.

The R^2 method of the intermediate detecting of periodicity shows (Fig. 9a) a very distinct 16-year cycle, most likely with circulation genesis (Fig. 8). The aspect of periodicity will be discussed more widely in the latter part of the chapter. Here, we only take notice of fact that the effect of the circulation factor (Figs 8, 9a, b, c) is spectacularly exhibited in the exposure of a 16-year middle range (II) not only in runs for *E* (Figs 2, 4) but also in those for *v* (1963–1978), but here (Figs 3b, 5b) there occurs a one-year phase shift in relation to *E*. In turn, in respective runs of *d* (Figs 3a, 5a) the middle range extends to cover 1955(56)
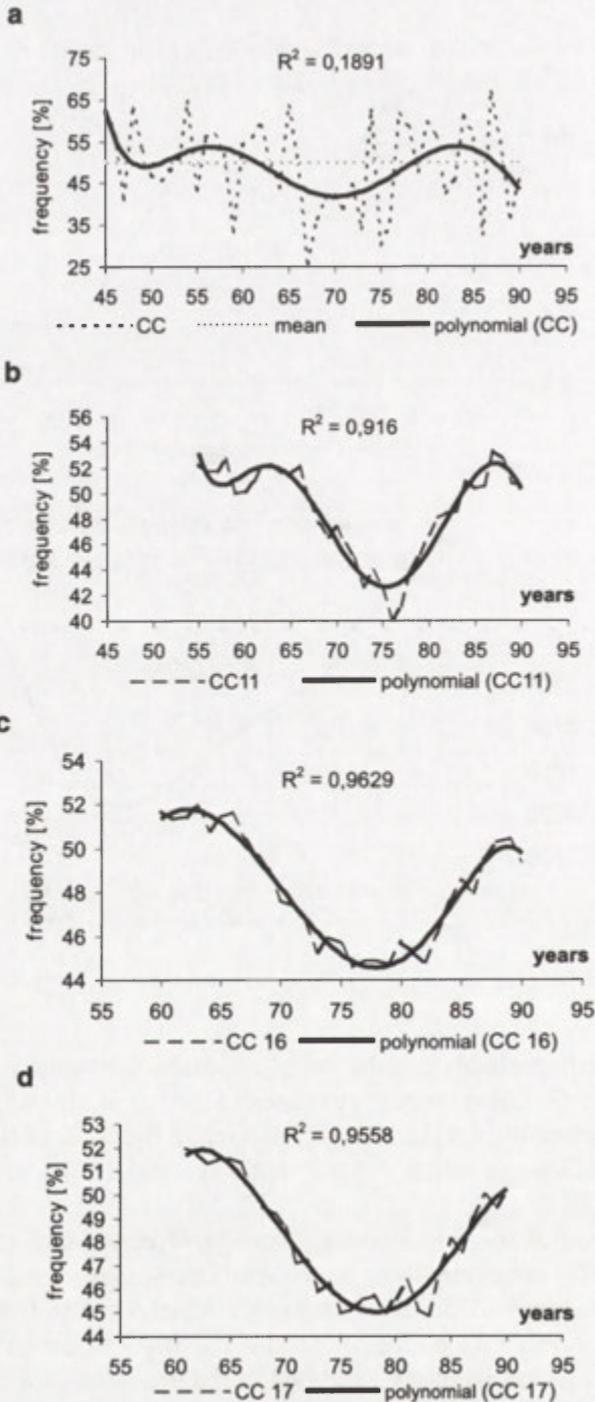
Figure 8. The courses of the frequency of cyclonic circulation macrotype (CC) for the period V–VIII in the years 1945–1990 over Poland and their 11-, 16-, 17-year consecutive mean values with trends (polynomial of 6th order).

–1977(78) and so corresponds primarily to the 21–23-year solar cycle (Figs 9a, b), something which is also indicated by the G run (Figs 3c, 5c). The effect of this last periodicity shapes the rhythm of the 6th order polynomial trend for v distinctly.

The picture of multi-year changes and studied source factors is made up by rhythms both longer than those mentioned (whose presence is probably signalled by polynomial trends of the 3rd order Figs 4, 5), and shorter (conditioned circulatorily as a response of the circulation system to a complex interaction of the atmosphere – hydrosphere – geosphere system on the global, regional and local scales). The 7–8-year rhythms of the latter (e.g. Boryczka et al. 1992) deserve more attention due to their universality. Their existence is most probably projected by the rhythms of the 6th order polynomial curves used in smoothing shorter (16–20 and possibly even up to 30-year) time segments (Fig. 2c). Some arguments for such suggestions are given in the interpretation of results obtained with the R^2 method (Fig. 9a) used by the authors in detecting periodicity. Besides the aforementioned 11, 16 and 21–23-year cycles, the method also discloses a distinct 8-year rhythm and perhaps ones of 25–27 (compare Ghil, Yiou 1997) and 32–33 and 35-year rhythms, though the last ones may be an illusion, being too near to an area of "white noise".

The analysis of the multi-year evaporation course must take into account the fact that it is the resultant of a variable, and in various time scales differing, effect of the basic factors controlling evaporation – d, v, G. For this reason apart from kind (periodicity), it must also consider the type of long- and short-term fluctuations. This requires more detailed studies on year-to-year variability, with the use of various indicators allowing for mutual comparisons. An example of the use of such indicators is, apart from the traditional statistical measures such as the variability coefficient (Tab. 2), the coefficient of year-to-year changes $|\Delta|/|\Delta|$ and its statistical (e.g. in F and T tests) and graphical (Fig. 6) use for the evaluation and comparison of changes in annual sums.

The usefulness of the a. m. techniques and research tools and the necessity for their application can be seen well when we analyse the conditions to multi-year courses of monthly E sums and their trends. However, this problem is beyond the scope of this elaboration. Let us only conclude that months V, VII and VIII in which evaporation reaches (except VI) highest mean values in a year (Fig. 4c), are closest to the relations present in the relevant courses of annual and summer half-year sums (Fig. 4a). They are, however, characterized by a different style of fluctuations. The months of the winter half-year only correspond in their total picture (Fig. 4b) to the basic features of the summer projection because in their separate presentations (Bryś, Bryś 2000) they are very different.

The courses of 11-year variable means for annual sums of the studied parameters (or their mean values) (Fig. 7), and their 6th order polynomial adjustment for E only ($R^2 = 0.96$) and v ($R^2 = 0.99$) show a very strong 21–23-year, most probably periodical, sequence of variability, which corresponds with the 21–23-year
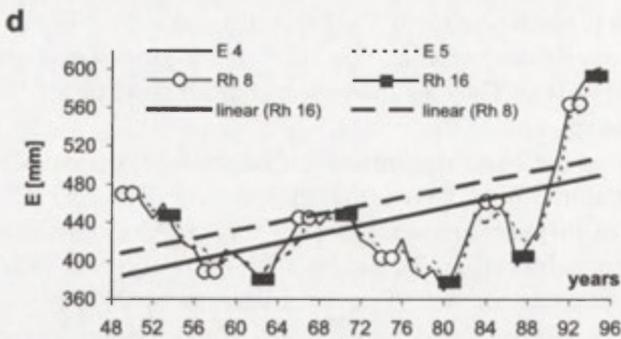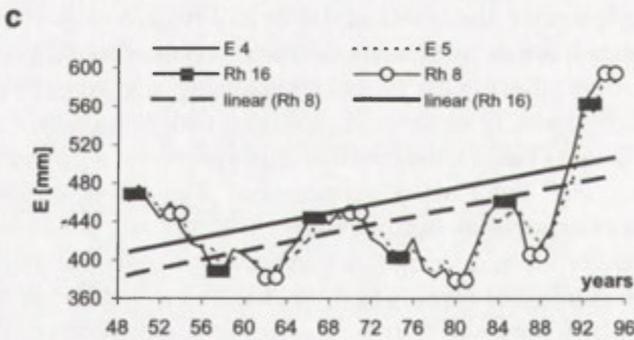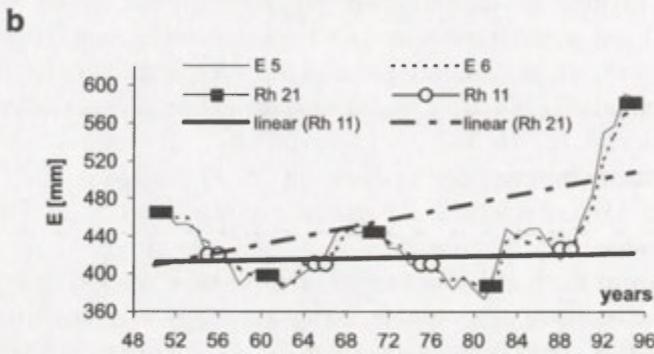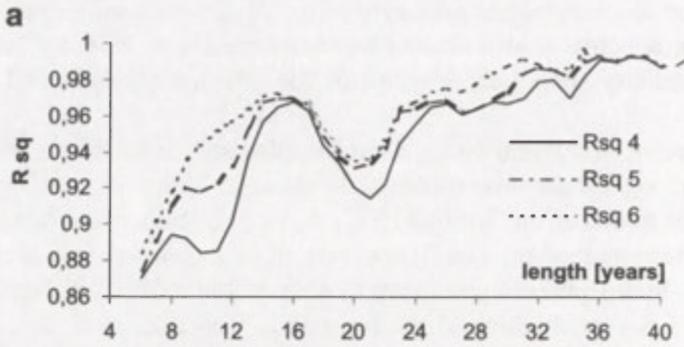
solar cycle. All the analysed cases exhibit the long-term directions of changes presented earlier. It should be added here that the suggested evaporation periodicity of 21–23 years can additionally be supported by the only-partly-published results for evaporation at Swojec for the years 1996–2000 (Bryś 2000), which are well fitted to the prognosticated shape of polynomial curve.

The picture for multi-year evaporation changes analysed over different time scales, is made up by meteorological parameters dependent on large-scale trends and circulatory oscillations. The summer period is decisive for annual evaporation sums and fluctuations of the summer frequency (period V–VIII) of the CC macro-type in 1945–1990 are therefore presented (Fig. 8), in order to combine their tendencies with the trends distinguished for *E* runs. Significantly, the best fitting of the polynomial curve for variable CC means was obtained not in the case of the 11-year consecutive values of this frequency ($R^2 = 0.92$) but for 16-year means ($R^2 = 0.96$). This is probably related to the 16–17-year periodicity of circulatory changes (Boryczka et al. 1992), being projected also in the polynomial rhythm of the 6th order curve, which smoothes the course of the summer CC frequency.

Provisional evaluation of the appearing shorter periodicities was carried out with the use of spectral analysis. The results of periodograms (periods 2.08 and 8.33) were subjected to critical analysis, on account of the relatively short time range taken into account in the analysis. The 2-year periodicity was excluded as too close to Nyquist's border frequency and most probably related to a false shift of a part of a power from the higher frequency (Fortuniak 1999). In contrast, the 8-year cycle shown in periodograms as a strong peak is linked with 7–8-year baric and temperature cycles in NAO and NHST spectra and other climatic oscillations registered in the northern hemisphere (e.g. Boryczka et al. 1992; Kożuchowski 1995, Trepińska et al. 1997), making its actual presence very probable.

The verifying analysis on the material of 3 calculated, alternative series of *E* sums (mentioned at the end of the Methodology chapter) gives in outline similar results and confirms the directions of the obtained trends and periods of rhythms.

Figure 9. The results of intermediate methods of detecting periodicity used in the work:
a) the courses of R^2 (Rsq) values from multiple smoothings by 4th, 5th and 6th order polynomials of runs of consecutive mean values of E (IV–IX) for succeeding lengths (from 6 to 40 years) of the basic period (for calculation of the averages);
b) the delimitation of 11- and 21-year rhythms (Rh) in 5-year (E5) and 6-year (E6) consecutive mean values of E (IV–IX) and linear trends of the rhythms (the trend of Rh11 only for so-called balance points);
c, d) two possible variants of the delimitation of 8- and 16-year rhythms (Rh) in 4-year (E4) and 5-year (E5) consecutive mean values of E (IV–IX) and linear trends of the rhythms.

SUMMARY

Fluctuations of 50-year courses of annual, half-year and monthly evaporation sums were found to be characterized by distinct trends to changes. With the exception of some monthly peculiarities, they are similar. It is possible to distinguish three different periods: 1) years of moderate or slow decrease in E sum values (1946–1963) associated in general with their high or medium-level year--to-year fluctuations, 2) a relatively "stable" turn of the following years in fluctuations, but with a continued downward trend, 3) a time of a strong but unstable increase in E sum values, and their fluctuations post 1977. A period of relative calmness characteristic for turning years, with features of weak continentalism and a prevalence of anticyclonic circulation, is followed by a time of strong oscillations, coupled both with a period of distinct activation of summer cyclonic circulation (1977–1988), and on interval of the domination of summer anticyclonic circulation over Poland (1989–1995). However, cyclonic years are characterized by greater instability of values and are most often linked with low and average-level E sums.

The courses and trends of the base factors controlling evaporation (d, v, G) also show that it is the resultant of the resultant of the variable action force of these three factors.

A strongly marked, increasing tendency for E observed in the last analysed period, is probably an initial fragment of a longer cycle, reflected by current, partial trends for long-term changes. Spectral analysis suggests the occurrence of an 8-year period. The presence of a similar cycle in baric and temperature spectra for the northern hemisphere gives this periodicity a more universal, climatic character. It is possible that its multiplicity is a 16-year cycle of summer CC frequency observable in consecutive means. The 6th order polynomials probably bring out a 21–23-year period of evaporation changes linked to the solar cycle. In turn, 3rd order polynomials may initially indicate the presence of cycles of longer (perhaps 32–35-year) periods, possibly also being a reflection of solar activity and, to some degree, its circulatory transformation. This seems also to be indicated by the trends distinguished in 11-year runs of consecutive values and the results of the so-called R^2 method introduced by the authors. Such a suggestion, however, requires verification with a longer, at least 100-year, measurement material.

The analysis also yields an unequivocal picture of connections between relatively high evaporation values and their gradual decrease in the second half of the 40s, along with the decline of climatic continentalism, so characteristic of Middle Europe in the 30s and 40s of our century, and the transition to an epoch of mixed features. The renewed, fast increase of E values in 1990–1995 need not forecast the return of a longer period of the domination of continental features in Central Europe, as it is linked with relatively strong year-to-year oscillations of the studied parameters which may suggest a dynamic equilibrium in the near

future between oceanic and continental features clashing in the climate of Lower Silesia. On the other hand, one should expect short-term evaporation abatement in the years 2001–2003, something which is characteristic of the "saddle" years in the 21–23-year evaporation cycle suggested by the authors of the paper.

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BOOK REVIEW

Hauptstadt Berlin by Süß Werner (ed.), vol. 1–3, 1681 pp., Berlin Verlag, Berlin 1995, 1996.

This three–volume monograph published in 1995 and 1996 comprises over a hundred papers by authors from the worlds of politics, business, science and journalism, who present their viewpoints concerning the current (the mid–1990s) and prospective development of Berlin. The basic aim of the editor was to discuss a number of specific questions regarding the transformation of Berlin following the unification of Germany. At the same time, the book offers a complex perspective on the development of Berlin, both in its national and international context. The book is to constitute a platform for information exchange and evaluations, showing processes that occur simultaneously though rather independently. This guarantees a variability with respect to the approaches taken (from the conceptual to the purely descriptive), though the price is the less-than-uniform scholarly standards of the individual contributions. Due to its length, diversity – it constitutes a detailed introduction to the debate on the current and future role of Berlin from the perspectives of political, administrative, economic, cultural and spatial change – and, last but not least its complexity, the monograph is quoted in most of the recent publications on Berlin, being at the same time the basic source of scientific information concerning this topic.

Each of the volumes of the monograph comprises numerous studies focusing on various areas of Berlin's transformation.

The first volume (*Nationale Hauptstadt, Europäische Metropole*) refers to the broadest perspective of the transformation – to the international position of Berlin. It touches upon such questions as the position of Berlin as a 'capital of Germany' in Europe, in European infrastructure and in contact networks. It tries to answer questions about the future of Berlin as a European metropolis or even a global city, and the new economic position of Berlin in Central Europe as well as in the EU. The authors find reference to such problems as Berlin becoming the symbol of a new German foreign policy and they trace new paths in the development of the city.

Why the editors decided that the opening volume should concentrate on the broadest perspective, showing Berlin in its European context, is an interesting question in itself. It seems, however, that the decision was a well-thought-out one; the first volume is undoubtedly able to focus the interest of many readers, as it constitutes a part of a wider discussion carried on throughout Europe since 1989 about the new geography of the old continent. Along with papers prepared by German authors, the volume presents three articles written by a Russian scientist, a British journalist and a Czech diplomat, which picture the outer per-

ception of 'the Berlin of today and tomorrow'. These papers are indeed a complement to the topic; and in this light, the lack of a Polish viewpoint would seem to be a major weak point of the volume.

Changing, or narrowing the perspective, the second volume (*Berlin im vereinten Deutschland*) is devoted to internal German questions. It focuses especially on the parliamentary and broader public debate about the new metropolitan status of Berlin, and its character as a new German capital in a country with strongly--imbedded federal traditions. We can see that there was as much enthusiasm as there was fear about the transfer of Parliament and the federal government from Bonn to Berlin. The biggest value of this volume is that it actually recalls important details – as well as the political and social atmosphere – of the debate and discussion of 1991, which culminated in the Resolution of the Bundestag of June 20, 1991. Most probably, the imperative of striking a political compromise with respect to the new German capital in the process of German unification necessitated a change in the character of the argumentation from the material to the symbolic and back again to the material meaning of the status. For this reason, the ultimate role of Berlin as a capital of Germany is defined somewhat incoherently. From the federal point of view Berlin should first and foremost contribute to German unity as another important city with strong regional functions situated in the eastern part of the country; while, from the perspective of political symbolism, Berlin should be credited with the status of *The Capital City*. In the variety of details presented, the studies in this volume constitute a rich and interesting introduction to the complicated questions of the uniqueness of the German state and its capital city, being at the same time a good review of these topics.

According to the assumptions of the editors, the discussion in the closing volume (*Metropole im Umbruch*) concentrates on the internal, domestic problems of the city. It portrays the complexity of the transformation of Berlin, showing the city on its way to becoming an economic region of international importance, and focuses on the main streams of the development of Berlin from the spatial perspective.

The actual value of the monograph lies in the complexity of the topics it discusses. It provides rich information and an interesting interpretation of phenomena which are both natural and breathtaking. The transformation of Berlin is one of the most unique and therefore attractive examples of contemporary urban transformation. It is at the same time an example of the integration of two completely different parts of a city which for over 40 years of the last century were developing in mutual confrontation.

Today, Berlin is a city developing at high speed, gaining more and more importance within the broader region. As it is especially important from the Polish perspective to follow, keep record and analyse these developments, this book constitutes a valuable library addition for the Polish reader and scientist.

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MEASUREMENTS should be given in metric units.

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