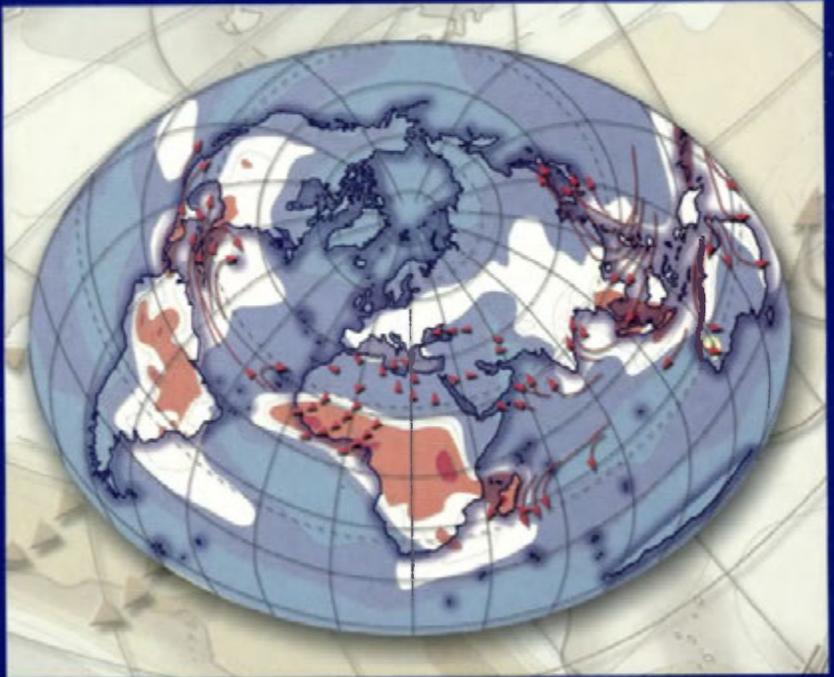


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THE DEVELOPMENT OF THE KNOWLEDGE-BASED ECONOMY IN EUROPE: THE REGIONAL TRAJECTORY

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INTRODUCTION

The best definition of the Knowledge-Based Economy (the KBE) was formulated in a recent OECD and World Bank publication (OECD and 2001): *"This book defines a knowledge-based economy as one where knowledge is created, acquired, transmitted and used effectively by enterprises, organizations, individuals and communities. It does not focus narrowly on high-technology industries or on information and communications technologies, but rather presents a framework for analyzing a range of policy options in education, information infrastructure and innovation systems that can help usher in the knowledge economy. It also makes the case for better co-ordination among the government, the private sector and civil society to enhance competitiveness and advance economic and social development."*

There are many visions of Europe of the 21st century (Bertrand 1999). The KBE is an important element of these visions (Kukliński 2000). Within this framework a very bold statement was formulated (Blair... 2000):

"We are committed to help Europe become the most dynamic knowledge-based economy in the world by 2010 through reforms in capital, product and labour markets."

This prospective political judgement and obligation was formulated by the Prime Ministers of Great Britain, The Netherlands and Sweden and by the German Chancellor. This is a very optimistic interpretation of the power of Europe in the strategic global triangle of the 21st century – Europe-America-Asia. Even if we accept a less-optimistic interpretation, that Europe will not be the most dynamic – but only a very dynamic – Knowledge-Based Economy in the world by 2010 – the challenge for our continent is still immense. At the present

moment there are only five or six countries in Europe (OECD 1999), where the KBE is already a prevailing phenomenon. We can anticipate that, by 2010, this set of countries will have grown to number 15 or 20.

The development of the KBE in Europe is a dramatic and multidimensional challenge. In this paper we will concentrate our attention on the regional trajectory, which to our mind is one of the leading trajectories in the development of the KBE. In this context I have chosen the following thematic construction of this paper:

- Why a regional trajectory?
- The dilemma of spontaneous versus guided development.
- The six dimensions of the regional trajectory: the KBE enterprise, the capital market, the labour market, the system of education, the R & D system, the regional governance system.
- A European Research Programme.
- The four inspirations of the Programme.
- Towards a new vision of a KBE in Europe.
- Towards a new vision of regional policy in Europe.
- The role of the Regional Studies Association.

WHY A REGIONAL TRAJECTORY?

In the ground-breaking paper of G. Eliasson (Eliasson 2001), we find the following intriguing generalization:

“Economic growth can be described at the macro level, but it can never be explained at that level. To understand economic growth, and to design policy we have to take the analysis down to the micro market level where individuals live and firms behave and new innovative technologies are created.”

I think that the macro-versus micro-level dilemma reflects a failure to grasp the complicated nature of the real world. We need to see a third level – the meso-level – i.e. the regional level. This level is creating a powerful framework for the development and promotion of the KBE. Within this framework the most important item is the strategic triangle – the KBE enterprise – the R & D institutions – and Regional Governance. In the conditions of the 21st century, the competitive and innovative region is a direct actor on the global scene (Kukliński 1999). This region can have the capacity and will to develop a strong regional KBE. It is worthwhile analyzing from this point of view the list of 46 regions and cities presented as global hubs of technological innovation (UNDP 2001). Naturally – the concept of the global hub of technological innovation is a much more restrictive concept than the concept of a European KBE region which will emerge in the course of the empirical studies proposed in this paper.

THE DILEMMA OF SPONTANEOUS VERSUS GUIDED DEVELOPMENT

The term “regional trajectory” implies the integration of software and hardware approaches and the integration of guided and spontaneous change. We accept the following definition (Freeman 1992):

“Trajectories are self-fulfilling prophesies based on the ‘actors’, decisions and expectations of the future. Like any institutions, they are sustained, not by ‘naturalness’, but by the interest that develops in their continuance and the belief that they will continue”.

In the global perspective we see two types of emerging regional KBEs. There is a laissez-faire type – accepting the mechanisms of spontaneous change as the most important driving force behind development with California being presented as the most illustrious example (Scott 1998). We have to remember, however, that the case of California was created with very strong participation of the American Military Industrial Complex which is not a particularly laissez-faire institution.

The performance of California can be compared with the experiences of Singapore (Hing Ai Yun 1998). This is a case of successful integration of the mechanisms of the global market and strong, strategically-oriented, long-term planning - in other words – a rather dirigistic approach.

I am convinced that a comprehensive, comparative analysis of the experiences of California and Singapore can generate interesting conclusions for the European KBE Regions facing the dilemma – laissez-faire versus dirigistic development. This dilemma is also visible in a broader comparative analysis – the European KBE versus the US trajectory.

THE SIX DIMENSIONS TO THE REGIONAL TRAJECTORY

The regional trajectory is a deeply-rooted path-dependent economic, social, political and cultural phenomenon. In the context of this paper we will restrict our attention to six crucial dimensions of this trajectory:

- KBE enterprises,
- the capital market,
- the labour market,
- the system of education,
- the system of R & D,
- regional governance.

To my mind a comparative analysis of these six dimensions would create contributions exploring the mechanisms of development of the KBE in Europe.

THE KBE ENTERPRISE

We have to answer a question as to how deeply rooted in European reality the

model of the KBE enterprise is. How to outline the map of European countries and regions in which the KBE enterprise is coming to be a dominant feature of the economic landscape?

Also how to analyse the Knowledge – Enterprise – Knowledge interactive framework? How to define empirical measurement of the phenomenon of an enterprise which is recognizing that knowledge is the foundation of the constant development of competitive advantage? (Eliasson 2001).

THE CAPITAL MARKET

The KBE enterprise can only function in the conditions of a stimulating capital market and especially a venture capital market. To a rapidly growing extent capital market conditions are created by global financial realities. This does not however mean that the reality of the European Union and the realities of the individual European countries have no influence on the capital market at the regional level. In fact – the experience of some other highly-developed regions is indicating that the endogenous power of a region to create a *differentia specifica* in the performance of the capital market can be a major autonomous factor in the development of the KBE.

This is an especially difficult problem, since the venture capital market in Europe is much weaker than that in the US. However some regions in Europe are able to overcome this continental weakness, something which is especially deeply demonstrated by the experiences of Central and Eastern Europe.

THE LABOUR MARKET

The creative human being is the most important driving force in the development of the KBE. The KBE enterprise can function only in the framework of a competent and elastic labour market. A dynamic KBE enterprise must find, at relatively short notice, a sufficient supply of the knowledge, abilities and skills able to implement the expansion strategy for the enterprise.

It is widely recognized that the elasticity of the European labour market is very low and that important changes in this domain should be envisaged in the next decade. To what extent can this change be accelerated by promoting activities at the regional level?

THE SYSTEM OF EDUCATION

The success of the KBE has deep roots in the social reality of the given country. The society which is building the KBE must have two features:

- it must be a competitive society,
- it must be an innovation-prone society (Rodriguez-Pose 1999).

The system of education is the most important long-term instrument in the creation of competitive, innovative societies in Europe *in toto* and also in the individual regions. The idea of regional systems of education directly related to the driving forces of the KBE should be outlined as a matter of urgent necessity.

THE R & D SYSTEM

The doctrine of the KBE is an inducement to find new approaches to the development of an R & D System at the regional level. Three phenomena should be noted in this context:

- the emergence of regional innovation systems as an institutional instrument to organize the dynamic interaction between the innovative enterprise, the system of research and education and the system of regional governance,
- the emergence of the KBE enterprise as a new actor on the regional scene, not only in the absorption, but also in the production of knowledge,
- the deep transformation of the processes involved in the production of knowledge as a multidimensional socially-distributed process transgressing the traditional border between the pure and applied sciences and between the domain of academic and industrial research. The transformation and development of regional R & D systems in Europe is a fascinating object for comparative studies (OECD – *Cities and Regions ...* 2001).

THE SYSTEM OF REGIONAL GOVERNANCE

The content of the ground-breaking volume – *Governance in the 21st century* (OECD – *Governance....* 2001) – should be tested at the level of 100 regions in Europe. There is no doubt that a new system of regional governance will emerge in the European reality. The shift from the old to the new system can be analyzed in a variety of ways. In this context we will mention only one important pattern of transformation – the transformation from passive into active governance.

The majority of weaker European regions are still dominated by the old system of passive governance. This passive governance is fascinated by the idea of diminishing interregional disparities, leading to a moral duty on the part of the stronger regions to create permanent assistance streams for the weaker regions. In this political, social and economic climate, the weaker regions are often not able to build up the necessary capacity for endogenous development.

The KBE is a great inducement for regional governance to develop active attitudes and approaches to joining the group of stronger regions – seeing in the KBE the competitive advantage to find a new place on the global scene.

THE DEVELOPMENT OF THE KNOWLEDGE-BASED ECONOMY IN EUROPE – THE REGIONAL TRAJECTORY. A EUROPEAN RESEARCH PROGRAMME

This paper should be seen as an inducement to design and implement a grand European Research Programme testing the idea of regional trajectories in the development of the KBE. Such a Programme will have triple validity:

- an empirical validity to extend our knowledge related to the mechanism of the emergence of the KBE in the different European regions,
- a pragmatic validity extending our ability to design proper policies on the scale of European Union and on the scale of the European countries and regions.
- a theoretical validity as in the contribution of the theory of regional development to the theory of the KBE.

The Programme should be an example of well-organized comparative regional studies – covering 20 countries, 100 regions, 500 enterprises and 500 R & D institutions. This scale of research is necessary to create a breakthrough in the state of our knowledge on the processes of regional development in Europe – seen in the perspective of the KBE as a powerful instrument enhancing the competitive capacity of our continent on the global scene. The preliminary version of the thematic structure of the Programme can be outlined in the following way:

- the regional trajectory in the development of the KBE (theoretical versus pragmatic approaches and the laissez-faire versus dirigistic approaches),
- the theoretical and empirical foundation of the Programme – the selection of countries, regions, enterprises and R & D units. The selection of hypotheses which should be tested in empirical studies,
- the six dilemmas of the regional KBE trajectory (the comparative analysis of 100 regions, 500 enterprises and 500 R & D institutions – representing the experiences of the 100 regions),
- the organization of a pragmatic network of communication and cooperation under the auspices of the European Union – involving 20 countries, 100 regions, 500 enterprises and 500 R & D institutions,
- the critical evaluation of the OECD doctrine in the field of the KBE,
- the critical evaluation of the doctrine of the European Union in the field of regional policy.

Naturally this outline is only a very preliminary proposal just to open the discussion related to the feasibility of the design and implementation of the proposed Programme.

THE FOUR INSPIRATIONS OF THE PROGRAMME

The first inspiration is a constant flow of publications on the KBE generated by the pioneering intellectual and pragmatic activities of the OECD. These publications and activities are very important for the construction of the conceptual framework of the Programme.

The second inspiration is related to the contribution of the European Commission in the field of a regional information system and regional RTD system. Especially important are the results of the Regis Project presenting the

experiences of 11 European Regions (European Commission 1998). The critical evaluation of it, and especially the difficulties in the field of empirical analysis, could provide valuable inputs in the design and implementation of our Programme.

The third inspiration is related to the theory of the Experimentally-Organized Economy developed by G. Eliasson (Eliasson 2001), who presents his thinking in the following way:

“New technology creates new business opportunities, but it also subjects laggard producers to sometimes devastating competition. This situation is the same for the advanced industrial, the formerly planned and the developing economies alike. In all three quarters there is the hope of entering the New Knowledge-Based Economy effortlessly on the back of new technology, but there is also the problem of the local receiver competence needed for a successful economic systems transformation. To the extent possible the content of the needed industrial knowledge is defined and its role in economic growth explained in this paper. I approach this problem in terms of the theory of the Experimentally Organized Economy (EOE) with radically different [from the Walras – Arrow – Debreu (WAD) model] properties. In the EOE growth occurs by way of competitive selection of projects and organizational change. The entry and exit processes play a particularly important role. Above all, tacit knowledge and autonomous behavior of agents are allowed for, behavior that moves macroeconomic growth. Competence bloc theory explains how selection through competition is organized. Competence bloc theory broadens the concept of human capital to a stock of collective tacit knowledge capital integrated through the organization of people within firms and over markets”.

The approach of G. Eliasson is especially important in the discussions trying to give a new interpretation to the concept of industrial policy rejected by the conventional wisdom of the last decade.

The fourth inspiration is incorporated into the Human Development Report 2000 – Making New Technologies Work for Human Development (UNDP 2001). This is a quite new approach trying to build new bridges linking the grand domains of human and technological development. This way of thinking should be strongly reflected in our Programme.

TOWARDS A NEW VISION OF THE KBE IN EUROPE

The proposed Programme via the comparative analysis of regional KBE trajectories in Europe will demonstrate that the KBE is a deeply-differentiated phenomenon – reflecting the path-dependent development of KBE in different economic, social, political and cultural conditions. This Programme will challenge the simplistic and uniformistic approaches to the development of the KBE.

TOWARDS A NEW VISION OF REGIONAL POLICY IN EUROPE

The Report of the European Commission (European Commission 2001) is a great laudatio of socially-minded regional policies fascinated by the mission to diminish the interregional disparities in Europe. This model of regional policies is not representative of the prevailing attitudes in many European countries, but is still dominating in the ideological and pragmatic framework of the European Commission.

The promotion of the development of KBE in Europe is a strong inducement to a shift from socially-to globally-oriented regional policies (Kukliński 1999) which sooner or later must be accepted by the European Commission if this Commission would like to recognize the KBE as a highest priority for Europe as a competitive continent on the global scene (Kukliński 2000).

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APPLICATION OF THE POTENTIAL MODEL TO THE ANALYSIS OF REGIONAL DIFFERENCES IN POLAND

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ABSTRACT: The article analyses regional differences in Poland within the framework of the core-periphery concept. The method employed in the study is that of the ratio of income potential to population potential, which is a systemic measure of the level of socio-economic development of regions.

KEY WORDS: regional structure, core regions and peripheral areas, potential ratio, Poland.

INTRODUCTION

The transformation of the socio-economic system initiated in Poland in 1989 has brought about several changes in the spatial organisation and operation of the country's economy. Diagnostic studies in the field of regional spatial analysis are carried out in Poland in terms of its voivodeship system. It is assumed that the voivodeship, being an administrative region with a high level of institutionalisation, is a special kind of territorial region. A territorial region is a basic unit of the structuring and spatial organisation of a country's socio-economic reality (Chojnicki 1996).

Until 1998, the reference system in the research on regional differences in Poland was made up of 49 voivodeships. However, the new territorial organisation of the country that has been in force since 1999 has made regional studies switch to a new system composed of 16 large voivodeships (Fig. 1). The introduction of the division into large voivodeships has crucially affected the nature and scope of analysis of regional differences and their spatial picture.

The aim of the present article has been to study Poland's regional differentiation



Figure 1. The 16-voivodeship pattern in comparison with the 49-voivodeship one.

into core regions and peripheral areas on the basis of the potential model. The reference system for the spatial analysis is one embracing the territorial units of the NUTS 3 type, which are sub-voivodeship units wholly contained within particular voivodeship¹. The NUTS 3 units, called subregions in Poland as units of a lower order than the voivodeships, are more homogeneous in terms of their socio-economic development. In the NUTS 3 system, spatial differences in the development level stand out more clearly, thus allowing for their better understanding. While in the voivodeship system the coefficient of variation in per-capita income (1998 data) was of 19%, in the NUTS 3 system it equalled 28%².

The delimitation of core regions and peripheral areas in Poland's regional structure has been carried out using Friedmann's (1967) core-periphery model and Boudeville's (1972) concept of the polarised region. The core-periphery model of the spatial structure of a regional system, being based on the unequal distribution of power in the economy and society, describes the nature of the relative locations of rich and poor regions. The main components of the system are core regions and peripheries. A core region is characterised by a high level of socio-economic development, in contrast to its neighbouring peripheral zone,

which has a low level. The core region dominates the periphery in most economic and social respects. Thus Friedmann's notion of the core region corresponds to Boudeville's polarised region, which falls within the category of a nodal region. A polarised region is a heterogeneous, hierarchical, and integrated territorial system composed of a pole and its field of influence. The pole is a spatial concentration of socio-economic activity in the form of a metropolitan area with a high potential for generating and absorbing innovation and economic growth, and exerting a strong influence on its hinterland.

Regional studies carried out in Poland have embraced many attempts to interpret regional development during the transformation period in terms of polarised development. The concentration of growth in the most advanced regions with urbanised agglomerations has been seen as a manifestation of an increasing polarisation tendency (Czyż 1994, 1997; Korcelli 1995; Rykiel 1997; Gorzelak 1998), while the theory of a regional polarisation of development also plays a big part in Polish socio-economic practice, being employed in regional policy and planning and providing a basis for scenarios of the transformation of spatial development.

In the present article, which is a study of regional polarisation in Poland, attention is focused on the spatial aspect of the regional system. This aspect manifests itself in the form of the spatial relations present in the set of regions. As spatial relations combine with the inter-regional interactions which determine the structure and operation of the regional system, a major cognitive problem in regional analysis concerns the connection between the spatial configuration of the regional system and the location of regions within it on the one hand, and the pattern and intensity of inter-regional influences on the other (Chojnicki 1999: 261).

In the research procedure aiming to identify Poland's regional structure, use is made of a systems approach which takes account of inter-regional influences. This approach employs a mathematical model of potential (Chojnicki 1966).

THE POTENTIAL MODEL

In the analysis of a regional system, potential is interpreted as a measure of interactions among regions making up the system. It thus defines the intensity of interaction among the regions, as a variable dependent not only on their size (or characteristics), but also on their relative locations, i.e., the distances between them. The systemic character reflects the potential model's characterisation of each region with reference to the remaining elements of the system and itself. A region may have a low self-potential, but it can be reinforced by an advantageous location in the regional system of interactions.

Applications of the potential model to the analysis of the level of socio-economic development in regions have so far focused on two kinds of potential rela-

ting to income and population. Income potential is a measure of income accessibility in a regional system. It is a function of the income generated in region i , as well as incomes in the other regions, and of the distances separating them. Thus, income potential allows one to consider the effect of inter-regional flows of income on the spatial variability thereof. In turn, population potential defines the accessibility of region i to the inhabitants of all the other regions of the system. In relation to region i it measures the contribution of the populations of all the other regions, as augmented by the influence of the region on itself.

In the study of inter-regional influences, income potential is thought to be of greater cognitive value than population potential (cf. Isard, Freutel 1954; Chojnicki 1966). At the same time, the results of empirical studies show a high correlation between the spatial variability of population potential and that of several indices of the level of socio-economic development (cf. Chojnicki 1966; Stewart, Warntz 1958; Czyż 1978, 1995, 1999; Rich 1980; Pooler 1987). Hence, population potential tends to be treated as a substitute for many socio-economic phenomena, and that is how its use in the study of inter-regional links is being advocated.

In the 1980s and '90s the potential model found many uses in geographical works concerning the regional analysis of Europe. Especially worth noting is that by Keeble et al. (1982), who adopted regional income potential as a measure of accessibility to economic activity and employed it in the study of changes in the regional diversification of the European Community. In turn, Vickerman et al. (1999) used the distribution of population potential to define differences in the accessibility of regions at the scale of Europe and tried to establish the relation between changes in accessibility and economic development.

Another methodological proposal for employing the concept of potential in regional studies is that of the ratio of income potential to population potential. The first to use the ratio in geographical inquiry was Dutton (1970), who defined the income potential/population potential ratio U/V , where V is proportional to intrinsic demand and U to total consumption, as a measure of the opportunity for extrinsic satisfaction (after Coffey 1978). This index is posited "to indicate the distribution of potential for satisfying demands as a function of the intensity of those demands" (Dutton 1970: 33). The application of the potential ratio in empirical studies was presented by Coffey (1978), who delimited income regions in the metropolitan areas of Boston and Toronto. The ratio of income potential to population potential in a region is an equivalent of the per capita income index and does not differ from it in denomination. Its superiority as a measure of the level of socio-economic development of regions consists in the facts that: (1) it takes the effect of inter-regional relations on this level into account, (2) it is a systemic measure, and (3) it is a variable with a continuous spatial distribution. The present article shows an application of the potential ratio as a measure of regions' levels of development in an analysis of regional differences in Poland (cf. Czyż 1989).

THE RESEARCH PROCEDURE

The analytical approach to regional differences in Poland using the potential model embraces four stages.

In the first, based on 1998 data for 38 subregions of the NUTS 3 type³ (Fig. 2), potential values are calculated according to the following three versions of the model:
(1) Income potential in subregion i (U_i):

$$U_i = \sum_{j=1}^n \frac{z_j}{d_{ij}} + \frac{z_i}{d_{ii}}, \quad i=1,2,3,\dots,38$$

where:

z_j = the Gross Domestic Product in subregion j ,

d_{ij} = the distance of subregion i from subregion j .

It is assumed that $d_{ii} = 1$ (cf. Pooler 1987). As a result, the self-potential of the subregion is equal to its income.



Figure 2. A modified pattern of NUTS 3 units (subregions). Numbers and names of units: 1. Jelenia Góra-Walbrzych, 2. Legnica, 3. Wrocław + Wrocław city, 4. Bydgoszcz, 5. Toruń-Włocławek, 6. Biała Podlaska, 7. Chełm-Zamość, 8. Lublin, 9. Gorzów, 10. Zielona Góra, 11. Piotrków-Skierniewice, 12. Łódź + Łódź city, 13. Nowy Sącz, 14. Cracow-Tarnów + Cracow city, 15. Ciechanów-Płock, 16. Ostrołęka-Siedlce, 17. Radom, 18. Warsaw + Warsaw city, 19. Opole, 20. Rzeszów-Tarnobrzeg, 21. Krosno-Przemyśl, 22. Białystok-Suwałki, 23. Łomża, 24. Słupsk, 25. Gdańsk + c. of Gdańsk, Gdynia & Sopot, 26. North Silesia, 27. South Silesia, 28. Central Silesia, 29. Świętokrzyski, 30. Elbląg, 31. Olsztyn, 32. Elk, 33. Piła, 34. Kalisz, 35. Konin, 36. Poznań + Poznań city, 37. Szczecin, 38. Koszalin.

(2) Population potential in subregion i (V_i):

$$V_i = \sum_{j=i}^n \frac{l_j}{d_{ij}} + \frac{l_i}{d_{ii}}$$

where: l_j = the population of subregion j .

(3) The ratio of the potentials of subregion i (P_i):

$$P_i = \frac{U_i}{V_i}$$

A description of the procedure in potential calculations is given in Czyż (1995).

In the second stage, the relation between the potential ratio (P_i) and regional income per head (g_i) is defined in the form of the equation:

$$P_i = \frac{1 + \frac{\sum_{j=i}^n \frac{z_j}{d_{ij}}}{z_i}}{1 + \frac{\sum_{j=i}^n \frac{l_j}{d_{ij}}}{l_i}} \times g_i$$

It follows from the equation that the P_i/g_i value in subregion i depends on: (1) the proportionality between the potential generated by the surroundings of subregion i and its self-potential in terms of income and in terms of population, and (2) the relation of equality or inequality between these quantities. As a result, P_i/g_i can assume values smaller than, greater than, or equal to, 1.

Next, a comparison is made between the positions of subregions on the scales of P_i and g_i values. On the scale of the potential ratio (P_i), no fundamental changes occurred in relation to their ordering on the scale of per capita regional income (g_i). The slight shifts did not lead to a change in the composition of classes of subregions with low, average and high levels of development. In the national system, nine subregions show $P_i < g_i$. They are those making up the class with the highest P_i (and g_i) values and containing urbanised agglomerations. They show a higher spatial concentration of income potential than of population potential⁴. This means that the role of the surroundings of subregion i is greater in generating its population potential than its income potential. For 29 subregions of the system, $P_i > g_i$. Among them are regions from the class with the lowest P_i (and g_i) values, situated in the vicinity of the Warsaw subregion (with the highest income at the national scale). They show a lower spatial concentration of income potential than of population potential. This means that the role of the surroundings of the given subregion i is greater in generating its income potential than its population potential. Thus, the analysis of relations

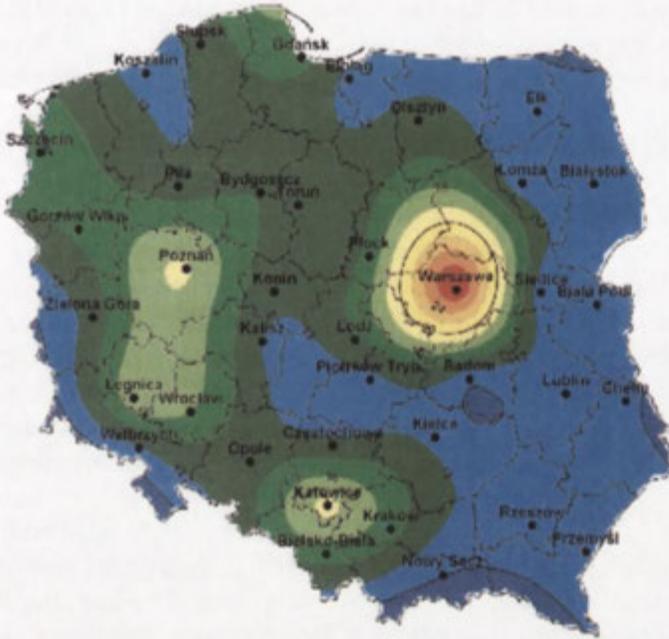


Figure 3. The spatial distribution of ratio P_i .

between P_i and g_i in the subregion system leads to the conclusion that, in comparison with the index of per-capita regional income, the potential ratio is a measure of the level of development that blurs regional contrasts to some extent by 'reducing' the highest values in the distribution and 'raising' the lowest ones.

In the third stage of the research procedure, the obtained potential ratios (P_i) are used to construct a map of their distribution. This presents a continuous surface whose relief is defined by isolines forming peaks, troughs, slopes and gradients⁵ (Fig. 3). In the fourth stage use is made of the core-periphery concept, with the spatial distribution of the potential ratio (P_i) being treated as a measure of the level of development and serving to distinguish core regions and peripheral areas in the regional structure of Poland.

THE RESULTS: CORE REGIONS AND PERIPHERAL AREAS

On the map of potential-ratio distribution, continuous patterns of subregions with high ratio values correspond to patterns of influence in the form of core regions (Fig. 3). A core region consists of a socio-economic pole and its field of influence. Regional poles are subregions with the highest values of the potential ratio understood as an indicator of the development level. Fields of influence form concentric patterns of isolines, either regular or deformed, around the poles.

The distribution of the potential ratio values on the map of Poland is multipolar, with the distinguishable poles being: Warszawa, Silesia, and Poznań. The highest potential ratio at the national scale can be found in the Warszawa pole – 27,000 zlotys per head. The much weaker Silesian and Poznań poles have similar ratios (18,000 zlotys per head). It is assumed that the boundary of the zone of strong influence of the poles is delineated by a closed isoline representing the value of 14,000 zlotys per head.

The field of influence of the Warszawa pole has a regular, radial, pole-oriented pattern of isolines. Its characteristics are a relatively short spatial range and steep gradients of potential ratio values (i.e., of the development level). The eastern, southern and western boundaries of the Warszawa core region do not coincide with those of Mazovia voivodeship. The Warszawa core region does not embrace the eastern part of the Ostrołęka-Siedlce subregion nor the southern area of the Radom subregion, which are part of Mazovia voivodeship, whereas

it does extend to the south-west to include fragments of the Łódź and Piotrków-Skierniewice subregions from Łódź voivodeship. The circular isolines of the field of strong influence of the Poznań pole are deformed by its being elongated north to south. The Poznań core region is not confined to the limits of Wielkopolska voivodeship, but extends much farther. While it does not embrace the northern fragment of the Pila subregion and the eastern Kalisz subregion of Wielkopolska voivodeship, it does cover the subregions of Legnica and Wrocław of the voivodeship of Lower Silesia, the Szczecin subregion of Western Pomerania voivodeship, and the south-western part of the Bydgoszcz subregion of Kujawy-Pomerania voivodeship. The field of strong influence of the Silesian pole is flattened along a south-north axis and includes almost the entire voivodeship of Silesia (excluding the northern part of the Northern Silesian subregion) as well as the western fragment of the Kraków-Tarnów subregion, together with the urbanised agglomeration of Kraków, within Małopolska voivodeship.

The areas situated on the peripheries of (outside) the core regions distinguished present a marked contrast to those regions with their much lower potential ratios, and hence lower development levels. They can be divided into two kinds: those with a low, and those with an average level of socio-economic development. Their spatial distribution takes the following form. In the west of Poland lies a peripheral belt of frontier subregions with an average level of socio-economic development which belong to the three voivodeships of Western Pomerania, Lubuskie, and Lower Silesia. In central Poland, the peripheries include subregions with an average level of development forming a belt which extends from the Opole subregion in the south through the Toruń-Włocławek subregion to the Gdańsk subregion in the north, and those with a low level of development forming the enclaves of the Koszalin subregion in the north and the Świętokrzyski subregion in the south, as well as the southern fragments of the Łódź, Piotrków-

-Skierniewice and Radom subregions in the central part of the country. These peripheries are mainly parts of the five voivodeships of Opole, Świętokrzyskie, Łódź, Kujawy-Pomerania and Pomerania. They are external areas of the three core regions of Poznań, Warszawa and Silesia. The peripheries embracing the north-eastern, eastern, and south-eastern parts of the country are made up of subregions belonging to the voivodeships of Warmia-Mazuria, Podlasie, Lublin, Podkarpacie, and Małopolska, each with a low development level. These peripheries contrast strongly with the Warszawa and Silesian core regions.

In the regional structure of Poland, the Warszawa, Poznań and Silesian core regions are well-crystallised polar influence systems. However, the wide disparities in the size and functions of their poles, that is, subregions containing large urbanised agglomerations, affect their impact. Outstanding among them is the Warszawa pole, which contains the largest, multi-functional, urbanised agglomeration of Warszawa. All the core regions have a high level of socio-economic development and well-developed industrial-service functions. The peripheries are fields of weak internal links. They form longitudinal zones corresponding to western, central and eastern Poland. Their feature is a fuzzy pattern of interactions. The western and eastern peripheries are the foreland of the respective neighbouring core regions. They are less urbanised, agricultural areas, poorly equipped with technical infrastructure and modern services. The peripheries of central Poland have a poorly-crystallised nodal regional structure wherein the factor inhibiting growth is the transformation-generated crisis of the economy and limited adaptability of industries to free-market conditions.

FINAL REMARKS

The empirical results reported here suggest that:

- in Poland, at its present stage of advancement of socio-economic transformation, strong regional contrasts still persist;
- the division into new voivodeships does not fully coincide with the country's existing regional structure considered in terms of core regions and peripheral areas. Only three voivodeships (Mazovia, Wielkopolska, and Silesia) have equivalents in the form of well-crystallised regional patterns of interaction, though the latter extend beyond the boundaries of the former and differ widely in terms of the sizes and functions of their poles. However, the majority of the voivodeships do not show structural properties conferring a regional character upon them, and this is something detrimental to their socio-economic performance as evaluated in the context of social efficiency and the ability to pursue an effective regional policy.

The main methodological conclusion of this study is to support the adoption of the approach employing the income/population potential ratio in regional

analysis. The method is advantageous, in that: (1) it offers a systemic measure of the level of socio-economic development of regions, (2) in comparison with the development index in the form of regional income per head, it is marked by a 'contraction' of the value scale, and (3) it reduces extreme regional contrasts on the scale of the development level through the equalising effect of the inter-regional influence contained in the potential.

A drawback of the potential ratio as a method employed in the analysis of Poland's regional system is its underestimation of values in frontier areas, owing to the so-called boundary effect inherent in measurement of potential. It might be useful for a future study to test how the use of the various categories of distance specific to each type of interaction included in income potential and population potential affects the estimation of the value of the interaction, and as a result, the values of the potential ratio. There is thus scope for further research and testing of the procedure.

NOTES

- ¹ The division into NUTS (Nomenclature of Units for Territorial Statistics) units, which is in force in the European Union, was introduced into Poland in 2000. At the NUTS 2 level, the units are the voivodeships; while at the NUTS 3 level, there are 44 sub-voivodeship units.
- ² An important further argument for the use of the NUTS 3 system is the necessity of having small spatial units when calculating potential. With increasing size of a spatial unit, the distance between spatial units understood as the distance between their population centres becomes an ever less accurate measure of the distance between population elements (cf. Chojnicki 1966).
- ³ The system of 44 NUTS-3 type of units was reduced to 38 subregions through the inclusion of the urban subregions of Warsaw, Poznań, Cracow, Łódź, Wrocław, and the Tri-City (of Gdańsk, Gdynia and Sopot) into their respective surrounding subregions.
- ⁴ The spatial concentration of potential is defined by the ratio of self-potential to total potential.
- ⁵ The "Potencjał subregionów" (Potential of subregions) program, which served to calculate potential and Euclidean distances and to construct maps using computer-aided cartography, was devised and applied by A. Mackiewicz and A. Stach.

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METROPOLISES AND THE PROCESSES OF METROPOLITANISATION

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ABSTRACT: Metropolitanisation is one of the processes observed in the contemporary world that has an ever increasing influence on its economic and social development and that is an object of various types of scientific inquiry, including geographical. However, as this complex and multi-faceted process is perceived and interpreted in a variety of ways, it might be useful to resolve it more fully. The article therefore seeks to elucidate the terms metropolis and metropolitanisation in such a way that, by focusing on the functions and spatial structures characteristic of metropolises, the process of metropolitanisation is described in the context of urbanisation and globalisation. A classification of metropolises is also proposed and carried out, and European and Polish metropolises are described. In regard to Polish metropolises, which are still rather metropolises-to-be, attention is centred on the progress of metropolitanisation and prospects for the development of metropolitan functions within the next few years.

KEY WORDS: metropolis, metropolitanisation processes, metropolitan functions, spatial-functional structures, globalisation, cities, global cities

INTRODUCTION

One of the features of contemporary scientific (and not only scientific) language is terminological-notional inconsistency. On the one hand, new notions and definitions are intended to describe things, events and processes in a more precise and unambiguous way, and on the other, some other, popular concepts are used rather arbitrarily. Undoubtedly among the latter are those of a metropolis and metropolitanisation, which are mutually connected.

The aim of the present paper is to give a more precise definition of both

these fashionable, though not always consistently-used, notions. This will be done in a broader context of reflections about European metropolises and the process of their formation, or metropolitanisation. That is why references are mainly to the European and Polish literature on the subject.

METROPOLISES AND THE PROCESS OF METROPOLITANISATION

The term metropolis has at least four meanings in European languages. The Greek original, *metropolis*, denoted a city-state, a large, strong town that tended to subdue other areas (by establishing colonies). A *metropolis* was linked with its colonies by many political, economic and cultural relations. In colonial times, a metropolis was what colonies called their mother state. To this day a metropolis is a territorial unit of the Roman Catholic Church organisation embracing bishoprics and managed by an archbishop. The term is also used, usually colloquially, to denote the capital or chief city of a country or region.

In geographical, town-planning, economic and other works, the term metropolis refers, naturally, to a town, but very often to just any higher-order central place, to adopt Christaller's terminology. In this usage the term neither explains nor makes anything more precise; it is simply a synonym of a big city and its surroundings, or what used commonly to be called an urbanised agglomeration in the Polish literature. In the postwar years an agglomeration was taken to mean a central place with a population in excess of 50,000 together with its sphere of influence, usually highly urbanised and inhabited by another 50,000 people. Most agglomeration inhabitants found employment in non-agricultural jobs. On this understanding, an agglomeration was often identified with a metropolitan area, or metropolitan district, whose central place could rightly bear the name of metropolis (Beaujeu-Garnier, Chabot 1971). In the 1980s a metropolitan area started to be taken to denote a more populous urbanised area with a well-developed central place (or, less frequently, more than one), with a population of at least one million and dominating a region inhabited by a few million people (cf. Goodall 1987; Johnson, Gregory and Smith 1998; Markowski 1998). Similar criteria for delineating a metropolis are still used by French and some Polish researchers (cf. Jałowicki 1998). Town-planners, in turn, take a metropolitan area to denote a monocentric urban area with a metropolis as its nodal centre, while reserving the term agglomeration for an urbanised polycentric area (Karlóicz 1978). A recently popular synonym of a metropolis is probably the term global city understood as a world city (Lambooy 1990; Hall 1996; Lever 2000). There are authors, however, who use the term global city like that of a global village, or more concretely, an ethnoscape, cosmopolis, or heteropolis (Mc Neill 1999).

In order to give the notion of a metropolis a deeper sense, it seems one should assume that this class of central places is only represented today by 'city-states' that are highly developed, big urban centres strongly connected with other, similar places (Mc Neill 1999). This means that a metropolis is a big city which is the seat of institutions performing the highest-order political, administrative, economic, social, and cultural functions (i.e., at the highest level of centrality). Naturally, the development of such functions has to lead to the formation of specific spatial-functional structures within each metropolis.

The development by a big urban place of metropolitan functions and their accompanying metropolitan spatial-functional structures can be called metropolisation. This process seems to be a new aspect of urbanisation, or more precisely, of re-urbanisation. It clearly generates a new quality, as its characteristic feature is a planned and energetically implemented action to revive the city centre, and as a result, the entire settlement unit (van den Berg et al. 1982; Drewett, Engelstoft 1990). Metropolisation is recently understood as a factor of globalisation (Kukliński 1999, 2000). At the end of the 20th century it appears, however, to be a component or effect of this process rather than its factor. It is the internationalisation of the economic, social and cultural life generating the development of metropolitan functions and metropolitan spatial functional structures that lead to the formation of metropolises, the highest-order central places in the global spatial-functional system of towns of the contemporary world, that seems to be the characteristic feature of the process of globalisation.

Thus, from the point of view presented above, not every multi-million-person city can be considered a metropolis, especially when metropolitan functions are not performed and metropolitan spatial-functional structures have not developed. The population of the city and its surrounding region is certainly an important feature of a metropolis, but not the most important one.

METROPOLITAN FUNCTIONS AND SPATIAL-FUNCTIONAL STRUCTURES

Thus, metropolises are big urban places with well-developed metropolitan functions (contents) and metropolitan spatial-functional structures (forms). Metropolitan functions are generated primarily by:

- the presence of institutions representing the management structures of international economic corporations;
- the presence of management structures of financial institutions (banks) and main controllers of capital markets (exchanges);
- fast and frequent transport connections (aeroplanes, high-speed railways) with major centres of the economic life of the continent and the world;

- the presence of the highest-standard institutions, both scientific (universities, research institutes) and technological (high-tech centres, technopoles, technological parks);
- the operation of the highest-standard cultural institutions (museums, galleries, opera houses, symphony halls, theatres) that are venues of artistic events and festivals;
- the uniqueness of the city's milieu resulting from its location, specific atmosphere, beauty, standard of hotels and catering, diversity of cuisine, entertainment, etc.;
- a dominance of socio-economic and cultural links with other metropolises and big cities over those with the metropolis's own region and country.

Thus, metropolitan functions are characteristic of only a limited number of cities of the world and Europe, not to speak of Poland and other post-communist states.

The other feature of present-day metropolises is the occurrence in them of some spatial-functional structures, i.e. areas with characteristic land uses and spatial development, which are the effect of the interactive connection between functions and spatial structures. Thus, an urban place with well-developed or developing metropolitan functions has several characteristic areas.

- An administrative-economic centre located in suitable quarters, usually high-rise, modern office buildings or historic edifices, housing the boards of supranational industrial corporations, trade companies, transport companies, banks, exchanges, insurance agencies, consulting firms, economic unions and associations, etc. The area with this function is usually located in the city centre (like the City in London or the recently developed Potsdamer Platz in Berlin), or in a 'new' place (like La Defense in Paris, the Canary Wharf in the West India Docks in London, or the Esposizione Universale di Roma (EUR) in Rome). In some metropolises of the world, especially the largest ones, there is more than one such area.

- A cultural-artistic centre, which is usually situated in the old, historic part of the city, rich in monuments of architecture (both secular and ecclesiastical), museums, galleries, cultural centres, theatres, concert halls, etc. Quite often they are accompanied by the highest-class hotels (old and modern), exclusive restaurants, cafés, clubs, stylish pubs, cabarets, etc. In spatial terms, this can be quite an extensive downtown area with a variable density of these objects. The decisive factor is the spatial pattern of the city and such of its components as historic monuments, residential buildings, parks and green areas, as well as small architectural forms (fountains, memorials, obelisks, etc.). Such a cultural-artistic centre can certainly be found in the central part of old Paris, along both banks of the Seine, from the Alexander Bridge to the Sully Bridge; the Grand' Place and its environs in Brussels; Trafalgar Square and the neighbouring area in London; the Old Town in Düsseldorf; or the Ramblas promenade in Barcelona and the Barrio Gótico quarter adjoining it from the east.

- A downtown business centre, whose indispensable element is a glamorous, traffic-free shopping street, or streets (jeweller's shops, shops offering art and gift items, crafted products, porcelain, leather goods, coffee, tea and spices, salons of well-known fashion designers, etc.), sometimes taking the form of an avenue or boulevard with seats, fountains, etc. It features many restaurants (including regional and ethnic), bars, cafés, pubs, wine bars, and seasonal open-air catering establishments. There are also banks there that are individual-client-oriented, advertising agencies, travel offices, and similar establishments. Such centres can certainly be found in the downtown areas of Paris (the Champs-Élysées, the streets Rivoli, St. Honoré, de l'Opera and others in this part of town, the boulevard Saint-Germain and the Latin Quarter); London with its Piccadilly and Leicester Squares, Oxford Street, Piccadilly, Regent Street and the eastern part of Soho; the Baixa quarter in Lisbon (the lower city); the Old Town with the Koenigsallee in Düsseldorf; the Unter den Linden and Friedrich-strasse region in the eastern part of Berlin as well as the Kudamm in its western part; the district of several streets called the Storget in Copenhagen, including the old Nyhavn harbour; the crossing of the Italian, French and de Keyser Avenues and the traffic-free shopping precinct embracing Leys and Meir Streets in Amsterdam; etc. In many metropolises completely new, modern shopping centres are also built (e.g., Amoreiras in Lisbon, or the one on the Potsdamer Platz in Berlin).

- A transport-commercial centre embracing a railway station, a coach station, an air terminal, ticket offices, car-hire establishments, numerous stretches of shops and department stores, car parks, etc. This form of urban development often accompanies the administrative-economic or shopping centre of a metropolis. Classical areas of this type are, however, characteristic of the precincts of numerous railway stations of large European metropolises and main railway stations of smaller cities (e.g., Köln, The Hague).

- A political centre formed by a set of buildings housing state and government offices as well as international organisations. It need not be a compact area. Quite frequently it includes green spaces (parks, gardens, squares). Classical areas of this type can be found in London (the region of Whitehall and Downing Street, the Houses of Parliament, Buckingham Palace and its nearby parks, and Westminster Abbey), Copenhagen (the Christiansborg collection of government offices and the royal palace of Amalienborg), Paris (the Elysées Palace region), Brussels (the Brussels Park area), Berlin (the government precinct under construction, west of the Reichstag), and in other cities. What deserves special attention are quarters housing offices of international organisations, e.g. in Brussels (European Union buildings round the Schumann Roundabout), Vienna (the UNO-City with offices of the United Nations and other organisations), Geneva, and other cities.

- An airport with all the suitable maintenance facilities as well as passenger and cargo terminals, offering frequent connections with all the world, especially

other metropolises (e.g., Heathrow in London, Charles de Gaulle Airport near Paris, Leonardo da Vinci Airport near Rome, Schiphol near Amsterdam, or Kastrup near Copenhagen).

As to the relationship between metropolitan functions and the spatial structure, the homogenisation of the functions is accompanied, at present at least, by the individualisation of places and spatial-functional areas of particular metropolises. The process is conditioned by environmental factors, cultural tradition, properties of urban communities rooted in culture, the so-called collective memory, or traditional models of city management (Castells 1994). It seems impossible, moreover, to overlook the differences among metropolises of Europe, the USA, Asia, or South America in one's analysis, especially as far as spatial metropolitan structures are concerned (Mc Neill 1999).

An important feature of metropolises is the nature of their spatial links. There is clear competition between the links with the nearest hinterland based on the centrality of a metropolis (labour and higher-order services like education, culture, science and healthcare) and those with other metropolises generated by metropolitan functions. What is more, at some point in the process of metropolitanisation, links of the latter kind tend to assume paramount importance for the development of the metropolis.

For a particular city to be considered a metropolis, it must perform the functions, and display the spatial-structural patterns, discussed above. In other words, the urban space must have the metropolitan form and substance. The degree of their development (of form and substance) determines a metropolis's place in the hierarchy, and hence the strength of its connections and the range of its influence.

Various authors also point to other specific properties of a metropolis, like its social structure, e.g. a high level of permanent employment in the public sector, growth sectors of the economy, and big, private enterprises; a lower, also permanent, though less certain employment (with redundancies threatening) in services; fairly high employment in small and medium-sized businesses; diminishing employment in the stagnating sectors of the economy; and casual, especially seasonal, employment in trade and services. Another indication is a fairly well-balanced labour market, as evidenced by a permanent rate of unemployment of about 5%, growing at times to 7% (Jałowicki 1998).

METROPOLITANISATION AND GLOBALISATION

Even today, with the insufficiency of our knowledge about globalisation, its nature, pattern and consequences, one can hardly fail to notice the effect that globalisation has on the process of metropolitanisation (Lambooy 1990; Cooke, Wells 1992; Hall 1999; Kukliński 1999, 2000). If we assume that, in relation to

cities, globalisation may mean a return to the idea of a city-state, homogenisation of cities on many planes, and the formation of a global city, then each of these processes can be identified to a greater or lesser degree with metropolitanisation (cf. Mc Neill 1999). Assuming the city-state to be the model of a metropolis, as has been done in the present article, one can conclude that it is globalisation which leads straight to metropolitanisation. The development of metropolitan functions by individual towns followed by their gradual homogenisation in big cities can also be associated with the process of globalisation, like the similarity of problems facing Europe's major cities (Albrechts, Swyngedouw 1989; Albrechts 1992; Hastaoglou-Martinidis, Kalegirou, Papachimos 1993; Parysek 1995). Despite this uniformisation of functions and problems, each metropolis has its unique spatial-structural pattern and employs similar elements (ideas, buildings, building materials, architectural styles, decorations, composition, property, etc.). It seems that the process of globalisation will long be unable to change those historical, though gradually transformed, spatial-functional structures. The tradition, rooted in the collective memory of local communities, is supposed to be, not only a factor defining the cultural identity of European cities, but also one creating their image and a condition for the formation of a global economy (Castells 1994). On the other hand, views are also put forward about a crisis in the collective memory and the advancing alienation of the human being in the structures of a contemporary town (Portaliou 1998). Also, it is not clear if and when, if at all, a global city is going to develop, but not in the sense of a world city, or a metropolis, but of a multi-ethnic spatial-functional structure. Everything seems to indicate that the once fashionable ideas of open cities - multi-cultural centres of tolerance - have stopped enjoying wide popular support. The threat to the cultural, and to some extent also national, identity makes municipal, national and supranational (European Union) authorities take preventive, or even restrictive, measures. Among them are legal-administrative limitations imposed on the inflow of aliens (e.g., the Schengen Treaty) and such projects involving great financial outlays as urban renewal which, while strengthening a city's cultural identity, eliminates immigrants from its centre. The same idea seems to underlie such methods of shaping the historical consciousness of city dwellers as the organisation of cultural events referring to tradition and the recognition of 'cultural capitals of Europe' (Mc Neill 1999). It is hard to tell today, however, to what extent these and other activities are capable of preserving the cultural identity of European towns. The beauty of the world lies in its diversity, and from this belief, as well as from the awareness of possible threats that globalisation may bring, sprang the slogan of the 29th Geographical Congress in Seoul in 2000, "Living with diversity". At the same time action has to be taken against the development of nationalist and separatist movements and the spread of fascist or Nazi ideologies, which also pose a great threat to European civilisation and cultural identity.

Almost everything tends to globalise today: the economy, production, science, technology, culture and art, life style, fashion, nutrition, forms of spending leisure time, sport and recreation, even such forms of social deviance as terrorism and criminal offences. Yet, not every state, region, town, social group or individual person is ready to submit themselves to the machine called globalisation, especially when not all is clear in this process still under formation and displaying a multitude of faces (Cooke, Wells 1992; Krugman 1999; Kukliński 1999, 2000). Among the recognised effects of globalisation are the advancing polarisation of economic and social development, homogenisation of some places and individualisation of others, uniformisation of life styles and consumption models, and increasing interdependence of economies operating in the new global economy model. To counteract this, deliberate steps are taken to stimulate regional, especially local, development (Parysek 1997; Stryjakiewicz 1999). The growing interdependence in the development of towns and regions is met by measures aiming to improve their competitiveness, which is a source of some autonomy, or individuality. The polarisation of the face and effects of globalisation is distinctly visible in the 'metropolises vs. other cities' approach. The former are better able to resist homogenising tendencies, while smaller cities have to succumb to the process, with the effect still being unknown. It is those higher-order central functions considered metropolitan that seriously restrict the unification and primitivisation of both spatial structures and culture as broadly understood. That is why the mode of operation and image of those cities are defined by such features emphasising their metropolitan functions as exclusive shopping centres and not huge megamarket buildings; expensive shops for a glamorous clientele located in fashionable downtown streets and not supermarkets with foodstuffs; elegant restaurants and not McDonald's-type quick-eating places; museums and galleries and not repulsive, extreme avant-garde exhibitions; performances by Domingo, Pavarotti and Carreras and not those by techno or heavy metal groups; or balls at the opera and not discotheques.

It is hard to tell today whether globalisation will mean a new economic boom or lead to yet another crisis in the world economy (Krugman 1999; Kukliński 1999, 2000). It is even harder to predict for what states, regions or cities globalisation will turn out to be a beneficial process. Presumably not for all. That is why it is important to learn how global processes can be controlled and managed by state, regional and municipal authorities. As the latest history shows, the authorities try to influence those processes in various ways and with various results. The threats inherent in globalisation may affect the adopted model of European integration. Both models of "the Europe of homelands" and "the Europe of regions" guarantee the preservation of national, regional and, to some extent also local identities. The years to come will show how and with what results the European Union and its individual component states are going to respond to globalisation challenges. There is one thing highly probable, namely that metropolises are going to be those spatial-structural units that will derive ben-

efits from the process of globalisation. However, they will not be homogenised cities or the global ethnoscape-type of cities (cosmopolis or heteropolis), but city-states, i.e., the highest-ranking nodes of the world metropolitan network (Mc Neill 1999). For other cities, globalisation can mean a homogenisation depreciating the city and its inhabitants (a 'global city'). Rather, such a city will resemble a 'global barracks', with big capital as the commander, supranational economic corporations as officers, municipal authorities as orderlies, and ordinary citizens as soldiers.

METROPOLISES IN CONTEMPORARY EUROPE

While every metropolis is beyond any doubt a multi-functional entity, it is natural that some functions (finance, international organisations, a harbour, a large airport, science, culture, etc.) can figure more prominently than others.

The metropolises existing or emerging today form a hierarchical network system at the global or continental scale in which four levels of metropolitan places can logically be distinguished: the world scale, the continental scale, the subcontinental scale (regional when a region is understood as part of a continent), and the national scale. However, cities deserving the term metropolis are primarily those of the first three levels.

Since for many authors the properties of a metropolis and a metropolitan network system are not of such fundamental importance, other classifications of metropolises, not always consistent are often proposed. One of them distinguishes the following types: internationally ranking cities, nationally ranking cities, regionally ranking cities, European political decision-making centres, centres of economic management and capital flows, cultural centres, sea-port centres, and technopoles (Jałowicki 1998; Kukliński 2000). In this classification several criteria of metropolitan status are considered at once: the size of a city and its range of influence, the dominant function or distinctive feature, and other characteristics. However, it does not provide a good tool for the delimitation, ordering or generalisation of the properties of such settlement units as metropolises. One can hardly use the term metropolises for such renowned cultural centres as Florence, Salzburg, Bayreuth, or Kraków, such harbours as Le Havre, Zeebrugge, Genoa, Kiel, or Piraeus, and the Alpine or Mediterranean technopoles of France and Italy, because they have all developed only one of the metropolitan functions. It should be kept in mind that while each metropolis is an important cultural centre, and many of them are also major port cities, they are multi-functional urban places. When analysing the size, hierarchical level and functions of a metropolis, one can find the following regularity: when it descends to lower metropolitan levels, its multi-functionality decreases at the same time as specialised functions, not necessarily strictly metropolitan, increase.

B. Jałowiecki (1998) lists and classifies 57 European metropolises on the basis of analysis of many publications and his own judgement. One can agree that most of them have more or less well-developed metropolitan functions, but certainly not all. Those that should probably not be counted among metropolises of a European dimension include Salzburg, Basel, Florence, Venice, Bologna, Belfast, Nancy and Metz, and also Strasbourg, Luxembourg and others. It is easy to note that the cities were often categorised as metropolises on the basis of a single criterion rather than a set of metropolitan functions and metropolitan spatial-functional structures, e.g., in the case of Venice and Florence, their location, historical relics, tourism and culture; Edinburgh and Salzburg, historical relics as well as musical and theatrical festivals; Grenoble, Montpellier and Nice, science, technopoles, tourism and recreation; and so on. Very many of the cities chosen by Jałowiecki fall far short of the size (population) criterion, which cannot be altogether ignored in delimiting metropolises. P.J. Taylor (1997) puts forward a totally different classification in which the principal centres of Europe's economic life, which can be identified with metropolises, include the following: London, Paris, Frankfurt, Milan, Brussels, Amsterdam, Madrid, Düsseldorf, Munich, Lyon, Barcelona, Vienna, Rotterdam, Rome, Copenhagen, Zurich, Berlin, Moscow, and Prague.



Figure 1. Metropolises in contemporary Europe.

Thus, by the qualitative criteria presented earlier, and taking into consideration the size, the following cities on the European continent can be regarded as metropolises:

- world metropolises: London and Paris, although there are fundamental qualitative differences between the cities, starting with their physiognomies and ending with their dominant functions; within the next ten years they are sure to be joined by Berlin, the biggest urban construction site of contemporary Europe;
- continental (European) metropolises: Brussels, Rome, Milan, Berlin, Frankfurt, Hamburg, Munich, Vienna, Madrid, Barcelona, Amsterdam, and Copenhagen;
- subcontinental metropolises: Lisbon, Seville, Athens, Cologne, Düsseldorf, Rotterdam, Lyon, Marseille, Toulouse, Nice, Glasgow, Manchester, Naples, Turin, Geneva, Strasbourg, Zurich, Stockholm, Oslo, Warszawa, Prague, Budapest, and Helsinki;
- national metropolises: Genoa, Bologna, Venice, Innsbruck, Lille, Grenoble, Montpellier, Bristol, Leeds, Edinburgh, The Hague, Antwerp, Liège, Thessaloniki, Hanover, Stuttgart, Basel, Valencia, Luxembourg, and possibly many other cities. In the light of the considerations and classifications presented above, only the cities of the first three classes can be taken to be European metropolises.

Similar classes of metropolises are distinguished by W.F. Lever (2000), who puts global cities (= metropolises, J.P.) into the classes of metropoles, Euro-poles, and Euro-cities.

Today there is no doubt that at the start of a new century, in the age of post-industrial development and advancing globalisation, it is big urban places that have the best chances of socio-economic growth, especially if they have developed metropolitan functions. This holds for both the largest European metropolises and the biggest cities located in Poland and other Central European states. It does not mean, naturally, that Europe's largest metropolises and the biggest cities in Poland and other post-communist countries are going to progress in the same direction and at the same rate, and that ultimately they are all going to become similar. Neither does it mean that they are going to experience the same growth factors or limitations. One should realise that what we are dealing with in the case of European metropolises and big cities in the post-communist countries are totally different town-planning, economic and social entities. Equally dissimilar are the internal and external agents controlling the operation and development of those areas of the highest level of urbanisation and concentration of socio-economic activities. This is true today especially, when Central European states struggle with problems involved in the socio-economic transformation, and an unequivocal and conclusive date has not yet been set for their full incorporation into the West European structures, something which may turn out to be a major factor of their development.

THE METROPOLITANISATION OF POLISH CITIES

In Polish conditions, Warszawa is a subcontinental metropolis, though it has to vie for its international position with dynamic Budapest and Prague, with its charm and competitive prices of land and property (Kukliński 2000; Lever 2000). There are indications, however, that as the second largest investment site in Europe, after Berlin, Warszawa may win the competition. It is developing metropolitan functions and the proper spatial-functional structures. What provides grounds for optimism are the vigour of investment (the construction of new bridges across the Vistula, development of the airport, new class A office buildings, new hotels), the appearance of still new, potential investors, and a fairly substantial municipal purse (by Polish standards) (Korcelli 1999).



Figure 2. Metropolises in contemporary Poland.

Other national-scale metropolises probably include Poznań, Wrocław and Cracow, and possibly also Gdańsk, or rather the entire Trójmiasto (Tri-City) of Gdańsk, Gdynia and Sopot (fig.2). Poznań has grown to be the second-ranking urban place in Poland (after Warszawa) as far as the scope and depth of the transformation it has undergone is concerned, and it is considered to have a good chance of developing metropolitan functions (Lever 2000; Kukliński 2000). This chance has improved markedly as a result of Berlin's dynamic growth. There are many institutions of the business environment located in the downtown area which are the beginnings of true metropolitan spatial-functional structures. The development of the city's metropolitan functions is facilitated by

its location along a major European transport route (midway between Berlin and Warszawa), its commercial fairs/exhibitions, cultural-scientific potential, and milieu. The city's position is strengthened by its rapidly developing suburban zone. A limiting factor is the lack of a large airport with a big number of international connections.

Wrocław is another urban centre, beside Warszawa, with the best developed big-city type of building pattern. There are also many sites in its central area as broadly conceived that are capable of intensive development, something which offers a chance for fast growth and the acceleration of the process of metropolitanisation. The rank of Wrocław also stems from its economic, scientific and cultural potential, as well as its popularity as a venue for many important events (meetings of the Taizé Christian youth movement, the Eucharistic Congress, the Wratislavia Cantans musical festival, great operatic performances, etc.). The slogan "Wrocław as a city of meetings, a city that unites" is written in its development strategy. With its undeniably attractive natural and socio-economic environments, the city is perceived in an ever more favourable light by investors, being Poznań's most serious competitor in this respect. It offers better conditions for spatial growth than Poznań with its closely compact building pattern. What hinders Wrocław's development are its inefficient transport system and the effects of the disastrous flood of 1997.

Kraków improved its standing after it had been declared one of the European cultural capitals of the year 2000. The charm of this city and its cultural and scientific functions facilitate the development of metropolitan functions. Balice airport near Kraków has also grown in importance as new metropolitan connections have opened up (with New York, London, Paris, Rome, and Vienna). What weakens the city's metropolitan functions, in turn, is its unfavourable economic structure, especially the iron and steel industry, environmentally burdensome and detrimental to the city, which is a product of the Stalinist ideology and the development model it demanded. Another factor that hinders the development of a modern administrative-commercial central area is the city's historical layout, otherwise very valuable. However, even in the city centre there is an extremely attractive site (the region of the railway station) which is intended for a modern shopping and services mall.

The Tri-City is a settlement unit embracing Gdańsk, Gdynia and Sopot, well-known and important, especially in northern Europe. Gdańsk and Gdynia became known throughout the world after 1980 as the birthplace of the Solidarity movement, the generator of change that has ultimately led to the liquidation of the postwar, Yalta-determined order in Europe. In this way the Tri-City with its natural attribute (a coastal location) and socio-economic significance has acquired an additional historical value, viz. as a place in the most recent history of Poland and Europe. Naturally, the development of metropolitan functions is facilitated by the coastal location of the urban complex and by the complementarity of functions of its individual components reinforcing the economic potential

of the whole. Of no small significance also is the attractiveness of the socio-cultural milieu of Gothic-Renaissance Gdańsk and modernistic Gdynia.

Each of the above-mentioned cities and Tri-City should have become a sub-continental metropolis by the year 2020. Each has a chance to do so, and they should make the most of it by engaging in competition with other centres in this part of the continent.

It is also possible for Łódź to develop metropolitan functions within the next few decades, although the scope of the necessary changes is wide and the chance for growth diminished by the presence of nearby Warszawa and the lack of an airport and genuine railway junction. What does not seem feasible is the formation of a two-node Warszawa-Łódź complex termed 'Duopolis' by some authors (Kukliński 2000). The city's metropolitan prospects are likely to improve when the main national motorway junction has been built in its vicinity. Szczecin has a chance to become a subcontinental metropolis on the periphery of Berlin under favourable circumstances. However, Berlin's growth dynamics may draw this city overwhelmingly into its own zone of influence, something which would put an end to Szczecin's dreams of metropolitan functions, and this is a very likely scenario today. Another city that can strive to develop metropolitan functions is Katowice, especially when supported functionally by the other big towns of the Upper Silesian District. It seems, however, that the way to trigger metropolitanisation processes is the economic restructuring of this city and the entire region as well as a fundamental improvement in the quality of their natural environment, which is a formidable, costly and time-consuming task. The future of Lublin lies in the hands of Ukraine, Belarus and Russia, or more specifically, will depend on the political, economic and social situation in those countries, as well as the strength of their economic links with Poland. If the conditions are favourable, Lublin also can become a metropolis at the subcontinental level around the middle of the 21st century. The prospects of Białystok in this respect are decidedly worse.

Today everything seems to indicate that the process of metropolitanisation of Poland's largest cities will keep progressing, although slowly and not without difficulties. A serious acceleration can only be expected after Poland has joined European Union structures, and when the pattern of globalisation emerges as favourable to the country. These events will mean the liquidation of barriers to growth and better access to capital, but only for the best and most promising users. Given the serious financial shortages of towns in the post-communist states and the sharp differences in economic development and standards of living between those states and the most advanced countries of Western Europe, the progress of metropolitanisation will depend on external rather than internal factors. The former will be the actual driving force of metropolitanisation, while the latter can only play the role of catalysts or factors smoothing the course of this process.

CONCLUSIONS

It is an undisputed fact that the process of metropolitanisation of Europe's biggest cities is advancing fast. It is taking place in the conditions of a post-industrial model of development and globalisation. Globalisation and metropolitanisation throw a totally different light on production, management, employment, economic calculus, locational issues, and other factors of economic development. A decisive role is played by those sectors of the economy that are connected with the management of the economy and capital on the world scale. Other important factors are science and technology, services delivered to external customers, and a city's milieu. The process of metropolitanisation generates sharp competition among metropolises and generally has an adverse effect on the development of smaller urban places. The competition of metropolitan areas leads to the formation of a hierarchical system of metropolises which today seems to embrace (in an adequate and disjunctive classification): metropolises of the world dimension, continental metropolises, subcontinental metropolises, and national-scale metropolises. This situation, after all, offers an opportunity for development of local and regional economies based on endogenous growth factors. Metropolitanisation is a new stage of a broadly understood process of urbanisation called re-urbanisation, and its visible effect is the revival of the inner city and its more intensive development (van den Berg et al. 1982). While there are still distinct autonomous urban spaces with specialised functions that have formed in the Fordist model of the economy, we can now observe the process of overlap of certain functional areas leading to the development of a metropolis's multifunctional central area and new, external districts of a similar character (Albrechts 1992). The development of metropolitan cities does not proceed smoothly. They will have to cope with problems posed by the globalisation of the economy and social life, international competition, cooperation, and integration, differences in the levels of economic development and standards of living, unfavourable demographic tendencies and disturbances on labour markets, especially in relation to well-educated, young workers, a rising wave of immigrants from the poorest countries of the world, social stratification, civilisation-related diseases and social deviance, the operation of the urban infrastructure, changes occurring in the natural environment, changes in the economic and social spheres, the overlapping of spatial-functional patterns and competition in land use,) the scarcity of public finance at the disposal of city managements, and many other problems (cf. Albrechts 1992; Hastaoglou-Martinidis, Kalegirou, Papachimos 1993; Parysek 1995).

The process of metropolitanisation also affects the biggest cities of the post-communist countries, including Poland, though with the exception of Warszawa one can only talk of a metropolitan status at the national level. The cities that have a good chance of developing metropolitan functions of a subcon-

tinental or continental dimension in less than two decades include Poznań, Wrocław, Kraków, and the Tri-City. Naturally, this development will not take place of itself, but will require suitable action on the part of the state and regional and local authorities, as well as the inflow of substantial investment capital, which is also largely a problem to be solved by the municipal authorities. The metropolitan functions developed will lead to the formation of ever more distinct structural areas with specific functions. Above all, these will be administrative-commercial, scientific and cultural centres, as well as transport and recreational-sports infrastructure, and secondly, shopping centres and prestigious shopping thoroughfares and places of social contacts. The growth dynamics of metropolitan functions can be accelerated and reinforced by the integration of Poland into the European Union; another advantageous factor may be Poland's location as a bridge state in post-Cold War Europe.

Apart from factors favouring the development of metropolitan functions, there will also be barriers to this process, both internal or external. Those among the internal barriers that might have the strongest effect include the underdevelopment of technical infrastructure, especially poor accessibility of Poland's biggest cities, delays in the construction of motorways and in the modernisation of the railway network, backwardness in the development of wireline telecommunications, the ageing of the population and depopulation, unsolved housing problems, and the inflow of immigrants from the poor countries of Europe and Asia, to a lesser extent from Africa and Latin America. Among the external factors, the most dangerous can prove to be a crisis in the world economy, a delay in Poland's admission to the European Union, an unfavourable pattern of globalisation, and competition from other European cities, not only Berlin, Vienna, Copenhagen or Stockholm, but also Budapest, Lvov, Vilnius and Riga, and in the near future Dresden and Leipzig when they have recovered from the massive desertions by their old residents after 1990, and possibly also Kiev and Minsk. The development of metropolitan functions by Polish cities will also depend on the adopted and implemented model of development of the country as a whole. It seems that the post-modern model offers better growth opportunities than the model implemented in the late 1980s and the early 1990s (Albrechts, Swyngedouw 1989; Cooke, Wells 1992; Chojnicki 1995).

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RAINFALL, RUNOFF AND SOIL EROSION IN THE EXTREMELY HUMID AREA AROUND CHERRAPUNJI, INDIA (preliminary observations)

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ABSTRACT: The present paper includes a characterization of the environment in the extremely humid Cherrapunji region (with annual rainfalls from 8 000 to 24 000 mm), as well as a description of a new project and preliminary observations on runoff and soil erosion. Due to deforestation, soils are degraded. The investigation is based on existing meteorological records, measurements of rainfall intensity by way of pluviometers, and observations of selected geomorphological and hydrological processes conducted in an experimental catchment. Heavy rains mainly occur during late evening and continue till morning. The runoff follows the heavy rains immediately, even if the soil profiles may absorb 100 mm of rainfall over 3-4 hours. Deeper layers of the soil profile are still saturated during the first half of the dry season. During the rainy season, saturated sheet flow also prevails in the valley bottoms. The present-day rate of soil erosion is very low due to heavy overland flow continuing for centuries, and the formation of a stony pavement on slope surfaces as well as of river channels cut in resistant rocks with iron crusts. This has been documented by measurement of ¹³⁷Cs contents in soil profiles.

KEY WORDS: rainstorm, overland flow, soil erosion, Cherrapunji plateau, ¹³⁷Cs

INTRODUCTION

The Cherrapunji region located on the southern slopes of the Meghalaya plateau is (Fig. 1) known as an area of the highest rainfall, ranging from 8 000 to 24 000 mm annually. The specific natural environment and anthropogenic activities created conditions for the acceleration of water circulation and soil erosion. An active tectonic horst, rising up to an elevation of 1960 m a.s.l. and

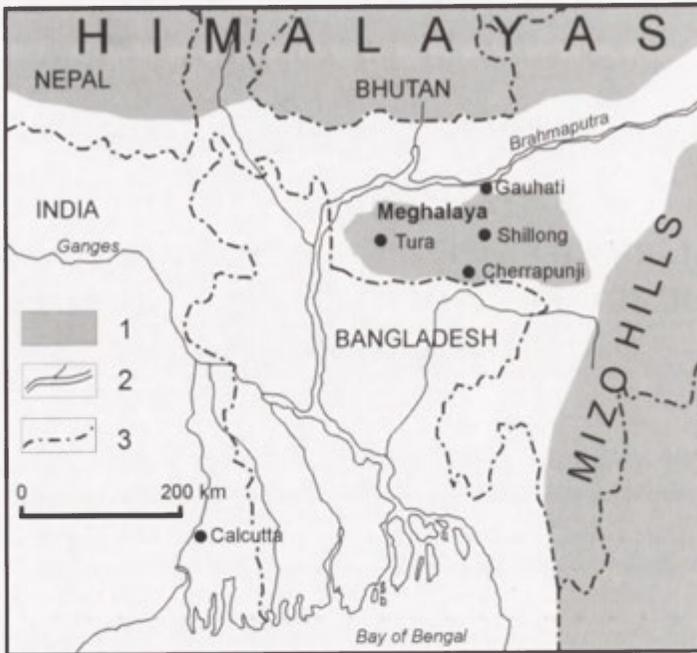


Figure 1. Location of Cherrapunji and Meghalaya Plateau
1 - mountains and hills, 2 - rivers, 3 - state boundaries.



Plate 1. The deep canyon dissecting the Meghalaya Plateau east of Cherrapunji (by L. Starkel).

dissected at its southern margin by steep canyons, creates a barrier for humid air masses which flow in from the Indian Ocean (Plate 1). The deep weathered igneous and metamorphic rocks are overlain at the southern edge by thick horizontally bedded limestone and sandstone beds (Rai 1987, Starkel 1996). The progressing deforestation, extensive cultivation and overgrazing combined with surficial exploitation of mineral resources among many causes of the degradation of soil cover, with the exposure of hard rocks and formation of an impermeable residual crust on their surface (Tripathi et al. 1995). In such conditions, an overland flow dominates during the rainy season, while a water deficit is noted during the dry season. The recovery of natural resources, especially the soil and vegetation cover, and the management of water resources which are scarce in abundance, are the major problems, and poses a serious challenge to the scientists working on hydrological and geomorphological problems.

THE STATE OF RESEARCH

In the mid-19th century Oldham (1854) observed and highlighted the environmental problems of this area after his visit and experiences on the Cherrapunji plateau. During the 1960s, Chatterjee (1968) presented the detailed characteristics of the environmental and socio-economic problems of the Meghalaya plateau. Starkel (1972), Bandyopadhyay (1972) and Majumdar (1978) in turn gave a detailed description of relief features (the structure controlled surface of the plateau, with deep canyons) and the geomorphic processes of the Cherrapunji region in relation to other parts of the monsoonal hills area of India.

The period of the last twenty years, since the University in Shillong was established, has brought numerous studies on various aspects (notably poor soil fertility, the disturbed ecological conditions of agro-forestry, the impact of shifting cultivation (jhum) on the environment and so on) by many ecologists (Toky and Ramakrishnan 1981, 1982, 1983a, 1983b, Ram and Ramakrishnan 1988, Khiewtam 1986, Ram 1986, Ramakrishnan and Ram 1988, Umashankar 1991, Borthakur 1995, Tripathi et al. 1995). They generally adopted the ecological approach for a solution to the problems of the degradation of natural resources. A variety of ecosystems of degraded grasslands, agricultural areas and barren lands have been studied by them, and also by geographers (Singh 1996).

On the other hand, a few studies on hydrological processes operating in much-disturbed ecological conditions were conducted by the Indian Council of Agricultural Research (ICAR), in Barapani, on the northern slope of the Meghalaya plateau. By establishing experimental plots and micro-watersheds, the runoff on various hill slopes was predicted using the parameters of the unit hydrograph (Sathapathy 1994-1995, 1995-1996) while water-harvesting techni-

ques for the North-Eastern Hill areas were suggested through adoption of the water balance approach (Sathapathy 1996). A calculation of direct runoff in the Cherrapunji area was done by Prokop (1999), using remote-sensing data for geomorphological parameters employing the GIS technique and SCS method of runoff assessment. There are only several papers describing geological controls in the formation of scarps and flat valley floors over the plateau, karstification, the armouring of slopes by creeping blocks and the development of drainage systems with steep valley heads in the Cherrapunji region (Rai 1991, Starkel 1989, 1996). From this review we may conclude that, in the case of the Cherrapunji region, there seems to be a deficiency of any scientific explanation as to the hydrological processes, and the causes of soil erosion, in this area of heaviest rainfall on the global scale.

After the visit of the Polish team (L.Starkel, W. Froehlich and R.Soja) from the Department of Geomorphology and Hydrology, Institute of Geography and Spatial Organisation (Cracow) of the Polish Academy of Sciences (PAS), under a scientific exchange with the Department of Geography, North-Eastern Hill University, Shillong during late 1997, it was debated and decided with the Indian team (Surendra Singh and H.J.Syiemlieh) that collaborative research work on geo-hydrological processes (especially runoff and soil erosion in the globally-extreme humid area of the Cherrapunji region) should commence.

The project proposed was included in the Inter-governmental Programme of Cooperation between the Department of Science and Technology (DST), Government of India, and the Polish Committee for Scientific Research (KBN), Government of Poland, initiated for two and then for three years (2000-2002). This project entitled *Runoff and soil erosion in the globally extreme humid area in the Cherrapunji region* focuses on the following objectives:

- to find out the rainstorm characteristics and conditions of water circulation,
- to examine the physical and hydrological properties of soils and regoliths,
- to evaluate and measure the intensity of various processes, as well as the runoff and denudation rates in the Cherrapunji region, and
- to find answers to questions about the origin of existing degraded geoecosystems and possibilities for the recovery of water resources, natural soils and vegetation cover.

METHODS USED FOR INVESTIGATION

The information and data for the study on water circulation and soil erosion in the Cherrapunji region are collected from different sources. The monitoring and laboratory work is still being continued. For the same, there is a need for (1) data on the environment and human activities, (2) existing rainfall records and details of rainfall intensity in space and over time, and (3) a detailed investiga-

tion of soils, hydrological and geomorphical processes in a selected experimental catchment.

Ad. 1. Registration of relief and land use components is based on analysis of 1:50 000 scale topographical maps and satellite images supplemented by various field surveys. Some information is also being collected from available cartographic and written documents on geology, land-use changes and so on. IRS-1D false color composites (FCC) of bands 3, 2 and 1 of 1998 have been used for visual interpretation of the land cover/land use system. A reconnaissance survey of the study area was made to correlate the image characteristics and ground features using the standard visual interpretation technique.

Ad. 2. The annual rainfall records for the last century, and daily records for the 15 years 1986-2001 have been collected from the Indian Meteorological Department (IMD) in Gauhati. There are no available rainfall statistics for an hourly time scale. However, the meteorological observatory of the IMD is equipped with a syphoned pluviograph, which may distinguish total rainfall during a period longer than 15-20 minutes. Records from it are unpublished, with Indian publications referring to rainfall intensity calculated on a scale of 24 hours. The monthly rainfall intensity is calculated from the total amounts of rainfall on days with rain, as divided by the number of rainy days (Singh and Syiemlieh 2001).

For an understanding of the mechanism of rapid runoff and soil erosion, it is important that information on rainfall intensity be obtained on a scale of a 1-minute unit of time. For this purpose, an oscillation pluviometer well-equipped with a data logger (SEBA HYDROMETRIE, GERMANY) was installed in the study area recording an oscillation of 0.1 mm. The measurement of rainfall at several localities should help in understanding the spatial pattern to high precipitation. The first pluviometer was installed on the flat roof of the Catholic parish church in Cherrapunji at about 1430 m a.s.l. in May 1999. It later (as of November 2000) shifted to the station of the IMD Cherrapunji observatory at an elevation of about 1320 m a.s.l.. In order to find out the orographic impact on rainfall variation, another pluviometer was installed on the edge of the plateau at Thankarang Park (c. 850 m a.s.l.).

Ad.3. For the purposes of evaluating runoff and soil loss, an experimental representative catchment of about 20 ha (namely the Maw-Ki-Syiem) was selected. The catchment was surveyed and mapped to understand relief features, soil and land-use characteristics. A contour map, geomorphological map and channel and slope profiles were prepared for the catchment, followed by measurements of infiltration rate, soil moisture, water storage, stream discharge and sediment load in the various creeks. The measurements of infiltration rate were carried out with a Burger's cylinder of 1000 cm³ volume. River discharges were measured in November at about 10 points, using the direct volumetric method. Soil samples were also collected for the assessment of textural and chemical

properties, as well as for the reconstruction of the denudation rate through the radioisotopic method. Reference sites for ^{137}Cs were sampled on top of grassed hillcrests at five spots on two transects of slopes and in the downstream part of the experimental catchment (overbank deposits and footslope waste cover) at three spots. The <2 mm fractions were packed into Marinelli beakers for gamma-ray spectrometry using an ORTEC HPGe coaxial detector at the Homerka Laboratory of Fluvial Processes in Poland. The activity of ^{137}Cs at the 661.62 keV photopeak was calibrated using International Atomic Energy Agency standard Soil-327.

CHARACTERISTICS OF ENVIRONMENT AND LAND USE

GEOLOGY AND RELIEF

The main basement of the Meghalaya plateau is built up of Pre-Cambrian metamorphic rocks with granitic intrusion. The southern part is covered by sedimentary rocks of the Cretaceous and Paleogene transgression. In this littoral zone it was mainly limestones and sandstones that were deposited. These rocks are interfingering with coastal-deltaic sandstones and siltstones containing the coal beds (Goswami 1960, Majumdar 1976, 1978, Fig. 2). The Meghalaya plateau was planated from the Mesozoic era through to the Tertiary. The southern part has been dissected due to intensive uplift along the complex fault system, still active.

The total uplift of the plateau exceeds 1000-1200 m while the aggradational plain of Bengal extends out in its foreland. The tectonic scarps of the plateau were dissected during the Neogene and Quaternary creating river canyons up to 800-1000 m deep. The young canyons contrast with the late mature relief of the plateau (Plates 1, 2). Its central part elevated from 1700 to 1960 m a.s.l. has undulated relief with structure-controlled monadnocks and wide flat river valleys

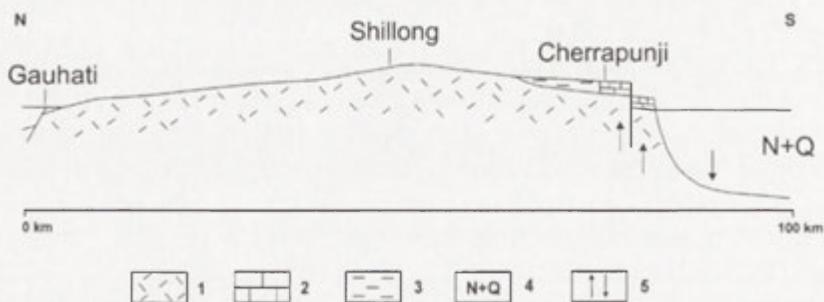


Figure 2. Geological transect across the Meghalaya Plateau.

- 1 - metamorphic and igneous rocks, 2 - limestones, 3 - sandstones and shales,
- 4 - Neogene and Quaternary deposits, 5 - tectonic tendency



Plate 2. The Mawsmai waterfalls in the valley heads during the rainy season.



Plate 3. The flat lower portion of the Cherrapunji spur, where the Meteorological Observatory is located. Convective clouds are just rising above the edge of the plateau (by R. Soja).

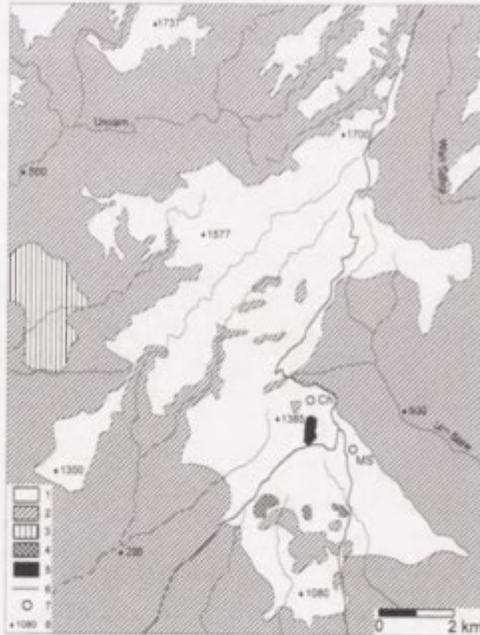


Figure 3. Cherrapunji spur at the southern slope of the Meghalaya Plateau.

1 - flat or hilly deforested plateau, 2 - forested areas, mainly steep slopes of canyons, 3 - dense scrub, 4 - limestone quarries, 5 - experimental basin, 6 - main roads, 7 - location of pluviographs, (M.S. - meteorological station, Ch - parish church), 8 - elevations in meters



Plate 4. A small creek dissecting sandstone beds of various resistance (by R. Soja).

50 to 200 m deep. The slopes still preserve thick lateritic regoliths with corestones. A typical table-land is developed over the sedimentary rocks of the Cherrapunji region. This is inclined to the south divided by several flattenings and separated by cuesta-like scarps (Plate 3). It is dissected by shallow valleys with many rapids and waterfalls on the resistant beds. Closer to the main tectonic escarpment over the flat valley floor are small limestone mesas 100 to 150 m high with karstic phenomena (Fig. 2, 3)

The alternate sandstones and siltstones block gradual downcutting and thereby facilitate lateral slope retreat and the widening of river channels (Plate 4). The deforested slopes are built of less-resistant rocks with residual lateritic crusts. On these slopes, the sliding of blocks derived from more resistant sandstone beds takes place (Starkel 1996).

Deep canyons start rapidly or in some places gradually. Over the metamorphic rocks, even the larger rivers increase valley depth gradually. In contrast, the smaller catchments near Mawmai and Cherrapunji form canyons with steep cirques (Plate 2). Their walls, 300 to 600 m in height over resistant limestones and sandstones, are modelled by rockfalls with scree talus at their base.

CLIMATE

In the Cherrapunji area there is marked seasonal variation in temperature and rainfall. Temperature varies from 16°C in winter to 26°C in summer. Most of the rain falls during summer (May-September) because of the effective S-W summer monsoon (O'Hare 1997) and orographic rainfall (Starkel 1972). Areal

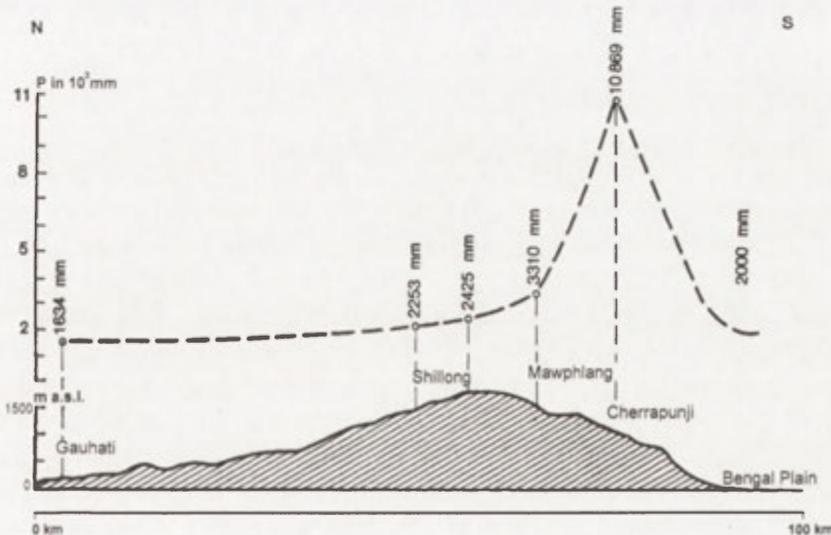


Figure 4. Cross section of Meghalaya Plateau with annual precipitation curve.

variations in rainfall distribution are influenced by the relief features, as the Bengal plains at an elevation of about 100 m receive less than 2500 mm annually (while Cherrapunji at 1320 m in the elevation records 8 000 to 24 000 mm of rainfall annually - Plate 3 - and the Mawphlang located on the upper part of the slope at 1800 m a.s.l. receives about 3300 mm). The southern edge of the plateau where Cherrapunji and Mawsynram are located receives the highest rainfall (Fig. 4). In some years more falls in Mawsynram than in Cherrapunji.

SOILS

The Cherrapunji region is relatively diversified with respect to climate and parent material (sandstone, limestone sedimentary deposits). Horizontally-bedded rocks have shallow soils compared to the upper parts of Meghalaya which have originally 10-20 m thick regoliths. The spatial variations in soils reflect local relief or the land cover/land use system. In line with the soil studies done by the Agriculture and Soil Division IIRS (*Report...* 1987) and the Regional Office of National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) in Jorhat (*Soil...* 1993), the soils of the Cherrapunji area belong to two orders: Alfisols and Inceptisols which may be placed within the Ultic Hapludalf and Typic Dystrochrept subgroups respectively. The soils are coarse textured, very shallow to moderately deep but with a dominant soil depth ranging from 25 to 50 cm. If the soil depth is more than 1.3 m soil rarely falls within the order of Ultisols.

The soils of the plateau directly exposed to heavy rainfall are extremely shallow, with gravelly pavement and occasionally large boulders on the surface, low pH values of 4.0-4.5 and a low organic matter content of 1.0-1.5%. In contrast, the soils on steep slopes under dense forest vegetation are sandy loams, slightly acidic (pH 4.5-5.5) and moderately rich in organic contents (2-3%).

LAND COVER/LAND USE

Administratively, the Cherrapunji area falls under the Shella Community Development Block of the East Khasi Hills district. Culturally, the area is called 'War' locally and its socio-cultural traditions are different from the table-land culture of the Khasis. The people of this area have historically developed interaction with Bangladesh because of accessibility and transport connections. The land-use pattern is thus influenced by socio-cultural traditions of the people.

The land cover/land use and cropping patterns of this area are found to be influenced by topography. In the northern part, where flat and shallow valleys are formed by low-gradient rivers, rice is a staple food grown together with some potatoes and vegetables. Grass cover dominates in the land use of the central part of the Cherrapunji area. Towards the southern slopes of the plateau, just in the belt of highest precipitation, there is a decrease in the percentage of grass cover and the surface is often barren and rocky due to increasing surface mining



Plate 5. The undulated plateau dissected by small coal and sandstone quarries, partly drained by incised gullies (by R. Soja).

Table 1. General land use in Shella Block and changes there in 1980-1981 and 1990-1991.

Land use categories	1990-1991		1980-1981		Changes	
	Area		Area		Area	
	ha	%	ha	%	ha	%
Total Reporting Area	57,800	100.00	57,800	100.00	-	-
Forests	21,748	37.63	20,760	35.92	+988	1.71
Area under Non-Agricultural Uses	2,352	4.07	2,340	4.05	+12	0.02
Barren and Uncultivable Land	8,855	15.32	8,870	15.35	-15	-0.03
Permanent Pasture & Other Grazing Land	-	-	-	-	-	-
Land under Miscellaneous Tree crops & Groves	4,324	7.48	5,370	9.29	-1046	-1.81
Cultivable waste land	13,640	23.60	15,310	26.49	-1670	-2.89
Fallow Lands						
Other than Current Fallow	426	0.74	800	1.38	-374	-0.64
Current Fallow	240	0.42	500	0.87	-260	-0.45
Net Sown Area	6,215	10.75	3,850	6.66	+2365	4.09

Source: District Economics and Statistics Department, East Khasi Hills District, Govt. of Meghalaya, Shillong.

and quarrying of coal and limestones (Plate 5). The sub-tropical evergreen forests can be seen on the steep slopes of the southern escarpment and in deep river valleys. The patches of permanent plantation crops like oranges, arecanut, betel-leaves, medicinal herbs, bay-leaves and other fruits, also occupy the forest areas on steep slopes. Primitive agricultural practices like the shifting cultivation locally called *jhum* are still to be noted.

Apart from shifting cultivation, the other anthropogenic activities connected with population pressure like mining, extensive grazing, forest cutting for timber and clearing for permanent agriculture have also influenced the existing land use pattern. However, recorded population density in the Block is of 79 persons per sq. km (1991 census), which is almost the same as the state figure, but far lower than that for the district of the East Khasi Hills (128 persons per sq. km). Nevertheless, agriculture is the mainstay of the area's economy and more than three-fourths of the total main workforce of the Block is engaged in agricultural activities. The figure is of course much lower in the area around Cherrapunji, where grassland and coal mining dominate. There is a significant shift in land use from tree crop cultivation to permanent cropping because of increasing population pressure over recent decades (Tab. 1).

CHARACTERISTICS OF THE MAW-KI SYIEM CATCHMENT

The Maw-ki Syiem experimental catchment of about 21 ha is located in the middle part of the flat Cherrapunji spur facing towards the south and lying just 1 km west of the Meteorological Observatory (Fig. 3). The catchment slopes down from the ridge of about 1400 m elevation to the widening crossed by the road connecting to the Cherrapunji cement factory. South of the road bridge that is a valley bifurcation and the stream crosses a flat basin before disappearing in the karstic ponor after 200-300 m.

The catchment is about 700 m long and 300-400 m wide (Fig. 5), and is drained by one main creek with several short permanent tributaries and an even-more dense network episodically drained (Plate 6). The sandstone beds are inclined 1-2° to the south, interbedded with siltstones and coal beds. Sedimentary rocks control the evolution of valley floors as well as of slopes. The more-resistant beds forming steeper parts of slopes are visible on ridge tops at about 1370-75 m and 1340 m, as well as in the valley floor at elevations of 1320 and 1330 m. The slopes of hummocks are in the upper part of the catchment convex, their inclination increases from 5-10° up to 20-30°, but several structure-controlled hills have steep slopes just from the top. These were dismembered later on by shallow or gully-shaped tributary valleys. In the lower part, the valley floor is wider, and slopes have convex-concave profiles with a long basal part inclined at only 2-5°.

The main valley starts in the shallow W-E depression and then follows an incised channel about 815 m long. Its upper portion 300 m long is steep and

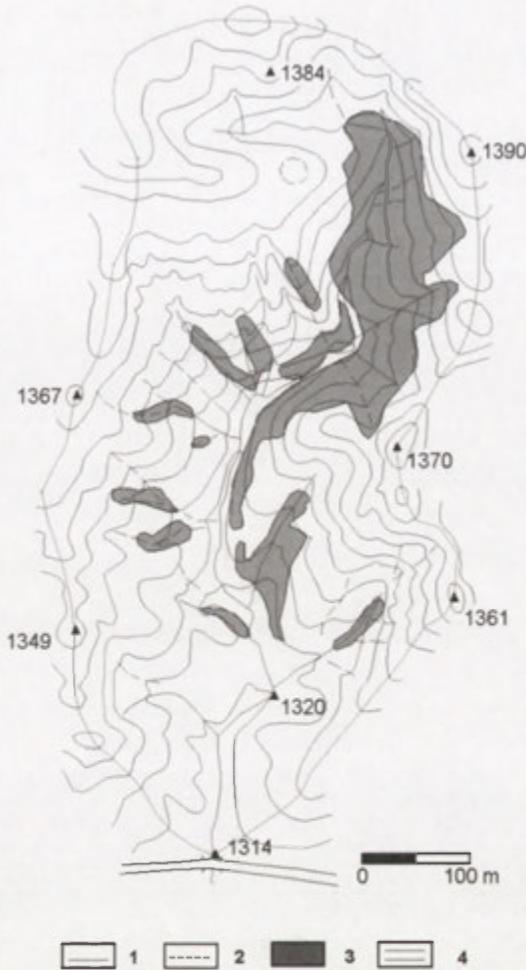


Figure 5. Hypsometry and land use in the Maw-ki Syiem experimental catchment west of Cherrapunji, as surveyed by the Polish team (contours every 5 meters).

1 - perennial creeks, 2 - seasonal or episodic creeks, 3 - forest and scrub, 4 - main road

filled by big boulders. After a 200 m gentle part with gravel-sandy bars downstream, there is a 4-meter waterfall. Downward the channel is cut 1-3 meters in the sandstone beds. These beds have been controlling a valley floor 30-60 meters wide, with thin (up to 20-40 cm) layers of slope wash and overbank sandy deposits. Beside the channels a bedrock is exposed only on the steeper slopes and in gully heads, where there are many hollows and sinkholes connected with the abandoned mining activities. In small quarries on the slopes and along road cuttings there are exposed, less-resistant, weathered beds, as well as colluvial deposits which are inherited from the older stages of valley evolution. Such loamy deposits are covered on the surface by several or more centimeter thick pavement of iron-rich stones and gravels several cm or more thick and connect-



Plate 6. The Maw-ki Syiem experimental catchment with patches of forest or scrub on steeper slopes. In the background the Upper Cherrapunji where a second pluviograph was located at the parish church (by P. Prokop).



Plate 7. Coarse pavement on the steeper slope with sparse grass cover in the Maw-ki Syiem catchment (by R. Soja).

ted with slope wash over the sparse grass cover (Plate 7). Most of the slopes are deforested and bear traces of abandoned fields and settlements. The density of grass cover is usually very low, as it does not exceed 30-50%. The scrub-forests on steep slopes directly influenced by man do not occupy even 15% of the whole catchment (Plate 6). Young trees and shrubs bear traces of overgrazing and exploitation for fuel. Compared with other parts of the Cherrapunji spur, the Maw-ki Syiem catchment is fully representative of response to relief and soil parameters, as well as land use and stage of land degradation.

PRELIMINARY OBSERVATIONS

RAINFALL

The annual course of rainfall is typical for a monsoon climate, with a concentration from May through to September accounting for 88% of the total by volume (Fig. 6). The mechanism of such heavy rainfall is connected with the monsoonal circulation (O`Hare 1997, Starkel and Basu 2000). The areal extent of annual rainfall of more than 10 000 mm probably does not exceed 200 sq km in the Cherrapunji region, because it is typical orography. Both Cherrapunji and Mawsynram are located just near the edge of the Meghalaya plateau rising via a steep scarp to 1200 m and being dismembered by deep canyons to several spurs (Plate 8). The humid air is blocked by these scarps but it may invade deeper along the canyons. The summer monsoon reaches the plateau during late May. However, there is an upward trend for daily rainfall up to 500 mm from the beginning of May. The highest monthly precipitation has been recorded during the months of June and July, with daily rainfall of more than 700 mm. In some exceptional years, rainfall totals pass to the level of 24 000 mm, especially as in the years 1896 and 1974. The monthly rainfall records show that Mawsynram received the highest rainfall of more than 10 000 mm in July 1974 (Fig. 6).

The preliminary results for hourly statistics for rainstorm intensity during 1999 show an interesting pattern. During rainy days with totals of 300-500 mm, the rainfall intensity reaches up to 40-60 mm per hour (Fig. 7). However, there is significant hour to hour fluctuation in it. The high rainfall totals are more associated with duration of the rainstorm than its intensity. To date, we have not registered the heavy downpours of more than 1-1.5 mm min⁻¹, known from the Mediterranean region or Central Europe. However, there are records of continuous rains of 30-50 hours' duration, with distinct diurnal cyclicality. The heavy rains frequently start during the late evening and continue till early morning. The highest hourly rainfall intensity (mm min⁻¹) is recorded during the night hours, when the convective movement is coming to an end. During the day time, there are 2-3 hour breaks in rainfall or periods with low intensity.

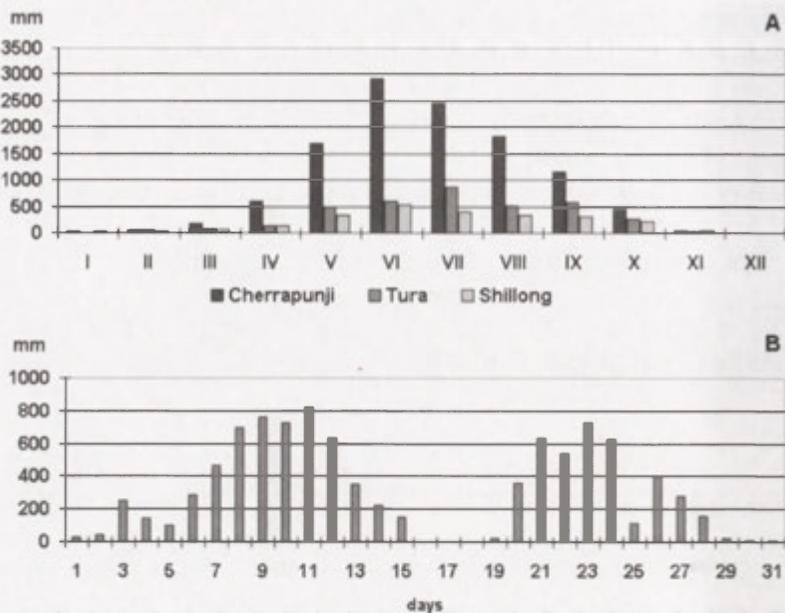


Figure 6. Mean monthly precipitation (A) at three stations in Meghalaya (after records from the India Meteorological Department), and daily precipitation at Mawsynram in July 1984 (B).



Plate 8. The Indian Meteorological Observatory at Cherrapunji (by R. Soja).

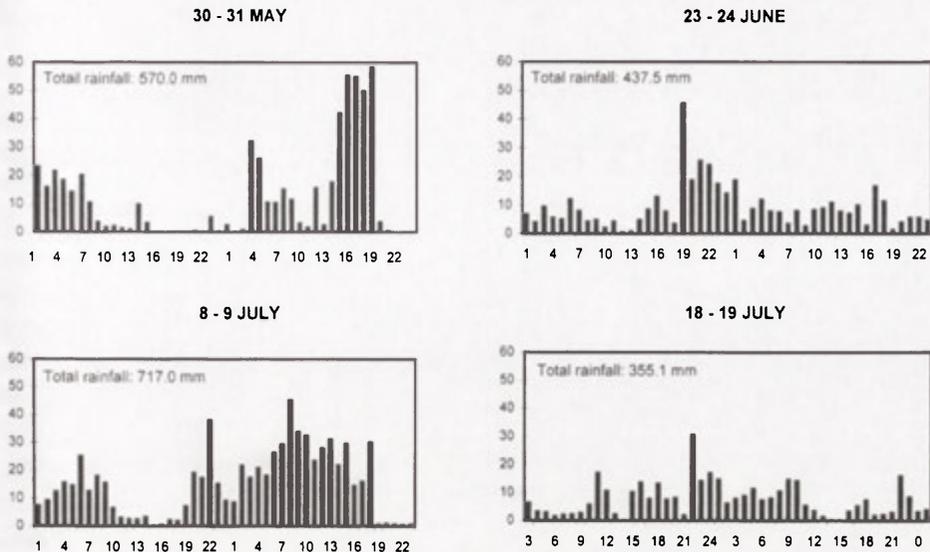


Figure 7. Examples of rainfall intensity (mm per hour) during selected heavy rains in Cherrapunji.

CIRCULATION OF WATER

In the circumstances of such a high-rainfall regime, it is infiltration generation which plays an important role where the conditions of rainfall infiltration are concerned. An observation of streamflow fluctuations indicates that, during the rainy season and after each peak discharge, the falling stages are very sharp. This reflects the very limited retentive capacity of laterite waste cover, and the important role of overland flow in runoff generation.

The relatively low infiltration rate of laterite waste cover is also connected with armouring by a residual skeletal fraction of up to 5 cm diameter. The typical grain-size composition and texture of the laterite waste cover are controlling factors where differences in permeability at various depths are concerned (Fig. 3). Measurements of infiltration rate during the dry season (November 2000) were performed on the ground surface and at depths of 5, 10, 20 and 30 cm. The soil profile was found to be capable of absorbing 100 mm of rainfall over 3 to 4 hours (Fig. 9). It generates a hypothesis that, during the monsoon season, the threshold for the start of saturated overland flow is passed during practically each rain. In the month of November 2000, during the beginning of the dry season, it was possible to observe that the soil profile was still fully saturated. The saturated dispersed overland flow and delayed return flow is perhaps a characteristic feature for slopes, with the saturated sheet flow prevailing in a swampy waley bottom. The linear runoff within the gullies and along paths also plays an important role in streamflow generation.

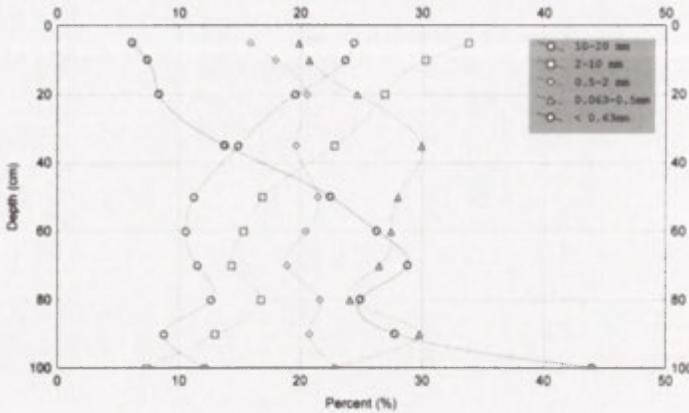


Figure 8. Grain size composition of a representative soil profile in the experimental basin, showing the much coarser fraction of the top layer.

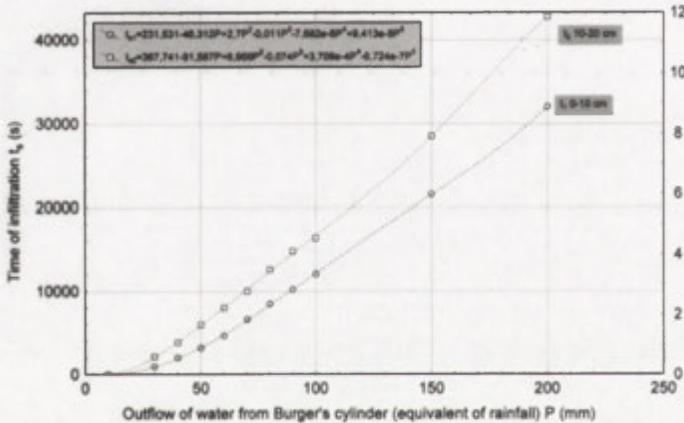


Figure 9. Sequence for the infiltration rate of 200 mm rainfall on the slope of the experimental catchment during drought (measured on 10 Nov. 2000).

Therefore, during the dry season, the outflow from the catchment is of the order of $0.01\text{m}^3\text{km}^{-2}\text{s}^{-1}$ with the result that the regression of streamflow discharge is very slow. It suggests a great efficiency of groundwater reservoirs in controlling runoff generation. The most efficient is the headwater part of the experimental catchment, deeply incised in the bedrock with the partly forested slopes. In the middle section, several water pipes take most of the discharge before the discharge finally increases again downstream of the waterfall from below 1.0 l s^{-1} to $2.3\text{-}2.8\text{ l s}^{-1}$. In the month of July 2001, a very low discharge was observed during several days without rain. A surface storage of water may be noted over the foot of slopes in the lower part of the catchment, over saturated but impermeable thin soil cover.

SOIL EROSION

Findings on the character and rate of soil erosion are based on indirect observations of the character of surficial microforms and sediments, several measurements of dissolved load as well as analysis of soil loss and deposition by the ^{137}Cs method.

The presence of an armoured layer built up of coarse material from several mm to centimeters in diameter over all slope surfaces, is connected with the absence of dense grass cover. Most of the finer grains have been washed out a long time ago. The finer washed material is now only deposited closer to the river channel. In the channel itself, bare rocky beds are exposed. The limit of summer floods is marked by the presence of vegetation cover retaining finer soil particles. On the rocky benches in the channel small sandy-gravelly bars appear from place to place as well as single rounded gravels up to 10-20 cm diameter, indicating the size of particles carried during flash floods. Transportation of such material is connected with heavy rains. In the middle part of the catchment, there are three right-side active tributary gullies which probably deliver most of the material deposited in the section upstream of the waterfall and partly carried down by the main creek.

The measurements of water conductivity in microsimens and of the pH of flowing water and rainfalls were carried out during the rainy and dry seasons. In the areas built of shales, sandstones and granites, the conductivity of flowing water recorded is extremely low, reaching up to 20-25 microsimens during higher discharges, while the rainwater is of only 7-18 microsimens. In areas of limestones, the conductivity exceeds 80 microsimens. During low discharges the suspended load was not recorded.

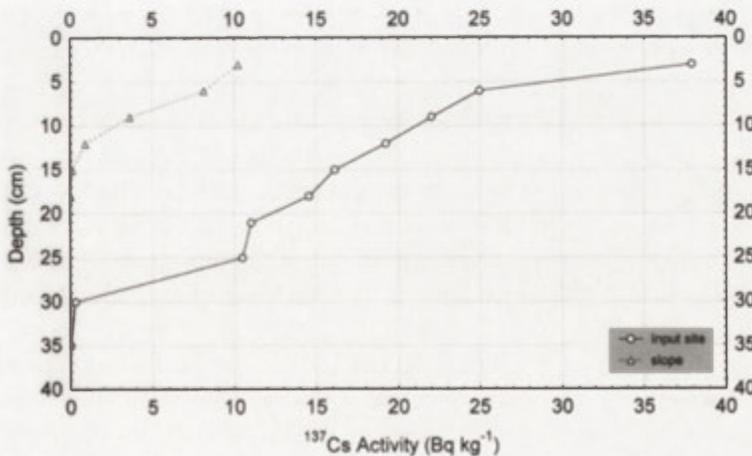


Figure 10. Measurements of ^{137}Cs in the soil profile of the upper portion of the slope in the Maw-ki Syiem catchment.

The experimental catchment was surveyed for soil loss and deposition estimates using the ^{137}Cs method and two soil-erosion and sedimentation models (i.e. Ritchie and McHenry 1990, Walling and Quine 1990). The five radiocaesium profiles collected from undisturbed locations provide a basis for determining the baseline ^{137}Cs inventory and for confirming that the majority of the ^{137}Cs inventory had been retained near the soil surface. The typical radiocaesium depth distribution is shown in Figure 10. The profiles exhibit an exponential decline in radiocaesium concentration with depth. The preliminary observations show that a very small amount of soil is eroded within the grass-covered slopes of the experimental catchment and is deposited at the footslopes. The magnitude of radiocaesium transfer from the slopes to the valley bottom, and its vertical distribution in footslope profiles, suggest an accumulation rate of about 1.5 mm y^{-1} . A low concentration of radiocaesium in overbank deposits of the fraction $> 0.063 \text{ mm}$ attest to the main sources of suspended sediment being active deep gullies within the limits of efficient linear erosion. This indicates that present-day sediment delivery ratios are low for grassland slopes, but relatively high for active gullies during extreme events only. Therefore, the recurrence intervals for extreme events are very short and relaxation time is not sufficient for sediment production and mobilization. The low rate of soil erosion and the acceleration of sediment routing are characteristic present-day features of the Cherrapunji region. Further work, exploiting the potential of ^{210}Pb , ^{226}Ra and ^{137}Cs methods are planned in order to develop an understanding of sediment transfer in this area.

CONCLUSIONS

The dissected southern margin of the Meghalaya plateau near Cherrapunji, which is built of sedimentary rocks, is affected by frequent heavy summer rains reaching up to 8000-24000 mm annually. Daily rainfalls may be of up to 700 mm, even if their registered intensity does not pass 40-60 mm per hour.

The Cherrapunji spur is deforested over more than 90% of its total area, with degraded top soils armoured by stony layers at their surface. The low infiltration rate causes quick overland flow, contributed from the whole catchment. The very low specific runoff during the dry season is of the order of $0.01 \text{ m}^3 \text{ km}^{-2}$ in the experimental Maw-ki Syiem catchment. At that time many other channels are seen to be dry, with iron pavements forming in the rocky channel floors.

The heavy overland flow probably continuing for centuries has created a gravelly layer up to 20 cm thick on the slope surfaces. The short inter-arrival time makes relaxation of the fluvial system impossible. Present-day suspended sediment production is insignificant. All available fine particles are immediately removed and deposited in the depressions. The system seems to reach the "sterile"

stage of high running water energy concentrated in short and frequent events, and suspended sediment transfer is insignificant. Consequently, the rate of soil erosion is very low. This hypothesis is supported by measurements of ^{137}Cs content in the residual soils and overbank sediments. There is a need for more records to examine the mechanism of runoff generation and the circulation of matter.

The Cherrapunji area differs very much from most uplands located in the humid tropics (Starkel 1972, Starkel, Basu (eds) 2000, Thomas 1994). In such extreme conditions of the monsoon climate after the degradation of vegetation and soil cover, there is a distinct difference in the course of processes between the rainy and dry seasons. Many processes accelerating in these areas are more similar to the conditions prevailing in semiarid zone, like rapid overland flow or precipitation of iron-manganese crusts. The recognition of the mechanisms of land degradation being under study in this project is proceeding to supply answers to questions related to the possible recovery of soil, water resources and vegetation in the most humid region of the world.

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LAND-USE CHANGES DURING THE 19TH AND 20TH CENTURIES THE CASE OF THE Odra RIVER CATCHMENT AREA

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ABSTRACT: The results of an investigation of land use in the Odra River catchment in various historical periods have been presented. Analysis of monographs and archival cartographic material points to the area of the Odra Valley having been managed by humankind since around the end of the first millennium. It was in this period that settled lands developed, and around them agriculture. Colonisation of the area and the spread of agriculture has been achieved at the expense of forests, such that, in the middle of the 18th century these occupied only about 30% of the area. This situation remained almost unchanged till the end of the 19th century. Analysis of land use based on information obtained from historical maps and satellite images suggests that the distribution of the six main types of land use (forests, arable lands, meadows, built-up areas, waters and marshes), in the Odra River catchment have not undergone major change. This confirms the supposition that land use in the area has an exceptionally stable configuration.

KEY WORDS: Odra River catchment, Sudety Mts., Silesian Lowland, flooding, topographical maps, satellite images, land use changes.

INTRODUCTION

The disastrous summer 1997 flooding in the Odra River Valley has stimulated the interest of the European Commission in the flood protection problems of this transnational catchment. The Space Application Institute of the Joint Research Centre in Ispra (Italy) joined other institutions in undertaking the Flood Risk Assessment Pilot Project which aims at developing and implementing a rainfall-runoff model for flood prediction and prevention measures in the Odra River Valley. The flood susceptibility of an area depends not only on the level of precipitation and stream characteristics, but also on land cover and

land-use practices in the basin. Forests, and especially those in the upper sections of rivers, help to retain the water from torrential rains and the melting of mountain snows. The organisation of agricultural activities along the river also influences the water budget significantly. This is why land-use/land cover information is one of the required inputs for a hydrological model. The Institute of Geodesy and Cartography in Warsaw together with the Institute of Geography of Wrocław University, undertook the task of elaborating databases to present land use and land cover in the Odra Catchment in historical and recent time, using old maps and documents, as well as recently-acquired satellite images as sources. This was a Polish contribution to development of that model. The study has been performed for the catchment of the Odra River, but excluding that of its largest tributary, the Warta (Fig. 1).



Figure 9. Location of the drainage basin of the Odra River (excluding Warta River).

GEOGRAPHICAL CHARACTERISTICS OF THE ODRA BASIN

The springs of the Odra River are located in Oderske Vrchy (Czech Republic) at an elevation of 652 m a.s.l. The river then flows through the Moravian Gate into the Ostrava Basin, where it enters the territory of Poland. Flowing in a NW direction, it takes tributaries from the Sudety Mountains and from the uplands to the east. The Sudety Mountains, a part of the old Bohemian Massif,

have been eroded significantly. They are not high, but the landscape is greatly varied. The range is about 300 km long and 50 km wide, stretching in a south-easterly direction from the upper Elbe to the Moravian Gate. In the Tertiary epoch, the massif was uplifted, with the result that considerable dislocation occurred along the entire range. Enhanced by the sharp limits of mountain forests, this dislocation is still one of the most characteristic features of the landscape, clearly visible on satellite images. The climate of the Sudety Mountains is very harsh, precipitation increasing with altitude to exceed 1 000 mm year⁻¹ at the highest elevations. In contrast, the Silesian Lowland is one of the warmest areas in Poland (*Atlas Śląska Dolnego i Opolskiego*, 1997). Rich, loess soils have formed here since the glacial period. As the climate improved, mixed and deciduous forests moved in and covered almost the entire territory. The favourable natural conditions encouraged the early settlers; and this part of the Odra Basin was the first to be inhabited by people.

In its middle course, the Odra flows through the Wielkopolska Lowland, a part of the Great European Plain. The present relief of the region (as well as that of land up to the Baltic Sea) has been shaped by the Scandinavian glaciers. As it moved, the ice-sheet destroyed and levelled away the pre-Quaternary landforms, burying them under masses of rock debris carried from Scandinavia or collected on the way. The receding glaciers deposited a mixture of clay, sand, gravel and stones. The lowlands were covered with glacial deposits of varying thickness, in some places over 100 m deep. Further geomorphologic processes led to the stratification of deposits and formation of a typical post-glacial landscape with lakes and marshes interspersed with clayey and sandy soils. In a temperate climate, it is mixed and coniferous forests that prevail in the landscape.

In the middle stretch the Odra changes its course several times from north to west and to north again. This configuration of the river course has been shaped during the successive recession stages of the last glaciation, when a system of *pradolines* (wide, east-west valleys) was formed. In its lower reach the Odra flows through mostly-forested lowlands, before emptying its waters into the Baltic Sea (Kostrowicki 1980).

SOCIO-ECONOMIC INFLUENCING OF THE DEVELOPMENT OF THE ODRA RIVER BASIN FROM THE EARLIEST KNOWN COLONISATION TO UP TO THE 1990s

The earliest permanent settlements in the Odra River Basin date back to the Neolithic period (4300 – 3000 BC). The early farmers first occupied the territories with the most fertile soils. During the Bronze and early Iron Ages, the entire southern flatland part of the basin was settled. The further spread of settlements was connected with the so-called “Amber Route”, a trade route between the Baltic and Adriatic Seas. The Celts left traces of their settlements in the region

in the period from the 1st to the 5th centuries AD, before they moved further West. As the great migration on the Eurasian continent continued, the region was gradually settled by Slavic tribes between the 6th and the 9th centuries AD. The feudal economic structures were fully developed by the 10th century, the period of formation of the Polish State (Kostrowicki 1980).

For a long time settlements developed along the Odra and on its left bank within the boundaries of the Silesian Lowland and part of the Sudety Foreland. Slowly, settlers moved towards the Sudety Mountains. During the 13th century, the process of organising existing towns and setting up new ones according to "German" or "Magdeburg" Law brought about significant changes in land use and the economy. The influx of new town settlers, mostly from the German lands, was followed by another wave of farmers. A significant decrease in forested areas was the result of another planned settlement action in the foothills of the Sudety Mountains in the 14th century.

The exploitation of minerals (silica, copper, iron, gold, silver, lead, coal and precious stones) and related production, especially of glass and ceramics, grew steadily from the 16th century. This brought about significant changes in the natural environment of the Sudety foothills - deforestation, the growth of settlements and the expansion of mining and industrial areas. Further developments (in the 17th to the 19th centuries) included the growth of the textile industry (large plantations of flax), fish husbandry, coal mining and metallurgy. The growth rate of industry in Lower Silesia and the Opole region was slower in the 19th century than in the neighbouring Upper Silesia. Coal mining developed in the Wałbrzych basin, Wrocław became a big industrial centre, and a centre of the cement industry grew up in the Opole region. There was a development of the building materials industry, and the ceramics, glass and printing industries but above all it was the food processing industry, that developed, in connection with the speedily-growing agricultural production (Kostrowicki 1980).

In the period between the two World Wars, the economy of the Odra Basin did not enjoy favourable conditions for development, due to its peripheral position in the German Reich. There was a considerable outflow of population to the west.

In turn, the last phase of the Second World War caused great destruction to the region. The towns and cities suffered considerably, particularly Wrocław. Industry and the communication network ceased to exist there. As the outcome of the Second World War, the lands to the east of the Nysa Łużycka and the Odra came under Polish jurisdiction; Germany also lost the area to the south of the Sudety divide in this case to the Czech Republic. In 1946, about 1.5 million German citizens were repatriated to Germany. The native population only remained in place in larger numbers in the Opole region. Polish repatriates from the USSR and Czechoslovakia slowly settled the area. The new settlers were given land parcels, of 10 ha on average and not exceeding 50 ha. Most of the agricultural land was organised into large state farms. The agricultural owner-

ship structure from the Silesian Lowland up to the northern reaches of the Odra Basin is very well reflected on satellite images: a mosaic of very small peasant fields plus the large fields of the state farms. An extensive economy prevailed in the state farms up to the beginning of the 1990s, when almost all ceased to exist. The land was sold or rented out; with the result that the average area of one agricultural holding is now much smaller.

Throughout the ages, the development of the region has depended heavily on its main river - the Odra. Floods have always been a threat to inhabitants and embankments are known to have been constructed along the river as early as in the 13th century, mainly for the protection of agricultural fields. Severe floods of 1501 and 1515 are reported by historical sources. A disastrous flood occurred on the Odra in 1736, with the entire valley being inundated for several weeks. More human lives were lost as a result of this flood, than during the entire 18th century (Czerwiński et al. 1999).

Systematic, major hydrotechnical works were planned in the wake of this flood; the realisation of these plans, which continued well into the 20th century, changed the water regime of the Odra basin completely. Numerous meanders were cut off and filled up; and the river was directed to the excavated canals. The completion of the works caused the length of the river to be shortened by 16%, from 1020 to 860 km. The lower stretch of the Odra, north of the Warta confluence was shortened by 24%. The works included the construction of embankments and groynes and a large section of the middle Odra was fully canalised. Catastrophic floods occurred in 1854 and 1903, in spite of the measures undertaken. Indeed, the increased stream gradient in the upper course of the river resulted in accelerated runoff of water from the mountains. The cumulative effect of high-water peaks from mountainous and lowland parts of the basin has been disastrous, especially to the areas in the middle and lower courses of the river. Floodwaters not only inundate areas far beyond the Odra floodplain, but also penetrate the valleys of its tributaries (Czerwiński et al. 1999).

According to the earliest historical sources, natural forests covered close to 90% of the Odra Basin at the turn of the 9th and the 10th centuries. Continued deforestation due to the economic development of the area had reduced forest cover to about 30% by the middle of the 18th century. The first comprehensive geographical description of the area can be found in *Atlas Silesiae id est Ducatus Silesiae* printed in Nuremberg in 1750. According to this source, forests covered about 27% of Silesia (probably more in the northern parts of the basin). *Topographische Karte des Deutschen Reiches* elaborated between 1870 and 1890 (scale 1:100 000) is the next source of information on forests in the Odra River Basin. Comparing the two sources, J. Partsch wrote in his book *Schlesien* (Partsch 1896) that "the total area of forests remained almost unchanged between 1750 and the present". Close to the end of the 19th century, for example forests covered: 29% of Opole region; 21% of Wrocław region and 37% of Legnica region. The map *Land Cover changes in the Odra River Basin between the 10th and 19th Centuries*

printed in *Atlas Ostliches Mitteleuropa* (1959) summarises the knowledge about the most important changes in land use in the Odra River Basin during the last millennium. At the end of the 10th century, settlements and agricultural fields occupied only 16.5% of the area. Forests then covered over 70% of the territory. By the end of the 19th century the area of forests had shrunk to 31.5%. During an 800 year period, over 26 000 km² of forests ceased to exist as land came into agricultural use. Since the beginning of the 18th century, spruce species from the Alps and Scandinavia have been introduced in to many areas of the Sudety Mountains. This practice, continued up to the beginning of the First World War, led to the almost total elimination of the native spruce, better adapted to the local conditions. Monocultural spruce stands dominate in the Sudety Mountains to this day (Atlas Śląska Dolnego 1997).

Following, incorporation into the Prussian State, the Silesian economy developed rapidly. Intensive commercial exploitation of forests was accompanied by cultivation measures with the aim of retaining prolonged possibilities for exploitation. The development of tourism in the second half of the 19th century gave a new dimension to the way the role of forests in the life of society was perceived. Environmental protection measures were initiated; and forests were first to come under protection. Industrial development accelerated in the 20th century. Open-cost exploitation of brown coal and the production of electrical power in the borderland of Germany, Poland and the Czech Republic led to unprecedented air pollution and the devastation of forests. The region involved became known as the Black Triangle. Due to prevailing air circulation from the south-west, the Sudety Mountains also receive air pollution from Western Europe. By the mid- 1980s about 80% of the Sudety forests were heavily damaged, while the forests of the Izerskie Mountains had been almost completely destroyed. Large areas were reforested in the 1990s, however. Large forest complexes, prevailing of pine, have always dominated in the area of light, sandy soils in the postglacial landscape to the north of the Sudety Mountains. This area has not changed much for centuries; and forests still occupy over 50% of it, though sizeable areas were devastated by military activities (on Soviet bases) in the years 1944-1991. The devastation is so extensive that it is visible on satellite images.

COMPARISON OF THE LAND USE/COVER SITUATION IN THE ODRA RIVER BASIN IN THE PERIOD FROM THE MID 19TH CENTURY TO THE 1990s

MATERIALS USED IN THE STUDY

The study has been based on the interpretation of historical maps and documents, and on the results of interpretation of Landsat MSS images from the

1970s and Landsat TM images from the 1990s. The following historical maps have been analysed:

1. Karte des Deutschen Reiches, 1:100 000, Königliches (Preussische Landes (Aufnahme, Berlin, 1885-1914; Topographischen Bureau der Königl. Sachs. Geometres, Dresden, 1890; Bureau des Königliches (Sächsische Generalstabens, Dresden, 1904.
2. Spezialkarte 1:75 000, 1877-1886 K. at the K. Militargeographischen Institut, Vienna.
3. Topographische Karte von Preussischen Staate mit einschluss der Anhaltischen und Thüringischen Länder im Masstab 1:100 000; 1823-1832. Preuss. Generalstab, Berlin.

Information on land use in the 20th century has been derived from the following sources:

1. The Land Cover Database 1975 - based on interpretation of Landsat MSS images.
2. CORINE Land Cover Database 1992 - based on interpretation of Landsat TM images.

Six major land cover categories have been recognised on the basis of historical 19th century maps: built-up areas, arable land, meadows and pastures, forests, marshes and water bodies. The results of interpretation of Landsat TM images from the 1990s (CORINE Land Cover) and Landsat MSS images of the 1970s have been aggregated to embrace the same 6 land-use categories. Historical maps used for interpretation were with different scales, cartographic projections and periods (1830-1895). The ground resolution of satellite images used in the investigation of land use differed significantly (the MSS pixel represents 6400 m², while the TM pixel represents only 900 m²). All these factors influenced the geometrical and graphic accuracy of results. Notwithstanding, the difference between the total area of the Odra Basin computed from the interpretation of 19th century maps and that computed from satellite images does not exceed 0.08%.

LAND USE IN THE ODRÁ BASIN IN THE SECOND HALF OF THE 19TH CENTURY

From the detailed archival cartographic database on land use, as well as the map *Land use in the 19th century* produced on the basis of it, it is clear that, by 1850, the Odra Valley was in the main an agricultural area. Arable land accounted for some 57% of the total area and was dominant in the northern and southern parts of the drainage basin. The central part retained large forest complexes, however, and these combined with upland forests, those of the Opole region and riparian stands along the river valley to ensure that more than 28% of the total area was still afforested. The remaining 15% comprised

meadows, built-up areas, water and marshes. The meadows were mainly located within the river valleys, or else in the mid-montane belt, and occupied 9% of the basin area.

There has long been a very uneven spatial distribution of forests within the Odra basin. There remain here extensive coniferous forests as well as land almost entirely deforested. Among the latter are areas in the southern section of the Silesian Lowland between the Sudety Mountains and the Odra River. Here the good or very good soils ensured an early-historical commencement of the deforestation process (Konias 1995). Further deforested areas are to be found in the northern part of the Odra basin on the Szczecin Plain, where the quality of the soil was again reflected in an early onset of agriculture. In turn, extensive pine forests known as Bory Dolnośląskie (the Lower Silesian Pine Forests) occupied the western part of the Silesian Lowland. Just to the north are further large areas of forest around Zielona Góra, while still further in the same direction (on the right side of the Odra) lies another large complex of forests. Other well-forested areas occur to the north of Głogów. Overall then, a zone with Poland's greatest forest cover can be said to stretch from the foothills of the Sudety Mts. in the south, via Zielona Góra and Gorzów Wielkopolski, as far as the Szczecin Lowland in the north. There are further large forest complexes in the south-eastern part of the basin near Opole. In turn, there are also large areas of forest to the south of the Gliwice Canal, in spite of the immediate proximity of the Upper Silesian Industrial District. These cover the least fertile areas with soil formed from fluvioglacial sands and gravels from the times of the Central Poland Glaciation. While the forests of the western part of the area are mainly coniferous, those in the east have more varied stands which may be mixed or even predominantly broad-leaved deciduous. Montane forests are confined to the Sudetic Mountains and Beskid Śląski range. Spruce predominates in the former, with mixed, oak-spruce-beech, beech or beech-spruce forests confined to just a few places. However, the Sudetic forests are almost entirely secondary, with the renewal conducted at the turn of the last century and in the inter-War period mainly involving the introduction of alpine and Scandinavian varieties of spruce. To the east of the Sudety Mts. in the Beskid Śląski (Silesian Beskid) range it is fir that is widespread, along with spruce and beech, mountain ash and to a lesser extent larch. Such a combination of species reflects a situation less transformed from the original one and more in tune with the prevailing climatic and habitat conditions. The forests here are more diverse in general, with some showing such relict features of the primeval situation as a species-rich shrub layer and ground cover.

Settlement in the Odra basin mainly comprises villages, small towns and just a couple of larger urban centres (Wrocław and Szczecin). Together these form a more or less even network across the entire area, occupying just less than 4% of it. The urban settlement network was in essence established by the late 13th and early 14th centuries. Subsequent changes were very largely confined to the

limited conferment of town status on what had previously been villages. The gradual bringing into use of the Sudetic Mountains saw a development of urban areas linked closely with mining for copper ore, iron, gold, silver, lead and decorative stone. The development of glass production, ceramics, coal mining and the processing of iron ore followed this. In the 17th-19th centuries, the whole area of the Sudety and Zielona Góra region came under flax cultivation for the production of linen. This took on industrial dimensions in the 19th century, leading to the establishment of the two internationally-known centres of the textile industry in the Sudety and Lubuski districts. The 19th century witnessed dramatic development of industry and mining in the Upper Odra basin, especially in the western part of Upper Silesia, Moravian Silesia and Cieszyn Silesia. Large industrial centres also arose on the Odra itself, as well as its tributaries.

The landscape of the Odra basin has been shaped by the activity of ice sheets, which extended into the area at least twice. Only the most recent glaciation (taking in the northern part) has left its mark in today's landscape in the form of lakes and typical relief. Indeed, the presence of numerous lakes has given the northern part its name of the Pomeranian Lake District. A further large cluster of lakes is to be found in the shallow and once-marshy basin of the River Barycz. Relief conditions here, with very limited inclines and a dense network of water-courses, permitted the creation of a whole system of ponds and small lakes. Indeed, the complex of fishponds in the Barycz Valley was Europe's largest in the 17th and 18th centuries, with fish becoming an important export item. Although the characterised area is of post-glacial origin, there is in fact a lack of larger marshes. Even in the mid 19th century marshland occupied less than 0.5% of the area and was confined to the Odra Valley itself, as well as the valleys of its larger tributaries.

The latter half of 19th century saw the development along the Odra Valley of a new agrarian structure to agriculture based on large estates and relatively large farms. This development affected almost all of Silesia, Wielkopolska and Pomerania, and persisted without more major change until the end of the Second World War. A similar agriculture structure also developed to the west of the Odra in Saxony and Brandenburg.

LAND USE CHANGES IN THE PERIOD 19TH CENTURY - 1970s

Analysis of land use information obtained from historical maps and satellite images taken in 1975 show that land use changes in this period were minimal. The most important changes that are to be noted for the last hundred years are those concerning forests, which increased in area by more than 3000 km² (4.9% of the basin area). Contributory factors in this were above all the country's policy on agriculture, whose aim was to withdraw marginal soils from agricultural production. The result was the reforestation of the weakest soils least suited to agriculture. Unfortunately, the increase in the area of forests was accompanied

by deterioration in their quality. This was linked post 1945 with the stationing of Soviet troops within the forests, and the resultant conversion of considerable areas into military bases and training grounds. The largest such areas were to be found in Bory Dolnośląskie. A second cause of the worsening in the condition of forest was of course air pollution and resultant acid rain. Masses of air highly polluted with sulphur dioxide and oxides of nitrogen continued to encroach upon Polish territory from a south-westerly direction, causing an environmental disaster in the Western Sudety Mountains, with almost complete destruction of forest ecosystems in the Izerskie range. The area known as the "Black Triangle" has the highest level of air pollutants anywhere in Europe. Another area of deterioration in forests was the Głogów pro-glacial meltwater channel, affected by excessive emissions of sulphur dioxide from newly-opened copper works. The devastation over large areas forced foresters to fell damaged and dead trees and attempt to renew the lost stands. This changed species composition, with broad-leaved species (beech) taking the place of conifers in many cases.

Looked at over the period of 100 years, a major change in land use within the Odra basin concerned the dynamic development of industry associated with the exploitation and processing of varied sources of mineral raw materials, i.e. iron ore, copper, gold, precious stones and hard and brown coals. The development of industry in this area occurred in many places, and led to the appearance of large industrial plants in almost every larger locality. After World War II, the area of the exploitation of hard coal within the Upper Silesian Coal field expanded markedly in a southward direction. A similar dramatic development of coal mining took place in the Ostrava Coalfield, as well as in the Walbrzych Coalfield of Lower Silesia. The development of industry in these centres has been associated with increased output of hard coal and the appearance of many metallurgical, smelting and fuel plants. The industrialisation and associated urbanisation of Upper Silesia and the Ostrava-Karvina Industrial District were factors exerting the most decisive impact in changing the way in which land in the southern part of the Odra basin was used. Of the more than 3000 km² witnessing changes in land use, the majority lay in the two aforementioned areas.

Changes in land use were also encouraged by the development of mining for brown coal stretching back into the 19th century. Open-cast mining for this resource took in huge areas after World War II, as the technology required was based on the use of special diggers and a conveyor-belt system used to supply nearby power plants with the product. Within south-western Poland, the area of open-cast mining for brown coal took in the Bogatynia region to the south of Zgorzelec. Continually expanded, it has come to encompass the area to the south of Bogatynia, with the exploited depths extending down to almost 250 m. A huge spoil heap has in turn developed to the north of the town, being made up of the entire layer of rock overlying the deposit of brown coal. The surface exploitation of coal was of much greater extent on the German side, this being the basic energetic raw material of the former GDR. The huge Hirschfelde power plant was located

in the immediate vicinity of Poland's Turów plant, and a further area of brown-coal mining extended to the north of Zgorzelec.

A third type of industry shaping the landscape of the middle course of the Odra has been and is the copper mining (in the Lubin area). The land-use map showing the state of management of this fragment of the Odra basin in 1975 depicts, among the most noticeable features, the flotation reservoirs and other infrastructural elements of the copper extraction and processing industry. While the story of the Legnica-Głogów Copper District only goes back 40 years, the area has won for itself a strategic position in the Polish economy. Within the Odra basin – to the west of Legnica – lies part of the so-called “Old Copper District”. Here copper deposits are no longer exploited, but there is a high degree of environmental deterioration and contamination by heavy metals among other things. Groundwater is also contaminated, while the flotation reservoirs are now increasingly dilapidated leftovers from the time of copper mining.

Mining areas take up almost the whole north-eastern part of the Legnica-Głogów Copper District located between Lubin and Głogów. The inclusion of this area within a mining district denotes that at some future date there will be such developments associated with the exploitation of deposits as rail systems, industrial infrastructure (transport routes, waste dumps and a drainage network for minewaters and other effluents). The phenomenon of environmental degradation was revealed in all its strength when the processing of copper ore was initiated. At first this involved the modernisation and enlargement of the copper plant in Legnica; later also the huge mining concern of the Głogów copper plant situated close to the town of the same name and the River Odra. The expansion required the abandonment of several villages in the immediate vicinity, while the town of Głogów was itself within the range of direct impacts due to elevated concentrations of noxious emissions (mainly sulphur dioxide), as well as the fall of industrial particulates containing heavy metals *inter alia*. An analogous situation arose in the vicinity of the Legnica Copper Plant. The Legnica-Głogów Copper District and complex of brown coal mines around Turosszów joins the Turów power plant on the Polish side and the Hirschfelde power plant on the German side on the list of developments arising after the Second World War and changing the distribution of industrial centres in the southern part of the Odra basin drastically. The other large new developments or modernisation of existing industrial buildings involved the chemical works in Kędzierzyn-Koźle, the Opole Power Plant, the chemical plants in Kędzierzyn-Koźle, the pulping plants in Jelenia Góra, the artificial-fibres plants in Wrocław and Gorzów Wielkopolski and the Pollice chemical plants near Szczecin. A large number of people came into industry to work, with the result that towns and cities developed, while new urban centres emerged near the large plants. The increase in the number of inhabitants caused an increase in housing construction not only in industrialised areas, but also on land throughout the basin. The settlement network thus enlarged mainly at the expense of agricultural land.

The aftermath of World War II saw a general systemic change sweep through agriculture. Relatively large family farms of mean areas 17-20 ha gave way with resettlement to farms of 7-10 ha on average, with a large proportion smaller than this. At the same time, in line with the then political doctrine, it was state or co-operative ownership that was considered the main form in Poland, Czechoslovakia and the GDR. In some areas, especially those on the best soils, large state farms accounted for between 30 and 50% of all agricultural land (as for example in the voivodships of Wrocław and Szczecin). The agrotechnical foundation of such farms – often covering several thousand hectares – was the exclusive use of heavy machinery. Wheat was the major crop, along with barley and the industrial crops sugar beet and rape. In turn, the main means of increasing yield was the constant increasing of the amounts of chemical fertilisers and plant protection agents employed. The loss of agricultural land over 100 years was mainly concentrated in arable land and meadows, and amounted to more than 5500 km². The area of arable land declined markedly, by 4700 km², while the loss of meadows was of the order of some 800 km². There was also a decrease in the area of marshes, from 280 to just 130 km². By the 1970s, the only marshes remaining were those within the lower part of the Odra basin. Other marshes, especially those in the lakeland, were drained. The loss of agricultural land within the Odra basin can be observed from the end of WW2 onwards. Fallows accounted for more than 60% of arable land in 1946 and an increase in the latter's share back to the levels noted pre 1938 was only achieved at the beginning of the 1950s. The subsequent 25 years to 1975 saw a slow decline in the area of arable land with a simultaneous increase in the area of meadows, pastures, woods and built-up areas. The decline was very much a reflection of the assumptions underpinning state and co-operative agriculture, which reduced the profitability of cereal-growing while raising that of cattle- and pig-rearing.

LAND USE CHANGES IN THE PERIOD BETWEEN THE 1970s AND THE 1990s

Between 1975 and 1992 (when imagery from Landsat satellite was obtained), there were vanishingly small changes in land use within the Odra basin. The changes that were observed were mainly confined to settled areas, with the development of towns and cities leading to expansion and further crowding of built-up areas. This was particularly the case in Wrocław, Szczecin, Legnica, Frankfurt and other larger towns. An important factor behind the growth in urbanisation was the change in the administrative division of Poland taking place in 1975. This led to the emergence of new provincial centres of administration (voivodship capitals), which developed very dynamically as they took on new functions. The result was a considerable increase in the built-up area.

In association with the political changes in Eastern Europe, the 1990s brought a restructuring of industry that led to the closure of many plants in the former GDR and most especially of brown coal mines (at Görlitz and Forst).

Also shut down were unprofitable factories and plants in Poland and the Czech Republic. Some of the industrial areas (former spoil heaps) were reclaimed and reforested. Changes in forests concerned differences in use rather than area, resulting first and foremost from the rebuilding of stand structure. As a result of the environmental policies pursued in Poland, the Czech Republic and Germany, the forests of the Sudetic Mountains were in large measure reconstructed. Whole areas of forest destroyed on military bases were also re-established (near Legnica), as were areas of large forest fires. It should be stressed at this point that the forests in the Odra basin are almost entirely state-owned; something which has allowed for the pursuit of all elements of rational management in exploitation and stand tending, as well as in cutting and replanting and the gradual transformation of the species composition.

A further slow loss of arable land occurred between the mid 1970s and early 1980s. This took on more major dimensions in mountain areas (of which around 2% were affected) and concerned small farms above all. The abandoned arable land was transformed into meadow or pasture, or else gradually encroached upon by way of forest succession. An end to the depopulation of villages and decline in the area of arable land was only put in the mid 1980s, with lowlands even noting a small increase in the share of arable land within the land-use structure of the area. Changes within arable land are observed throughout the basin at almost uniform intensity. Only in Upper Silesia, Cieszyn-Silesia and to the west of the Odra between Frankfurt and Schwedt are there less-marked changes in land use.

The area of meadows also declined. This was balanced by an increase of c. 3% in the area of meadows within the foothills of the Sudety Mts.

The 1980s also brought a fall in the share of agricultural land taken by orchards. However, this trend was quickly stifled, with the total area of orchards even 008% greater at the beginning of the 1990s than in 1975.

Agricultural land marked on the land-use map in line with CORINE Land Cover methodology and nomenclature also takes in an area of diffuse settlement with the participation of natural factors. The total extent of these areas has not changed in recent years.

RECAPITULATION

The study of the land-use changes in the Odra River catchment has been based on analysis of historical 19th maps and satellite images acquired by Landsat. The source data were not fully comparable and did not allow for profound analysis of land-use changes during the surveyed period. The most important facts, as well as trends, could however be identified.

Forests and arable land were the most important land-cover categories in the Odra River Basin throughout the ages. At the turn of the 9th and the 10th centuries

forests occupied almost 90% of the territory. Colonisation of the area and the spreading of agriculture has been achieved at the expense of forests. In the middle of the 18th century, forests occupied only about 30% of the area. This situation remained almost unchanged until the end of the 19th century.

The most important changes in the Odra River catchment between the mid 19th century and the 1990s are best characterised by the following numbers:

- a decrease in the area of arable land by 4 752 km²,
- a decrease in the area of meadows by 1 090 km²,
- an increase in the area of forests by 3 107 km²,
- an increase in the area of settlements by 3 033 km².

One is thus entitled to say that the changes in land use between the middle of the 19th century and the end of the 20th century occurred on an area of about 6 000 km², eg. on less than 10% of the total area of the Odra River Basin.

During this period, the area of forests increased by 17.6%, in spite of the more recent ecological disasters, such as the situation in the Black Triangle. The quality of forests has changed considerably:

- the introduction of a spruce monoculture resulted in a lowering of the susceptibility of forests to air pollution,
- in introduced stands, due to reduced undergrowth, the water retention capacities decrease and the runoff from the mountain forests increases dramatically.

The Odra, as the main river of the Basin, has undergone very significant changes. The river has been straightened, shortened by 16%, regulated and canalised in large section. Thus has considerably shortened the time the floodwaters need to reach the Baltic Sea. Detailed land-use analysis indicates that natural polders on the floodplain of the river have been built-up. These areas are most vulnerable to floods and suffer the greatest losses.

The results of land-use analysis for the entire study area in the three periods are shown in Table 1 and in Figures 2-3. Between the 19th century and the 1990s, the area of towns and villages increased by 3 033 km² (2.07% of the study area) and the area of forests increased by 3 107 km² (2.02% of the study area). This increase occurred at the expense of arable land (the area of which decreased by 4 752 km²), meadows (decrease 1 090 km²) and marshes (decrease 139 km²).

Table 1. Land use in the Odra River Basin in the period between the 19th century and 1992.

Years	Area	Town and villages	Arable land	Meadows	Forest	Marshes	Water bodies	Total
19 th century	km ²	2741	35752	5483	17662	282	865	62784
	%	4.37	56.94	8.73	28.13	0.45	1.38	100.00
1975	km ²	5532	31023	4601	20739	132	742	62769
	%	8.81	49.42	7.33	33.04	0.21	1.19	100.00
1992	km ²	5774	31000	4393	20769	143	689	62769
	%	9.20	49.38	7.00	33.09	0.23	1.10	100.00

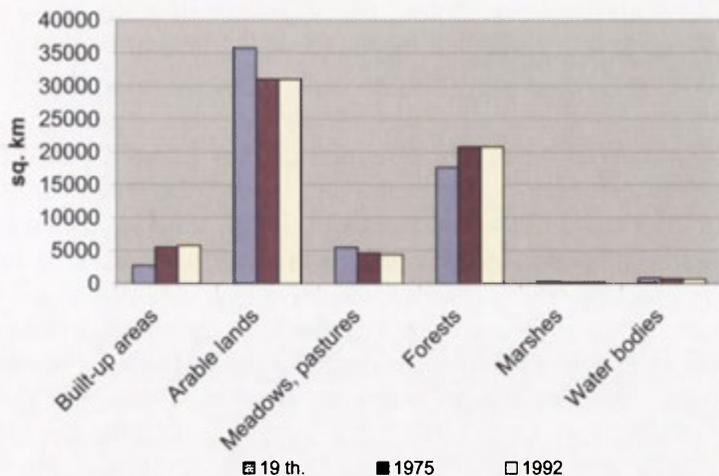


Fig. 2. Land use in the Odra River Basin in the period of the 19th century to 1992.

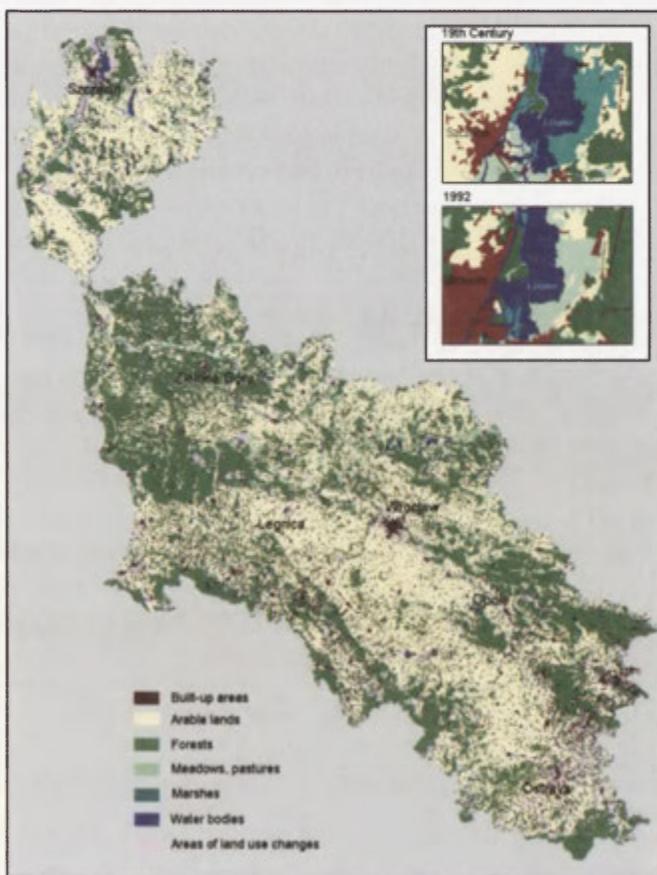


Fig. 3. Land use changes in the Odra River catchment 1850-1992.

Arable lands and forests have been the predominant land-use categories in the Odra River Basin throughout the study period. The difference between the 1970s and 1990s is negligible, but the decrease in the area of arable land between the 19th century and the end of the 20th century is significant; a drop of 7.5%. In contrast, the area of forests has increased considerably. During the last 150 years, between the 19th century and today, the area of forests has increased by 17%, i.e. over 3 100 km². Meadows are the third important element in the land cover. There was a decrease in this land use category between the 19th century and the 1970s. Further decrease have been observed during the last 20 years; the area of meadows diminished by 20% in comparison with the 19th century, and by 5% in comparison with the 1970s. The area of towns and villages has been estimated at 4.4% in the 19th century, 8.8% in the 1970s and 9.2% in the 1990s. In terms of area this means an increase of 3 033 km². The real increase in the area of towns and villages may be even larger. With respect to this land use category one has to point out the character of data used for interpretation. All the towns and villages existing in the 19th century have been marked on topographic maps of the period. The computed percentage of this category reflects the reality with high accuracy. In the case of this particular land-use category, satellite images do not guarantee such high accuracy of discrimination. Many residential areas in towns and sometimes entire villages are shielded from the satellite's sensors by trees, or obscured by surrounding low vegetation.

Analysis of land use based on information obtained from historical maps and satellite images suggests that both the means of using the land and the distribution of the main types of use (forests, arable lands, meadows, built-up areas, waters and marshes) in the Odra River catchment have not undergone major change. This confirms the supposition that land use in the area - as looked at on the regional scale and shaped hundreds of years ago (in the 13th -15th centuries) - is an exceptionally stable configuration. While the increasing population and post-war industrialisation did of course bring major land-use changes, these were very much confined to certain limited areas.

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HIGHER EDUCATION AND URBAN SYSTEM. THE CASE OF POLAND IN THE 1990s

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ABSTRACT: The present paper investigates the quantitative development of higher education in Poland in the 1990s and the distribution of higher educational institutions by urban size classes. It refers also to the recent studies on the impact of a higher school on various aspects of a city's economic and social life. It emerged that private higher schools, first organized in 1991, have been the most dynamic element of Poland's higher education system in the last decade and will certainly mark the future educational landscape as well. Private schools are also mainly responsible for a trickling-down of the higher schools through the urban hierarchy. Nevertheless, it remains the big cities that concentrate the highest proportion of schools and students, though their relative position in the urban system is weakening. The impact of a higher school upon a city has emerged as multifaceted and not as entirely positive as is commonly believed or expressed in official circles.

KEY WORDS: higher education, state and private schools, locational trends, impact of a higher school upon a city, Poland.



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AN ONLINE DATABASE OF POLISH TOWNS AND HISTORICAL LANDSCAPES USING AN INTERNET MAP SERVER

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ABSTRACT: A database of Polish towns and historical landscapes including town layouts, churches, and castles has been compiled and made available on the Internet. Lists of towns and historical landscapes, photographs of landscapes, and basic map components have been loaded to a map server system with GIS software which can be used to create web pages with maps, attribute tables, and photographs. Users can change the geographical area of the map, the map components, and the contents of the data table displayed. This system permits easy on-line browsing of the information in the database from anywhere in the world.

KEY WORDS: Poland, towns, historical landscapes, GIS, Internet map server.

INTRODUCTION

Localities in Poland (including cities and villages) often present historical layouts and traditional buildings constructed in the Middle or Modern Ages. They include highly valuable cultural monuments such as the historic center of Kraków, a UNESCO World Heritage site. The construction of a database of Polish towns and historical landscapes will be helpful for those who are interested in the history and geography of Central and Eastern Europe. The Polish government has published maps showing the location of towns, historical town layouts, churches, and castles. K. Saito, T. Oguchi and M. Grossman (1998) compiled lists of towns with historical landscapes from these maps. T. Oguchi

and K. Saito (1999) compiled the basic spatial data for Poland such as elevations and river systems from global GIS data. These data were input to a GIS database.

A system for accessing the information in the database via the Internet was set up. The system uses IMS (Internet Map Server) technology to enable the concurrent presentation of text information and map images (e.g., Plewe 1997; Harder 1998). The system permits viewing the data from anywhere in the world, using popular web browsers such as Microsoft Internet Explorer and Netscape Communicator. This paper introduces the components of the database, the characteristics of the map server system, and instructions for using the database.

DATABASE

TOWNS AND HISTORICAL LANDSCAPES

The database contains information about Polish towns, historical layouts, churches, and castles. A list of Polish towns was compiled using an administrative map *Polska Mapa Administracyjna* (1999). From the list, towns with historical layouts, churches constructed before the 19th century, historical castles, and remnants of old city walls were selected using tourism maps *Mapa Krajoznawcza* (1994-1995) and two types of topical maps *Polskie Ośrodki Kultury Religijnej* (1995) and *Polska Mapa Zamków* (1997). Text explanations of the historical landscapes in the selected towns were compiled from the tourist maps. Towns without historical landscapes and with less than 10,000 inhabitants were omitted from the list unless they are county seats. The final list includes information about 687 towns.

The data in the list were then converted into GIS point data with attribute tables. The projection of the data was converted from the longitude/latitude coordinate system into the UTM-34N system with a metric distance scale. The conversion was performed using IDRISI (Clark Labs). Finally the data were saved into an ArcView (ESRI) shape file.

MAP COMPONENTS

GIS data for the Polish border, hydrological network, major roads, and rail lines were selected from the "Digital Chart of the World" (DCW) set of global data, published by ESRI. The projection of the selected data was converted into the UTM-34N system using IDRISI. Raster elevation data for Poland and surrounding areas were taken from the GTOPO30 Digital Elevation Model provided by the US Geological Survey. The original data with a grid interval of 30 arc seconds were re-sampled into data with a 1-km metric interval on the UTM-34N projection using the Kriging interpolation module of SURFER (Golden Software). All these data were loaded into ArcView after file format conversions.

SERVERS

To enable the browsing of the data via the Internet, two server computers were set up. The computers are connected to the intranet at the Center for Spatial Information Science (University of Tokyo) and to the Internet.

ArcView with the Internet Map Server extension is running on the map server computer. Several files in the database have been loaded to ArcView to create the html and image files of the initial default web page. ArcView then forwards them to a directory on the web server computer. When external users access the web server from the Internet, the html and image files as well as a Java applet called MapCafe are sent to the client computers. The applet enables users to change the scale and contents of the map, and to show the attribute table of a town when the town on the map is clicked. When Java requests from users are sent to the map server via the web server, ArcView provides new html and image files and sends them to the web server. The web server forwards the files to client computers, and users can see updated maps or data tables.

BROWSING DATABASE

The users of the database first activate a web browser on a computer connected to the Internet. The browser needs to be configured to accept Java applets. The URL of the initial web page of the database is:

<http://www.csis.u-tokyo.ac.jp/~oguchi/pol.html>(as of April 2002)

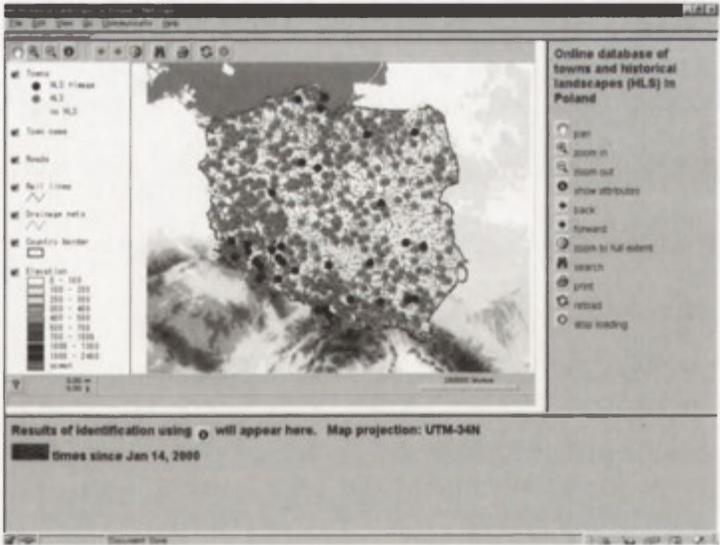


Figure 1. Initial web page for accessing the database

The initial page consists of three frames (Fig. 1): the map, legend, and tool buttons (upper left frame); the database title and explanations of tool buttons (upper right frame); and the space to show the attribute table and the access counter (lower frame). The map consists of the seven data components shown in Table 1. Although the structure of the web page is similar to the default setting of ArcView IMS, we modified page contents and frame structure by rewriting some html files.

Table 1. Components of the map.

Name in the legend	GIS data type	Note
Towns	Vector, point	With an attribute table; classified into 3 types: <ul style="list-style-type: none"> • with historical landscape(s) and photo image(s); • with historical landscape(s) but no images; • without historical landscapes
Town name	Vector, text	Name of towns; fixed size
Roads	Vector, line	Major roads
Rail lines	Vector, line	All rail lines
Hydrological network	Vector, line	Major hydrological network including the outline of lakes and ponds
Country border	Vector, polygon	Only the outline of the polygon is shown; inside is transparent
Elevation	Raster	Elevation data with a 1-km grid interval

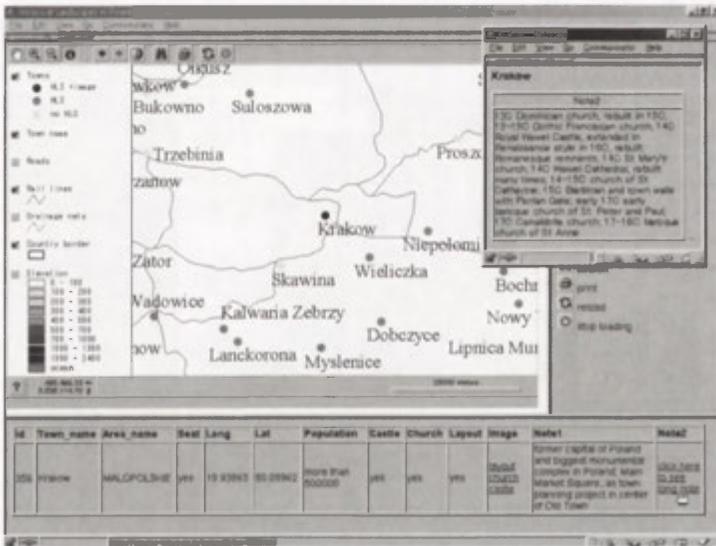


Figure 2. Map of the Krakow area with reduced components (no information about roads, river systems, and elevation) and the attribute table for Krakow.

Table 2. Contents of the attribute table.

Abbreviation	Content	Data type
Id	Identification number of the town	Number
Town_name	Name of the town	Text
Area_name	Name of the province in which the town is located	Text
Seat	Whether the town is the county seat	Text ("Yes" or "-")
Long	Longitude of the town	Number (in decimal degrees)
Lat	Latitude of the town	Number (in decimal degrees)
Population	Population class of the town	Text (classified into 8 categories)
Castle	Presence/absence of historical castle(s)	Text ("Yes" or "-")
Church	Presence/absence of historical church(es)	Text ("Yes" or "-")
Layout	Presence/absence of historical town layout(s)	Text ("Yes" or "-")
Image	Hyperlink(s) to photo image(s) of historical landscape(s)	Text ("castle", "church" and/or "layout" with hyperlink(s) or "-")
Note 1	Explanatory note of historical town layout(s)	Text (phrases/sentences or "-")
Note 2	Explanatory note of historical castle(s) and church(es)	Text (phrases/sentences, "click here to see long note" with a hyperlink, or "-")

If the map scale becomes sufficiently large after the zoom-in tool is applied, the labels of town names can be read. By clicking the check boxes in the legend to the left of the map, users can select the desired combination of map components (Fig. 2). When a user clicks the show-attribute tool and subsequently clicks on the location of a town on the map, an attribute table appears on the lower frame (Fig. 2). Table 2 summarizes the contents of the attribute table. If the photo image of a historical landscape exists in the database, a hyperlink text is shown in the attribute table (Fig. 2) and it allows for viewing of a new window of the web browser (Fig. 3).

There are two types of text explanations for the historical landscapes: Note 1 is about the town layouts, and Note 2 is about the churches and castles. Due to technical restrictions in ArcView, the length of each text selection in the data table cannot exceed 255 characters. However, nine towns (e.g. Warszawa and Kraków) have text (Note 2) longer than this limit. The attribute tables for these towns include a hyperlink to another web page with the complete text of Note 2.

If users click the search tool button, a dialogue box appears enabling users to find towns using a key word such as the town name. As the result the map automatically zooms in to the area around the center of a chosen town.

All the web pages and information in the database are written in English. The names of Polish towns, churches, and castles sometimes include characters unique to Eastern European languages. In the database, they are replaced with English characters with the closest appearance to the Polish letters.

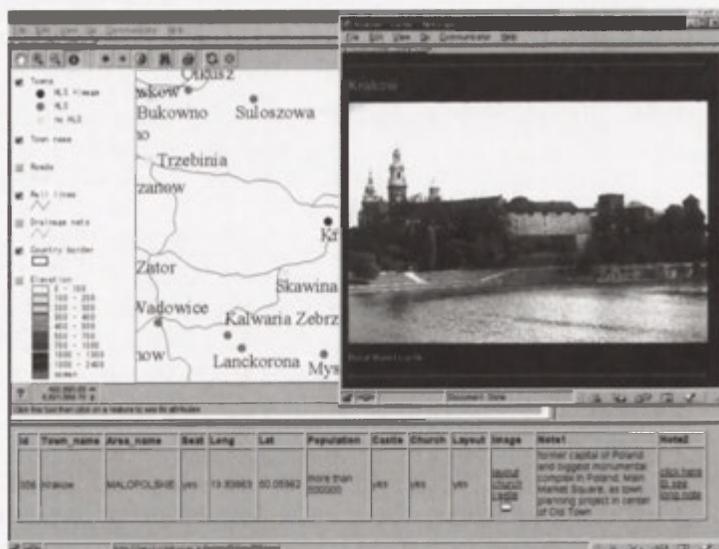


Figure 3. Explanation of churches and castles in Krakow.

CONCLUDING REMARKS

This paper describes an example of a geographical database using a map server system. GIS and the Internet are two important computer-related technologies for the future progress of geography. GIS enables various geographical applications to be performed including quantitative spatial analyses, and the Internet allows for the quick retrieval of geographical data for many regions of the world. IMS technology combines GIS and the Internet to permit the efficient presentation of geographical data with maps. It is important to examine how this promising tool might be used to facilitate geographical studies.

We would like to keep running the map server system introduced here for as long as possible. Although the structure of the system may not change significantly in the near future, we would like to extend and update the database. The addition of photographs of historical landscapes is particularly important.

Acknowledgements

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BOOK REVIEW

Rains, Landslides and Floods in the Darjeeling Himalaya

by L. Starkel and S. Basu (eds), Indian National Science Academy,
New Delhi, India, 2000, 168 pp.

This book is a result of the collaborative scientific exchange programme between the Indian National Science Academy and the Polish Academy of Sciences lasting from 1984 to 1996. Some scientists from the Indian universities were also involved in the team.

Contents of the present volume are: following the preface by the editors, (1) Mountains of the monsoon tropics (rainfall, hydrology and geomorphic processes). (2) History of research and methods. (3) Environment: geology, soils, relief, climate, natural vegetation, land use changes and population pressure. The authors in these chapters are S. R. Basu, W. Froehlich, S. Sarkar, L. Starkel, and R. Soja. (4) Rainfall characteristics by L. Starkel and I. Kasza. (5) Mechanism of slope processes and their evolution (typology of slope processes and forms, runoff generation, mass movements created during extreme rainfalls, landslides and water management in Darjeeling town, landslides along roads, landslides in the Lish basin, Ambootia (an example of an active landslide valley, and the role of mass movements and tendencies of slope evolution). Authors here are E. Gil, S. Lama, L. Ghatowar, in addition to those of the previous chapter. (6) Floods, sediment load and channel formation (geomorphic characteristics of basins and river channels of various orders, runoff and suspended sediment load in a small catchment, the generation of flood and sediment loads, channel formation during the flood of 1968, channel changes in mountain valleys of various order, and channel changes in aggrading rivers at a mountain margin. The authors are S. Patel and others from the previous chapters. (7) The role of extreme events in the transformation of the Darjeeling Himalaya, by Starkel and Froehlich. (8) The present and future of the Darjeeling Himalaya, by Starkel. And, (9) The case of the Darjeeling Himalaya in the context of environmental changes in the mountains of the monsoonal tropics, by Starkel.

As may be seen from the title and the contents of the book, the main concerns are geomorphological processes approached with detailed climatological and hydrological analysis. The region under study is world famous for being the wettest part of the world; annual rainfall ranges from 2,000 mm to 5,000 mm, with wide year-to-year fluctuations. The central region with heavy rainfall of 500-900 mm in 1-3 days occupies the area upto 3-4 000 km², but its spatial differences are not small. The description of the Darjeeling hills during the extreme event of October 1968 is particularly valuable, because we have never had such a case study.

The geomorphological approach was comprehensive. For example, it was shown that a very high percentage of sandy and coarser particles reaching up to 50-80% of the total is a characteristic feature of the grain composition of soils over the Darjeeling gneisses, as well as the Damuda and Daling series. A high content of coarser debris is present on the steeper slope segments.

Because of the sharp upward trends noted for populations, forest area is declining at a high rate. While, in 1901 about 51.5% of the total area of the Darjeeling district was covered by forest, by 1981 the figure has fallen to 38.2%. This paved the way for soil erosion, a reduction in groundwater storage and other disasters.

In a chapter on rainfall characteristics, the secular fluctuation of annual rainfall, number of rainfall days, continuous rainfall hours, observed maximum daily, hourly, or minute rainfalls, and heavy downpours are dealt with in reference to the areas affected and frequencies of occurrence. They give particularly important information.

The typology of slope processes and forms are well described showing figures such as infiltration rate of top soil depending on various land uses, and thresholds of rainfall at which dispersed overland flow commences. A model of the runoff mechanism during extreme rainfalls is presented, then mass movements created during the extreme rainfall event of October 1968 are described in detail with many pictures. This part can be expected to contribute strongly to our knowledge in the sciences concerned. In particular, it is shown that landslides along the road, debris slides within towns, etc. are worthy of mention. The authors also give recommendations based on their study results and these chapters are the highlight of this book.

Floods, sediment load and channel foundation are described and a table is dedicated to showing morphometric characteristics in the respective surveyed catchments basins. This can be useful in comparing values with other wet regions of the world.

In short, the book under review should be recommended, particularly to those researching hydrological geomorphology - as well as climatological geomorphology - not only in South Asia, but also in the humid regions of the world in general.

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Prof. Emeritus, Univ. Tsukuba, Japan

<http://rcin.org.pl>

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