THE DANUBE...
FOR WHOM AND FOR WHAT?

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FOREWORD

The Danube River receives water from more than a hundred tributaries, drains sediment and waste from a huge basin encompassing 76 million people from ten nations. The Danube's main waterway passes through ten cities of more than 100,000 inhabitants.

Conflicts of interest have always been smouldering between communities and varieties of users, but they have become more acute since the collapse of the Soviet authority: the development of hydroelectricity requires the construction of dams; navigation relies on a steady flow through calibrated channels; but irregular flow and even floods are indispensable for alluvial ecosystems, for fishing and agriculture; farming needs quantities of clean water, urban and rural populations also need potable water while industrial production, thermal and nuclear power plants draw on the river for cooling, and pollute the same river. Needless to say, all these conflicts become more severe because they are by essence, international.

As early as September 1990, less than one year after the downfall of the Soviet empire, I made a preliminary survey of the Danube, flying from its source to its delta. From my helicopter, it was obvious that the three main and characteristic problems of the Danube were the Gabcikovo dam, the Kozloduy nuclear plant, and the delta itself.

The Gabcikovo dam, seen from the air looks like a huge scar, cutting across a splendid alluvial forest. The problem raised by this monstrous project is exemplary. It involves energy production — water resources — fishing — forestry — national boundaries and the protection of natural ecosystems. It illustrates the complexity of environmental problems: systematic analysis of water is, today, insufficient. Holistic ecology includes all issues, environmental, political, economic, social, analyzed not only in the short term, but also in the long and the very long term.

The Kozloduy nuclear power plant in Bulgaria includes six reactors; four of them are of obsolete design, poor condition, and represent for all Europe a potential, closer and more drastic threat than the Chernobyl disaster. Its study was exemplary, because it revealed that, in the Eastern European countries, energy was wasted to such a degree that, if energy saving was comparable to the German level, those countries could afford several years of rapid development without needing new sources of energy.

The third critical area is the vast delta of the Danube, where the river's waters split in three main branches, enclosing a rich province of marshes, lakes, canals and woods gifted originally with a great variety of fish and serving as nesting grounds for hundreds of thousands of migrating birds such as pelicans and swans. This

unique natural park has been subject to damaging enterprises: digging transverse canals which obstruct the normal flow of water, a tentative polderisation, attracting foreign hunters, mining non-existent minerals, harvesting reeds for a paper mill that proved abortive, etc. However, the delta still remains unique and requires energetic but reasonable protection. It has been proposed that UNESCO declares the delta part of human-kind's heritage.

There is a striking contrast between the reasonable and picturesque way the river banks are doted in Germany with both historic castles and clean factories and further east, with old fashioned, polluting industrial "combinats". Urgent and elementary environmental protection measures must be implemented without delay. The international community has the responsibility to provide efficient aid to all the countries undergoing the difficult transition between state-planned and free-market economies.

As early as 800 AD, Charlemagne wanted to dig a navigable canal joining the Rhine and the Danube. The idea of a fluvial navigation system between the North Sea and the Black Sea was revived recently, and the canal Rhine-Main-Danube (RMD) was inaugurated in 1992. Earlier, the Constanza canal, bypassing the delta had been opened to barges and seagoing vessels. It remains to be seen what proportion of the freight will use fluvial, road, rail or air transportation.

Facing the above-mentioned incomplete list of conflicts, Equipe Cousteau and its partners, after two years of thorough investigations, now propose constructive and practical solutions: optimum exploitation of renewable energy sources and maximum energy efficiency — protection of the alluvial floodplains and of the delta considered as part of the world's heritage — realistic management of fluvial transportation — improvement of the water quality of the Danube. All such measures must be taken in the perspective of the long (or very long) term.

Finally, we propose the creation of a Supreme Council of the Danube. This international body would collect all available data on the environment in each Danubian country; it would issue proposals in fields as diverse as energy, transport, natural parks, tourism, water, atmospheric and soil pollution. These recommendations would help each government decently protect the rights of Future Generations in this part of the world.

Jacques-Yves Cousteau

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Equipe Cousteau

Pursuing and expanding the experience of The Cousteau Society, founded in the United States in 1974, in March 1981 the Fondation Cousteau was created in France. On January 1st, 1992, its name was changed into Equipe Cousteau.

This non-profit organization, presided over by Captain Jacques-Yves Cousteau, is devoted to studying the complex relationship between human populations and the aquatic system. Through expeditions led on the largest rivers of the world -the Nile, the Saint Lawrence, the Mississippi and the Amazon- the Cousteau teams acquired a significant knowledge of river ecosystems.

At the beginning of the 1980's, with the energy crisis imposing new research in renewable energy sources, Equipe Cousteau developed a wind-propulsion system, the Turbosail ®, on the ships *Moulin à Vent* and *Alcyone*.

Equipe Cousteau is currently leading a campaign for the Rights of Future Generations to an uncontaminated and undamaged Earth.

European Bank for Reconstruction and Development

The European Bank is an international institution with a capital of ECU 10 billion. Its members comprise forty countries, the European Economic Community and the European Investment Bank. The bank's objectives are to provide loans and equity investment to qualified applicants so as to foster the transition toward open market-oriented economies and to promote private initiative in the countries of Central and Eastern Europe committed to multi-party democracy and pluralism.

We welcome any additional information or statistics relevant to this document.

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The work was carried out under the general direction of Bertrand Charrier.

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We are very grateful to the official authorities from all the countries crossed by the Danube without which nothing would have been possible.

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ACRONYMS AND INITIALS

CEC	Commission of the European Communities
CIS	Commonwealth of Independent States
CMEA	Council for Mutual Economic Assistance
CNRS	Centre National de la Recherche Scientifique (France)
DDBRA	Danube Delta Biosphere Reserve Authority
GDP	Gross Domestic Product
IAEA	International Atomic Energy Agency
IUCN	International Union for Conservation of Nature and natural Resources
OECD	Organization for Economic Cooperation and Development
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WANO	World Association of Nuclear Operators
t	ton (metric)
Mt	million tons
toe	ton of oil equivalent
ktoe	1000 toe
Mtoe	million toe
MW	MegaWatt (10^6W)
kWh	kiloWatt.hour
GWh	GigaWatt.hour (10^9Wh)
TWh	TeraWatt.hour (10^{12}Wh)
DDT	Dichloro-diphenyl-trichloroethane
PCB	Polychlorinated biphenyl
PAH	Polycyclic aromatic hydrocarbon
HEOM	Hexane extractable organic material
Bq	Becquerel
Ci	Curie
Gy	Gray
Sv	Sievert
Bucharest Declaration:	Declaration of the cooperation of the Danube countries on water management and especially water pollution control issues of the River Danube, accepted in Bucharest, December 13, 1985
Ramsar Convention:	Convention on Wetlands of International Importance especially as Waterfowl Habitat, known as the Ramsar Convention from its place of adoption in 1971 in Iran (entry into force late 1975).

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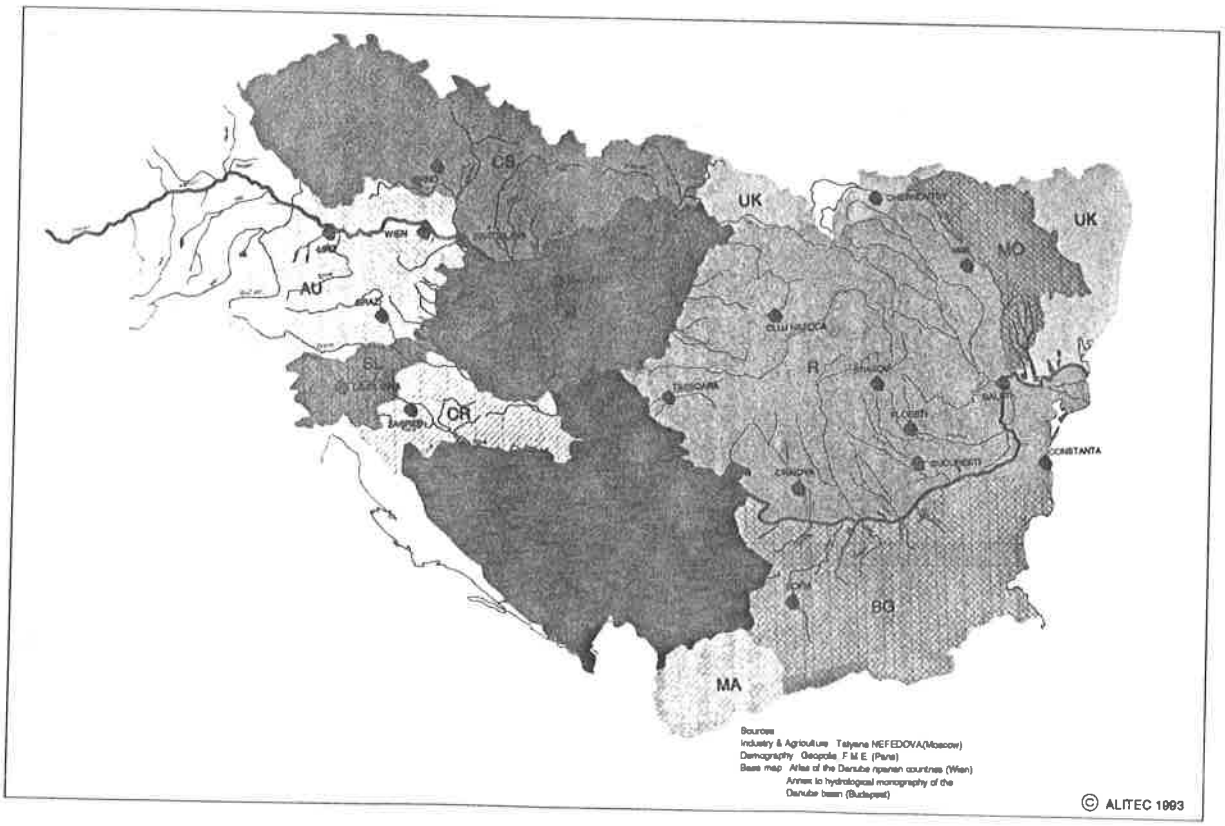

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MAIN RESULTS AND RECOMMENDATIONS

PART 1
WET ZONES OF THE DANUBE ALLUVIAL FLOODPLAINS AND DELTA

Equipe Cousteau, acting on the basis of two years' exploration and field study of the great alluvial plains of the Danube, has carried out an interdisciplinary and international research programme with the aim of developing a proper comprehension of how these river systems work and highlighting their role in order to envisage complete overall management enabling them to be conserved. This research work, which is based on the synthesis of knowledge acquired concerning western European and American rivers, had the objective of extrapolating lessons from mistakes in the management of developed rivers in industrialized countries and of stimulating experience transfer between Eastern and Western countries in order to prevent the types of irreversible mismanagement that caused the disappearance of the alluvial forests which formerly lined all the western European rivers.

ALLUVIAL FLOOPLAINS

The alluvial zones of the Danube basin constitute a unique heritage which is necessary to the river's life and to quantitative and qualitative maintenance of the groundwater tables, and consequently to the quality of drinking water for millions of people. They are the richest natural regions in Europe in terms of biodiversity, biomass and productivity.

Alluvial floodplains play a key role in the life of the river, to which they are closely linked: a large part of the fauna reproduce and develop in these plains, and they serve as a refuge from pollution and flooding. They are also used by animal and plant species as migration and travel corridors.

Alluvial floodplains, but mainly alluvial forests, provide a most efficient system for purifying water and recycling organic matter. The assimilation of nutrients (phosphates, nitrates) by terrestrial and aquatic plant life in the alluvial plain offers an important low-cost and efficient means to purify not only the water of the river but also the groundwater.

Alluvial plains also offer protection against flooding, by slowing the flow and giving the water space to spread out. In addition, the vegetation along the riverbanks and the plain generates friction that further slows water speed, and seepage decreases flood level. The present trend of canalization, on the contrary, increases the power and propagation speed of a flood.

These alluvial floodplains are threatened and run the risk of being definitively lost if immediate measures are not taken for their conservation. The drying out of the Hungarian Szigetköz and of the Slovakian Csalloköz caused by diverting the Danube to fill the Slovakian Gabcikovo dam and the destruction of the alluvial forest of Kopacki Rit by the war in Yugoslavia are serious warnings.

RECOMMENDATIONS

The wet zones of the Danube constitute a unique heritage and it is the duty of national and international authorities to preserve them for future generations. All efforts that have already been made to protect these natural zones, which ought all to be classified by UNESCO, will be in vain if the social and economic situation of the countries through which the Danube flows does not improve.

• Experimental project for the restoration of the Gemenc alluvial forest

The Gemenc alluvial forest in Hungary is thus now the last great alluvial zone of the Danube still intact. It has recently been classified as a "wet zone of international significance" under the Ramsar Convention. Although the Gemenc is not entirely unscathed, it does constitute a prime site for successful completion of an interdisciplinary and international research programme and a pilot project devoted to restoring an alluvial plain.

The work could serve as a model for all such attempts made on the Danube or other rivers in temperate regions.

• Creation of a "green corridor" along the Danube banks

To ensure long-term protection, a "green corridor" should be created along the banks of the Danube which will connect alluvial floodplains to each other. Except in towns, the riverbanks must be allowed to revert to their natural state in order to expand the gene pool of alluvial plain species which are now isolated.

The banks of the Danube must be redeveloped by:

- relocating the dikes by about several hundred meters on each side of the low water bed,
- reinstating connections between the main river channel and secondary channels,
- destroying certain groynes which concentrate water flow in the direction of the navigation channel at the expense of the alluvial zones.

• Maintaining river flow irregularities.

High-low water alternations are vital. The construction of any new dams must therefore be prevented.

• Classification of wet zones by international institutions

Like the Danube delta, the alluvial floodplains must be the beneficiaries of international classifications from UNESCO or Ramsar for example, which recommend management and protection regulations.

THE DANUBE DELTA

Equipe Cousteau has been conducting field studies in the Danube Delta in cooperation with inhabitants, scientists and officials. The Cousteau team spent several weeks in the heart of the delta, both in winter and in summer. The team used all available means (helicopter, Zodiac, rowboat...), to explore the delta including its hardest-to-reach areas. Numerous meetings were organised with local people and special attention was paid to their vision of past and future changes in their region. The methodical grid-pattern helicopter survey of the delta played an essential part in the generalization of accurate but spotty field-collected information.

The Danube delta is still an unusually rich natural area, despite the sometimes heavy deterioration it has undergone in places. It constitutes an exceptional heritage recognized by the international community; as a UNESCO "Biosphere Reserve" its protection must receive absolute priority. Consequently, Equipe Cousteau paid particular attention to compiling an inventory of the ecosystem and to proposing a management plan which enables the inhabitants of the delta to live suitably by taking advantage of the riches of the delta while protecting them.

This work, carried out in close cooperation with the Ministry for the Environment, Romania, and IUCN, was presented at the Bucharest conference "Tourism and Conservation of Deltas" (September 1992).

RECOMMENDATIONS

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• Political driving force and legal framework

The considerable effort expended to achieve appropriate development of the Danube delta and protect this exceptional part of the world's heritage is likely to fail if it is not supported by a visionary political driving force. This political driving force needs a legislative framework consistent with application of the management recommendations made under the aegis of the Biosphere Reserve.

The Biosphere Reserve Authority will have to ensure that relations between local people and the various agents involved in developing and managing the delta remain on a human scale, so that this unique European natural area continues developing in a harmonious way.

Conservation of the alluvial plains and delta of the Danube is not a responsibility of merely national magnitude, but indeed one of international proportions. It is the responsibility of all the countries in the Danube catchment area, which must all take an overall interdisciplinary view in space and time. It would be useless to protect the delta if structures, such as dams, which limit the flow variation are built on the Danube or if measures were not implemented to reduce pollution upstream.

• Passive conservation

The reed marshes and the plaur (floating island made of reeds and decomposing vegetal matter) are so immense and impenetrable that they provide excellent protection to wildlife, especially the remarkably abundant birdlife. Before launching a costly and uncertain conservation programme, one should rely on the area's impressive capacity for natural regeneration and encourage passive conservation. If the delta is to be effectively preserved, some areas should remain hard to penetrate or even inaccessible. The waterway is the only access into the delta, and it must remain so. The canal network must not be extended.

• Isolating activity zones with buffer zones

The delta is large enough to allow for the creation of strictly preserved zones together with zones where traditional activities such as crafts and a controlled form of tourism (ecotourism) can develop. The delta people are practically self-sufficient and draw little benefit from major economic activities on a national scale. Their life-sustaining activities are not detrimental to the delta ecosystem, unlike the high-impact large-scale ones. If harmony between nature and inhabitants is to be maintained, it is preferable to isolate current activity zones and to prevent their extension with buffer zones, rather than surrounding preserved zones with buffer zones. This implies creating a legal framework which, while making life better for people in the delta, would prevent any large-scale alteration liable to upset its overall ecological balance.

• Ecotourism and accommodation with local people

In no case should tourism in the delta be considered, or its development planned, as a major source of currencies for Romania. Such an activity must remain moderate and be only one financial resource among others for the delta region's inhabitants.

The development of large hotel complexes which would only run counter to the interests of the reserve and above all of local people should be proscribed. On the contrary, tourist accommodation with local people should be promoted by furthering improvements in local housing (sanitary facilities, drinking water, rooms, etc.). This policy will have the double advantage of controlling numbers of tourists and of enabling local people to benefit directly from the richness of the reserve.

• Development: keeping things on a human scale

International banks, such as the European Bank or the World Bank, that because of their size cannot provide direct services to private individuals will need to find ways, possibly using local banks and linking with the Danube Delta Biosphere Reserve Authority to overcome this obstacle.

PART 2
NAVIGATION AND TRANSPORT

Eastern European traffic features an oversized freight industry and low mobility of its inhabitants. Freight transportation levels are two to four times that found in Western Europe per GDP unit. Most of this traffic consists of heavy cargo shipped by train. Since 1989, the economic transition experienced by these countries has led to a major modification in the production and trading structures. Furthermore, a demand for mobility is being increasingly felt. These changes have caused a relative and absolute increase in road traffic. For most observers, the road is considered a factor for increasing development. The growth of road traffic is unavoidable and investments in this area are very profitable.

Potential development of river traffic must be assessed in relation to the strong demand currently existing for development of road traffic. Improvement of navigation conditions is a positive factor that may enhance the competitiveness of river transportation. According to the Danube Commission, this improvement requires building eleven dams.

This type of development is highly detrimental to the environment. Experience derived from dams in Austria and at the Iron Gate (Romania, ex-Yugoslavia), as well as the more recent one at Gabcikovo, in Slovakia, has underscored their effects:

- Gradual damages to alluvial areas and forests, leading to their complete destruction in the long run,
- Contamination of groundwater tables and altered exchanges between river and groundwater,
- Modification of the overall fluvial balance (erosion, sedimentation).

The Danube, unlike the other European rivers, is only slightly developed, especially downstream of Vienna (Austria). This relative freedom constitutes the river's richness, and would come to an end if the Danube is developed.

It is therefore essential to assess the economic soundness of facilitating navigation through the development of the Danube. Equipe Cousteau was unable to find any economic or environmental study concerning these development projects, and thus had to launch its own. It was based not only on the transport statistics within the former CMEA, but also on the economic development prospects of re-structuring and opening up the Eastern countries to the world economic market.

A detailed analysis of statistics giving the number of days and the sections where the river level is lower than 2.5 meters, that being the minimum recommended for navigation by deep draft barges, shows that the Hungarian/Slovakian section is the only one where frequent navigation problems occur.

It is thus unnecessary today to build the series of eleven dams recommended by the Danube Commission. The section comprised between Vienna and Budapest, a real bottleneck, including the highly controversial Gabcikovo dam, should undergo major works to guarantee the required depths. The work carried out between Vienna and Budapest would include a comprehensive project of four dams equipped with twin locks (Vienna, Hainburg, Wolfstahl and Nagymaros), according to studies carried out by the Danube Commission, and the flooding of the Gabcikovo Dam. The project can only be effective if all the dams are built; otherwise, navigation difficulties would be increased because of problems linked to incision of the river bed.

Global economic analysis of the Danubian area shows that navigation should develop around two major economic poles: modern steel industry in Linz, Austria, and the Romanian harbour of Constanza, on the Black Sea. Most of the traffic increase between today and 2020 will occur downstream from the Danubian bottleneck: roughly 21 million metric tons over the current traffic will thus transit between the Black Sea and harbours downstream from Budapest. However, the traffic increase through the Danubian bottleneck will only amount to 1.8 million metric tons if the river is developed.

Investments would consist of the four dam/lock series situated near Vienna, Hainburg, Wolfstahl and Nagymaros. These works -except for Gabcikovo- will be approximately 707 million dollars at present value (up 8%). These values have been calculated for 23 x 34 m locks and for dams with the characteristics defined by the Danube Commission according to simple estimation formulas used for similar calculations in France during previous project evaluations.

These direct costs are initially to be compared with the benefits for navigation alone, estimated at $ 180 million in 2020, based on a conservative hypothesis that incorporates direct benefits. They are estimated at about $ 360 million using a more liberal basic assumption. The share of induced or new traffic volume directly linked to the improvement represents less than $ 30 mil-

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Water transportation is certainly a way to limit road congestion due to transportation of heavy materials. However, one must use barges suited to the river rather than transform the river to adapt it to the barges. Such transformations would be detrimental to the preservation of the river ecosystem and are not financially justified.

• To set a transport strategic master plan

The additional investments required by the current situation in Eastern Europe must be incorporated into a master plan which is strategic in that it covers all forms of transportation combined. Only well-negotiated international planning will make it possible to better distribute the means of transportation, i.e. lessen the importance of the road networks.

The current restructuring of industry offers the opportunity for an innovative policy of land development which strongly determines transportation system. Planning and controlled building must be considered in all events, with new schemes which do not copy those of Western Europe, which display their failures more obviously as each day passes.

• To avoid the excesses and aberrations of road domination

The search for solutions favoring the use of several means of transportation (multiple transport) would make the road network and automobility the cornerstone which will structure the organization of the transportation system. To avoid the excesses and aberrations of Western transportation systems, we propose three orientations:

- for freight, the development of competitive combined transportation, i.e. rail/road, river/road and sea/road;
- for travellers covering medium and long distances, competitive rail transportation must be made available;
- in urban areas, strict control and mastery of automobile traffic, and a fresh boost to the development of public transport.

The current policy is hooked up to road transport pressures. It consists of tagging along after demand in order to satisfy it. It is not enough to provide incentives, as it is well-known that there is no return from road to watercourse or rail. The States must favour collective transportation, not only at the national level, but at the Europe-wide level, too.

• The Danube does not become a large-gauge channel

The transformation of the Danube into a large-gauge channel must be prevented. It seems greatly preferable and far less expensive to use fleets suited to the river's irregularity, as the Romanians and Ukrainians have already been doing.

Nothing at this stage justifies the building of the eleven dams planned by the Danube Commission.

• To invest next to the Danube

So as to enhance the role of river transport, either by itself or as an element of combined transportation, it seems essential and profitable to invest next to the Danube. These goods-connection priorities require large organizational investments which will particularly affect the distribution, bulking and break-bulking infrastructures.

They require that numerous port, river, sea and land infrastructures whose functionalities are inefficient or deficient be reconsidered.

Sites for harbour infrastructures should be selected according to a process that takes navigational difficulty into consideration.

lion, and it would be $ 120 million in the most favorable hypothesis. Consequently, on the horizon 2020, it appears that the benefits for navigation can be expected to represent at best about 50% of the cost of necessary works. On the other hand, if direct benefits alone are taken into account, on the improved section alone, the percentage drops to 25%.

Developing the Vienna-Budapest sector will not be directly profitable for navigation (negative internal rate of return). The impact of these investments on the overall productivity of the fleet is not negligible, but it will not generate substantial profitability. Maximum profitability will be roughly 2.5%.

The beneficiaries of this investment will of course be the fleet operators, and therefore their clients. While Romanian and Hungarian farmers will be among the indirect beneficiaries of a more productive fleet, the Linz iron and steel industry in Austria would be the only direct beneficiary if the Danubian bottleneck were developed.

It seems that both the consequences of opening the Rhine-Main-Danube canal and the possibility of switching traffic from one mode to another have been overestimated.

Actually, selecting a mode of transportation depends not only on cost, but also on benefits obtained in terms of speed, frequency, reliability.

In spite of financial advantages, the experience in Western countries has shown that there is practically no transfer from road transportation to waterways, while on the contrary, road and train transportation gradually overtake the market share of waterway transportation.

PART 3

ENERGY IN THE DANUBIAN COUNTRIES

The problems of environment cannot be dissociated from energy production and use. Poor energy management, whether it is from fossil or nuclear sources, is one of the main causes of serious environmental damage in the Danube region.

The studies carried out by Equipe Cousteau and its partners dealt with:

- Analysis of global energy indicators (energy intensity, consumption by sector, consumption distribution according to energy sources) for the Central and Eastern European countries.
- Developing new energy policy proposals based on improved energy efficiency and greater use of renewable energy sources. The objectives for the Danubian countries should be to achieve a level of energy intensity comparable to that of Western Europe as quickly as possible, that is to say, in less than fifteen years.
- Proposing concrete projects in the domains of lighting, industry, transport and building which have rapid effects on the energy and finance system of the nation.

Such a new policy must include necessary measures enabling unsubsidized market pricing, regulations, incentives, responsible and human-scale institutions, clear programmes, sufficient financing.

A thorough survey was carried out of the safety of the four older nuclear reactors at the Kozloduy nuclear plant in Bulgaria, known to be the most dangerous VVER reactors still in operation in Central and Eastern Europe.

Renewable energies such as solar, biomass, waste constitute a little-exploited source of energy which we have evaluated. The new environmentally sound energy policy must give top priority to renewable energies.

The development and application of this new energy policy call for changes in thinking rather than new technology. The three-day conference in Sofia, Bulgaria, organized by Equipe Cousteau and EcoEnergetica, entitled "Citizens Concerned by an Energy-efficient and Environment-respectful Society," laid the basis for these changes.

RECOMMENDATIONS

Rational energy use, the cornerstone of any strategy for a sustainable future, has a positive impact on the environment and the well-being of the citizens of these countries. It is the responsibility of the international community, especially Western Europe, to share in the efforts and sacrifices of which the Danube countries will bear the brunt in making a successful transition toward an energy-efficient and environment-respectful society.

• To develop a new energy policy

Energy efficiency policies should be developed in all Danubian countries through:

- Planning of energy supply and demand.
- The creation of an expert group subordinate to the Prime Minister of each State, which will be in charge of the definition and follow-up of the energy efficiency policy.
- The creation of institutions at the national and the local levels to establish programmes for improving energy efficiency in the various sectors of activity and helping the appropriate partners and economic agents to implement them.
- A system of regulations to promote the rational use of energy, in particular for new buildings and electric appliances.
- An appropriate system of incentives to stimulate and promote energy efficiency improvements, initiatives, and projects, and corresponding mechanisms to facilitate financing of investments and programmes.
- National training programmes in energy efficiency for technicians, planners and engineers, managers, architects, local and municipal officials.
- A National Fund for Energy Efficiency financed by 1% of the bills paid by energy consumers on the final energy consumption to finance national energy efficiency programmes.

• To increase and to improve international cooperation

International cooperation must deal with:

- Training in energy planning methods.
- Creation of a "Danubian Center for Energy Planning" in one of the countries as a center for common training and to support needed applied research and technology innovation and adaptation.
- Institution and capacity building programmes for energy efficiency.
- Natural gas development, in particular through the laying of the Iran-Europe pipeline.

• To carry out exemplary actions

Exemplary actions must be carried out in the following fields:

- Domestic, tertiary and urban lighting: i.e. the use of economical solutions such as compact fluorescent bulbs which consume five times less energy than incandescent bulbs and last eight times longer.
- Household appliances, particularly refrigerators and TVs. It is now possible to obtain models that consume half as much as models currently on the market in Western countries.

• The development of hydroelectricity has to stay moderate

Hydraulic structures have serious effects both on the general equilibrium of fluvial ecosystems and on the drinking water resources associated with them (ground water tables), effects which are not always reversible. This is why:

- Exploitation of 100% of the economically operable hydroelectrical potential is not a reasonable objective. Development of hydroelectricity must be limited and moderate.
- Installation of new plants must be the object of strict and full prior consequence studies

RECOMMENDATIONS

which take the ecological, technical and economic aspects into account along with the possibility of alternative solutions.

- The building of dams in the plains regions, in particular on the Danube, must be prohibited.
- New ways of exploiting the existing dams must be envisaged. These must incorporate moderation of their consequences (sediment and water flow management in particular).

Development of small hydroelectric power plants, when kept under control, is possible if:

- The legislative framework which must be set up to accompany their development strictly imposes consideration of the consequences on rivers at both the construction design and output management levels.
- The renovation of old small hydroelectric power plants or the installation of turbines on existing constructions which fulfill other functions (e.g. water diversion for irrigation) should be favored over the building of new construction.

• To exploit renewable energies in priority

To ensure that other renewable energies, the potential of which is estimated as at least 12% of primary energy consumption, become a priority matter in energy policies which are currently being re-defined, it is important:

- to prepare a comprehensive evaluation of the potential of the main really accessible renewable technologies,
- to set up an overall survey of industrial capacities necessary for renewable energy technologies,
- to make an analysis of the institutional and financial framework necessary to develop such policies.

• The end of nuclear energy

The application of this new energy policy is aimed at balancing energy supply and demand in all the Danubian countries without resorting to nuclear energy. Nuclear energy is not only unsafe, it is above all unnecessary. Giving it up is thus the best strategy.

PART 4
EVALUATION OF THE POLLUTION OF THE DANUBE

The decision-making process and the successful management and sustainable and environmentally sound use of natural resources require on one hand an adequate assessment of the available resource quantity and quality and on the other hand, tools to use data collected for planning and management.

ENVIRONMENTAL RESOURCES ASSESSMENT

• CHEMICAL POLLUTION •

An important study of the Equipe Cousteau Danube programme is focused on chemical analyses of sediment samples and sentinel organisms from the Danube river for a total of over 100 parameters which reflect the current state of contamination of the river with pesticides, PCBs, oil, combustion products, selected industrial chemicals and sewage.

The data base includes over 10,000 measurements, the largest information base yet obtained for the Danube sediments. It is possible to identify levels and trends of contaminants in the Danube.

The Danube is not chronically polluted in its entirety. This is partly be due to the high flushing rate of the system which is, in turn, a consequence of the enormous flow rate of the river and its seasonal variability.

There is a large number of pollution "hot spots." These reflect the discharge of waste and effluents from human activity and may be seriously damaging the river environment and the quality of its water as well as that of the associated groundwater. With the exception of lindane, the levels of chlorinated hydrocarbons and PCBs are inferior to those measured in the more industrialized Western rivers. A clear gradient of pesticides is apparent, in some cases, evidenced by a fifty-fold increase in concentrations from the upper to lower reaches of the river.

Levels of oil and oil residue are rather high in certain hot spots but are generally inferior to those in chronically polluted rivers. Concentration for most heavy metals overlaps that recorded in polluted Western rivers.

Danube sediments are often heavily polluted with sewage. This is undoubtedly related to high population densities along the river and the lack of effective urban wastewater treatment.

Any dam in the river downstream of identified sources of pollution creates a potential buildup of contaminants and, in some cases, a future "chemical time bomb." Today such a situation exists in the Iron Gate reservoir and tomorrow, it would be true for the Gabcikovo dam.

Sediment monitoring is clearly a very useful tool to detect hot spots. Although this technique and biomonitoring are not to be considered as a substitute for systematic and regular monitoring of water quality, suspended particules and effluents, they allow for a global vision of the river.

The results of the macrozoobenthos monitoring programme are entirely consistent with the chemical measurements of contaminants. They provide valuable evidence for chronic biological stress associated with contaminated sites: the benthic biodiversity decreases downstream of recognized hot spots such as major cities - Vienna, Budapest, Bucharest - or major industrial centers on the river or its tributaries (Bratislava, the Vah river, etc.). A more detailed study is now warranted which should consider a more statistically valid sampling scheme and seasonal measurements at selected sites. Such information, properly correlated with chemical measurements, could eventually lead to a Danube biological monitoring system as an expansion of the Bucharest Declaration.

• RADIOACTIVITY •

Aerial gamma spectrometry was used to study natural and man-made radioactivity along 2,200 km of the Danube's banks and around nine selected nuclear and non-nuclear industrial sites. The approach used here combines collation of local experts' reports from Hungary, Bulgaria and Romania with new analytical studies of environmental samples specially collected for the study.

This combined approach provides consensus results.

The Danube river and catchment are radiologically "clean" both in absolute terms and in comparison to other European rivers. It has few source-points and fast water flow.

The only man-made radioactivity consistently observed in the river and its basin is from the 1986 Chernobyl accident and these levels are relatively low, decreasing systematically from Budapest to the Black Sea. It can generally be observed that major variations in environmental radioactivity are the result of different activity levels of natural radionuclides. Some of these variations are caused by changing shoreline geology, others by differing land-use (e.g. use of ^{40}K rich fertilizers) and others still by industrial concen-

tration processes. In this last category, two areas near fossil fuel power stations were mapped, one in Ruse, Bulgaria, and one in Giurgiu, Romania, at which there appears to be enhanced environmental ^{226}Ra from coal combustion residues.

The survey included the areas around of the nuclear sites at Paks, in Hungary, and Kozloduy in Bulgaria. The near-site river systems at both locations are unpolluted. At Kozloduy, an area of radiological contamination was observed, this being caused by liquid waste leakage into sewage/drainage channels. The detected contamination was produced mainly by a waste management accident in 1978 but leakage is continuing. Clearly, follow-up work is required to eliminate this leakage.

This aerial survey technique also showed its detective capabilities by pinpointing the use of an industrial radiography source in a shipyard in Galati, Romania.

An unknown contaminated zone has been identified in Romania proving the potentialities of the aerial survey technique for the monitoring of environmental radioactive contamination.

TOOLS FOR SUSTAINABLE ENVIRONMENTAL MANAGEMENT

• OVERALL EVALUATION OF POLLUTION AND HIGH RISK ZONES •

Using an upstream approach, which favours analysis of data concerning human activities generating pollutants, we are able to estimate quantities of four determinants (organic matter, suspended matter, nitrogenous matter and phosphorous matter) discharged into 66 sub-basins covering the whole Danube catchment area, to identify the most highly polluting sectors of activity within these sub-basins, classify sub-basins by the degree of pollution pressure to which they are subjected, and to define a certain number of "high risk" zones.

The wet zones, the karst zones and the natural protected zones constitute sensitive areas in which pollution is particularly damaging. Mainly located in the plains of the northwest, Bratislava (Slovakia), of the center, Tisza (Hungary), and in the delta region, they represent over 22% of the total basin surface area.

One quarter of the wet zones and over 10% of the natural zones are subjected to excessive pollution. This threat is affecting the drinking water resources in this region because the large groundwater tables are located in the wet zone. The delta which represents a highly sensitive and fragile ecosystem is especially in danger as it is the outlet of the whole basin and is immediately downstream of the most highly polluted basins.

All the large capitals are on the river or a direct tributary, and generally poorly served by waste water treatment plants. They constitute a major source of pollution in the sub-basins in which they are located. In some sub-basins, the impact of diffuse population is not negligible.

Industrial pollution is particularly serious in Romania and Bulgaria. It often combines with domestic pollution from the large towns as this is where the production centers are located. This particularly applies for Bucharest and Budapest.

It is in Romania that the majority of the sub-basins most globally under threat can be found. Bucharest is wide by both domestic pollution and industrial pollution (chemical industry) and the estimated burdens of pollutant are far greater than those of the other sub-basins.

Most of the results obtained by this comprehensive pollution evaluation method based on human activities are borne out by direct pollutant measurements carried out in the context of this programme.

• GLOBAL MANAGEMENT OF THE DANUBE ENVIRONMENT •

Equipe Cousteau and its partners proposed a project to develop an advanced approach to

decision-making in the field of environmental management. This Environmental Decision Support System presented is a tool which could provide help for the Environmental Programme for the Danube River Basin, and, in a longer term perspective, for the global management of the Danube environment.

It is based on the Geographical Information System (GIS) methodologies developed to evaluate the overall pollution of the Danube river basin. In order to ensure the spread of the system throughout the Danube countries, Equipe Cousteau organized an international workshop on GIS in Environment and Water Management in Budapest from the 28th to 30th of September 1992. It gathered 43 participants and more than 30 observers coming from most of the Danube countries (excepting Germany and Romania) as well as the Netherlands and international institutions.

RECOMMENDATIONS

The requirement for control and monitoring of the Danube's environmental condition can under no circumstances justify a lack of immediate action to limit environmental contamination.

• To stop the pollution from well-known sources

The countries' capital cities, largest towns and the industries causing most pollution must adopt a long-term comprehensive water management plan and be equipped with purification plants as a matter of priority. This measure should be accompanied by an improvement in industrial processes in order to limit the amount of polluted waste entering the Danube's waters.

Measures must be implemented as quickly as possible to reduce or eradicate the causes of pollution identified by means of hot spots and high risk areas such as the Romanian sub-basins, the delta and the wet zones of the basin's central plains.

• To protect drinking water

The groundwater of the Danube basin is particularly threatened by industrial and domestic pollution. Preventive measures must be undertaken as a matter of priority. Due to the highly probable risk of a chemical time bomb, the filling of the Slovakian dam at Gabcikovo should have been postponed and the construction of new dams along the river can no longer be considered until depollution measures have been taken and safety of groundwater quality has been proven.

• To take into account the survey and monitoring of hot spots

Diffuse pollution from agricultural sources can no longer be ignored in the Danube basin. Long-term consequences of diffuse pollution are sufficiently serious to warrant precautionary measures being implemented immediately.

• To improve the monitoring of pollution and the survey of hot spots

Sediments and sentinel organisms analysis and aerial gamma spectrometry techniques which demonstrated their efficiency, must be widely implemented in Central and Eastern Europe within a legal framework, i.e. the Bucharest Declaration (December 13, 1985). A network of laboratories will be set up to monitor and control the quality of the Danube waters. Polluted zones, hot spots and dams must be monitored with the closest attention to follow up the effects of depollution measures.

• To develop the means for a global management of the Danube basin environment including the delta and the Black Sea

The recognized unity of the Danube basin system including delta and Black Sea requires that the monitoring of the state of the Danube environment and the drive for rehabilitation of the fluvial, delta and coastal ecosystems be interpreted in a comprehensive management programme.

The upstream approach to identifying sources pollution by estimating pollution-producing human activities is the main element of the project of an Environmental Decision Support System for the Danube river basin. This programme combines all the elements of the state-of-the-art Decision Support System and Geographical Information System and which will eventually yield a widespread Network of National Nodes.

This workshop made possible:

- Evaluation of the knowledge and experiences in the Danubian countries as well as on the Rhine within the Rhine-Danube programme concerning the Geographical Information Systems and their uses. We observe that:
  - Most of the countries had a rewarding experience with GIS in the field of environment and water management.
  - The obstacles which slacken GIS development have been identified.
  - Two levels of GIS use have been defined: the international level, namely the Danube basin scale, and the national or local level with its more specialized objectives. In the long term, these two levels, today in parallel, must be able to be correlated for mutual benefit.
- Presentation of the system developed by the Equipe Cousteau and its partners.
- Initiation of the GIS network in all of the Danubian countries in relation with Western participants.
- Setting-up of recommendations to ensure the development and the use of the GIS in the Danube basin.

These recommendations have served as a basis for the draft project for the "Environmental Decision Support System for the Danube River Basin." This tool aims at integrating political, economic and social, ecological and technical data in the decision process.

The main steps of this three-year project are the following:

- Adapting the methodology developed by Equipe Cousteau and its partners on a national level.
- Developing and harmonizing the data collection necessary for proper system operation.
- Testing the method upon a pilot zone, the Tisza basin.
- Diffusing the system throughout the Danube basin.

Fulfillment of these objectives will require the development of the network initiated during the workshop, information exchange, international cooperation, and a training effort.

PART 5
GABCIKOVO

A global approach to environmental problems taking the long term into account is the basic tenet of the Equipe Cousteau study programme on the Danube. As the unfortunate result of an approach limited to the aspects of hydraulic engineering and technology alone, the Gabcikovo dam is a striking example of how financial and environmental resources are wasted when the global approach is not used.

The body of research from the Cousteau Danube environmental programme makes possible a complete evaluation of the advantages of the dam on an economic level and of the consequences it has for people and the environment.

Filling the dam at the end of October 1992 had serious consequences for the alluvial ecosystems, attacked their value as a heritage (biodiversity) and the functions which they fulfill in the context of water purification, protection against flood, and biomass production (fisheries and forestry). It was thus clearly shown that there is massive incompatibility between operation of the dam according to the plans (which schedule outputs comparable to those observed: 200 to 300m³/s) and survival of the ecosystems bordering the river.

The studies carried out confirm that water resources are seriously threatened by eutrophication and contaminated sediments which are being stored in the retention lake. The numerous sources of pollution identified upstream of the dam and the significant concentrations of pollutants measured in this area are conditions for a chemical time bomb. The loss or deterioration of these water resources will have serious effects at the economic and social level, since the drinking water supply for a large number of inhabitants depends on the quality of groundwater.

The energy and navigation studies show that Gabcikovo does not yield any economic benefits. The electricity produced does not respond to any real requirement for the future and is in any

case very marginal. The dam does not alter the navigational conditions except in a very limited sector. The analysis shows that potential traffic increase resulting from development in the Hungarian/Slovakian sector is insufficient to justify the required investments. The recent problems at the dam do not demonstrate that it improves navigational conditions; indeed, the reverse is true.

A complete overall approach to the Gabcikovo dam problem makes its drawbacks apparent and it is clear that, if it had been used from the start of the project, Gabcikovo would never have gotten off the drawing table. The decision to build this dam is clearly the stumbling block of a system in which the decision-makers integrate only a very narrow range of criteria. No alternative solution which would have yielded the same energy or navigation services, implementing alternative resources less detrimental to the environment and more profitable for the economy, was seriously studied.

RECOMMENDATIONS

Solving the Gabcikovo problem and saving the endangered zone would be a landmark decision and an example for the future.

• To refill the Danube as priority

Most of the water in the Danube (95%) must be returned to the river bed as soon as possible and at the latest before the spring growth season.

• To apply the principle of precaution for the intermediate period

The principle of precaution must be applied in decisions concerning the dam's future, especially concerning how the water is managed, decisions due to be made for the near future. The Danube must not become a laboratory where experiments are carried out.

• To engage in a global integrated reflection guided by democratic principles

Basic reflection on the matter must be engaged by incorporating the technical, ecological, economic and social data and drawing on international experts, the public and non-governmental organizations for environment protection. It must lead to an exhaustive and detailed cost/benefits analysis of all alternative solutions. It must be carried out in a spirit of transparency and its conclusions must guide decisions concerning Gabcikovo's future.

• Courageous and reasonable solutions must be supported by Western countries

Our own analysis leads us to the conclusion that abandoning the dam and reinstating the site is the most courageous and also the most reasonable solution with a view to achieving a sustainable future. This solution must have the advantage of solid financial backing from Western countries and the large international financial institutions. Such aid is indispensable for implementing alternative solutions in the field of energy and navigation and for a site reinstatement project if these are to have credibility with the public and with political leaders.

PART 1

WET ZONES OF THE DANUBE ALLUVIAL ECOSYSTEMS AND DELTA

WET ZONES OF THE DANUBE ALLUVIAL ECOSYSTEMS AND DELTA

Two years of exploration and field work have convinced Equipe Cousteau that the Danube is a very rich river. Its life and richness are largely due to the presence of large active alluvial floodplains. The Danube whose flow has not yet been entirely regulated nor confined with dams, still floods the vestiges of the great alluvial forests which lay alongside all the great European rivers such as the Seine, the Rhone and the Rhine some centuries ago.

Equipe Cousteau has launched a vast study of the Danube wet zones so as to gain better understanding of their functioning and role and to propose protection and management surveys. This bibliographical synthesis has been effected by Professor Claude Amoros (University Claude Bernard, Lyon), Professor Michèle Trémolières, (University Louis Pasteur, Strasbourg) and Professor Istvan Zsuffa, (Pollack Mihaly College, Budapest).

The wet zones of a river include the alluvial ecosystems and delta. Alluvial ecosystems are both superficial and subterranean, terrestrial and aquatic and are influenced by the superficial waters and groundwaters of the main channel of the river.

These alluvial ecosystems are closely linked to the fluvial ecosystem which is not simply a discharging channel. On the contrary, the alluvial ecosystems play a crucial role in the physical and biological functioning of the great rivers and their regulation. The complexity and the diversity of these alluvial ecosystems are the very expression of the river's dynamics.

1

THE RIVER AND THE FLOODPLAIN ECOSYSTEMS: A COMPLEX SYSTEM

The most important floodplains are presented in *Figure 1.1*. The surface areas are only estimations because they vary with the flood level:

- The Austrian Auswald, on the edge of the Danube between Vienna and Hainburg, covers approximately 6,000 ha. This floodplain forest, partly protected, is gradually drying up due to sinking of the groundwater level in conjunction with the excessive gouging of the Danube river bed, caused by the Altenworth and Greifenstein dams. This is known as "incision," and is common on rivers developed by man.
- The Hungarian Szigetköz and Slovak Csalloköz comprise an exceptional meandering zone around the low-water bed of the Danube, which today still includes the border between Slovakia and Hungary. It corresponds to the old fossil delta of the Danube 3 million years ago. Today, the active floodplain has been reduced by flood protection dams and only covers 6,000 ha on the Hungarian side and 23,000 ha on the Slovak side. However, if building of the Gabcikovo dam and its canal to Bratislava is maintained, the entire zone will be annihilated.

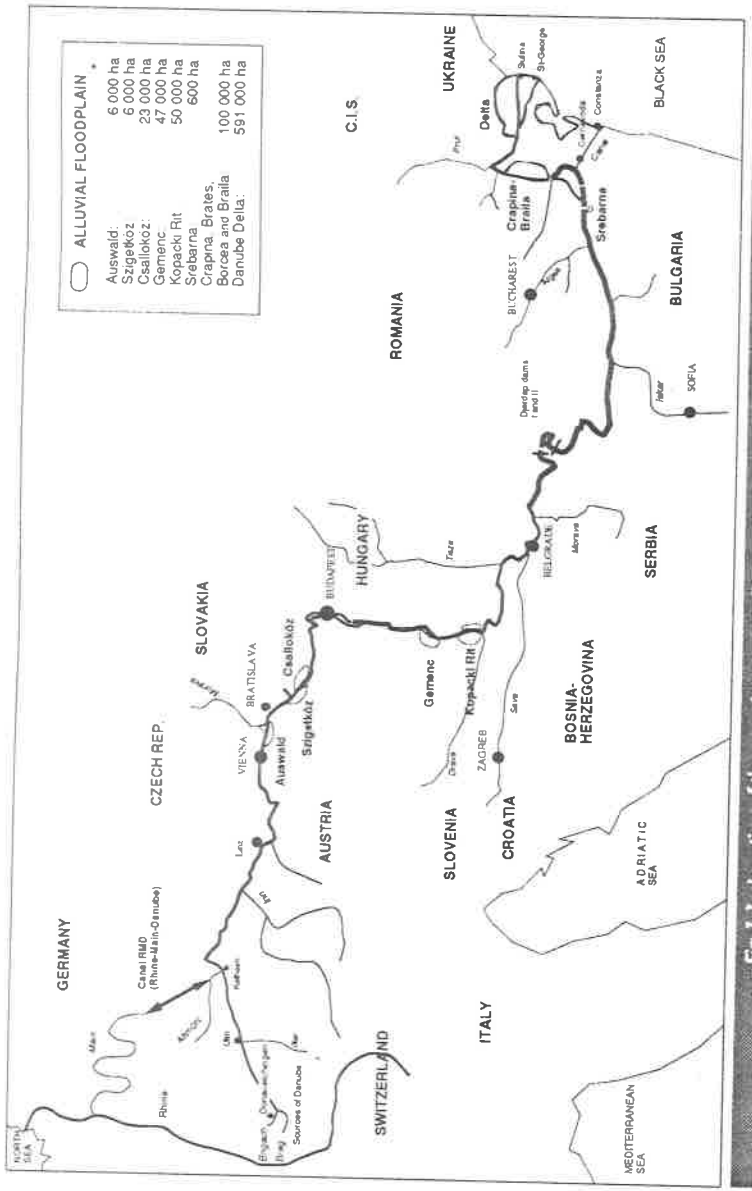


Fig. 1.1 - Location of the most important alluvial floodplains in the Danube basin.

The alluvial floodplains are the richest natural regions in Europe and they cover today less than 1% of the Danube basin area. They constitute the singularity and the richness of the Danube. During the two years of the Equipe Cousteau study two of the main alluvial floodplains (Szigetköz-Csalloköz and Kopacki Rit) have been threatened by war or development.

- The Hungarian Gemenc region covers approximately 47,000 ha, 18,000 of which are classified as protected land. This floodplain, which is exemplary in terms of resources and problems, is the subject of a detailed research programme.
- .The Kopacki Rit, which represents some 50,000 ha lying between the Drave and the Danube - now split between Croatia and Serbia - is the richest floodplain of the Danube. It is currently impossible to obtain reliable data on its situation due to the war, but we suspect there has been serious damage.
- In Bulgaria, the Sebrarna reserve covers 600 ha, set within a larger floodable zone.
- In Romania, the floodplains of Crapina, Brates, Borcea and Braila, which once covered more than 100,000 ha, are currently partly diked. They directly determine fish farming productivity in the delta.
- The Danube delta covers 591,200 ha classified as a Biosphere Reserve, including 312,400 ha classified as World Heritage. Its resources are also highly dependent on the extent of flooding.

The river and the aquatic and terrestrial habitats of the floodplain constitute one of the most complex ecological systems in the world. It is made up of a group of highly diverse, constantly interacting ecosystems: running waters of the river and its active arms, stagnant waters connected permanently or periodically to the river, temporary waters, terrestrial plant formations subject to variable flooding periods, and an underground aquatic ecosystem. The three spatial dimensions are therefore interacting *(Figures 1.2)* longitudinally along the upstream-downstream axis of the river channel, transversely between the river and the floodplain habitats, and vertically between the surface and underground waters.

In addition to this spatial complexity, there is the time dimension. Floodplain ecosystems are characterized by intensive dynamics and strong process interactions according to different time scales. The diversity of floodplain landscapes and the communities which live on them are due to both annual hydrological and seasonal fluctuations, erosion, sedimentation and plant succession processes spread over several decades, as well as incision and level rising phenomena which create river transformations over the centuries.

1.1

GEOMORPHOLOGY, HYDROLOGY AND MANAGEMENT CONDITIONS ON THE DANUBE

The geographical character of the Danube is highly variable, especially its longitudinal profile which is very irregular. The river can be divided into 3 stretches: the Upper Danube from the source to Vienna, the Middle Danube from Vienna to the Iron Gate, the Lower Danube from the Iron Gate to the Delta.

Outside of the gorge sections where the channel is constrained, the Danube has developed contrasting geomorphological patterns depending partly on the variations of the bottom slope. This gives a meandering pattern in the stretches with a slight slope, such as in the German course between the confluences with the Altmühl and the Isar, or downstream from the Hungarian town of Gönyü; a braided pattern occurs in the stretches with a higher slope, such as in the Austrian and Hungarian/Slovakian stretch.

The hydrological system of the Danube is very complex, due to its highly contrasting tributaries. The average discharge upstream from the Delta is 6500 m^3/s.

The major regulation works on the Danube were begun in the second half of the 18th century. Since then, the river bed, the bed load, the sediment transport, the hydrological system, the water quality and the connections between the river and its floodplain have been altered by continuous works developed for navigation, flood control, irrigation and power production purposes. In most cases, the result of these regulation works is a separation of an "active" floodplain still subject to flooding and a "fossil" floodplain which is no

Figure 1.2.a. - Vertical relations and exchanges between compartments of a hydrosystem (Trémolières).

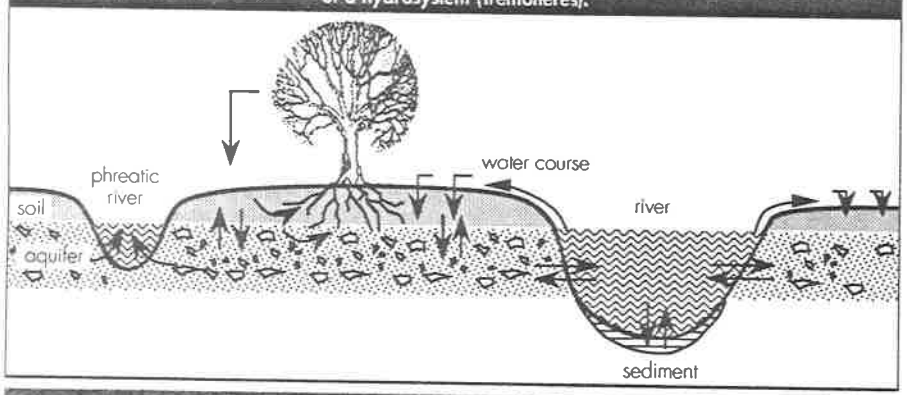
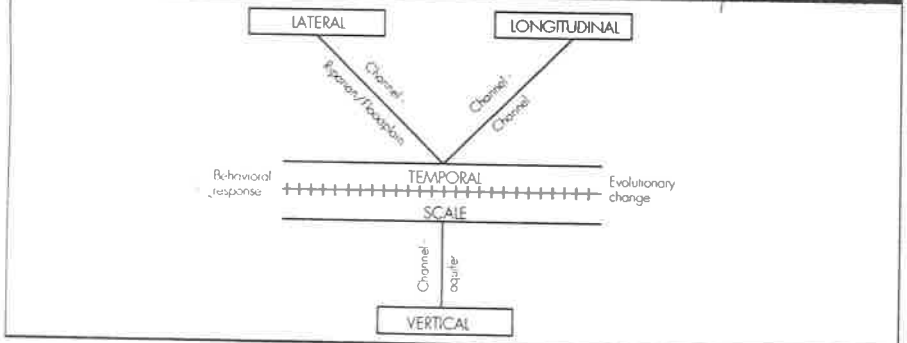


Figure 1.2..b -Schematic diagram of three-dimensional interactions in lotic ecosystems and their relation with the temporal dimension (Ward, 1989)



The periodic flooding of the alluvial flood plains conditions their richness and their diversity. Maintaining complexity and the dynamics of interactions within the lotic ecosystems is essential to their survival.

longer flooded. Another major outcome of rectification and straightening of the river is deepening of the river bed and sinking of the surface and groundwater levels. This is well documented in various Danube countries. Since the end of the Second World War, the Danube has been modified intensively in some stretches by the construction of hydroelectric plants. This is especially the case in the Bavarian and Austrian section.

1.2
WATER QUALITY AND NUTRIENT CYCLE

● WATER QUALITY ●

The impact of regulating a river and its floodplain on the water quality mainly affects the water temperature and the ions correlated with primary

production. In the main channel, the reservoirs act as thermal regulators (thermal regulation by the huge quantity of water, decrease in short-term and seasonal fluctuations) and as nutrient and sediment traps (suspended and particulate organic matter). The transport of nutrients, especially nitrogen and phosphorus, is often blocked in reservoirs. The physicochemical dynamics of a regulated river are essentially controlled by the type of reservoir, the storage capacity, the position of the water outflow and the way it functions, and the deep release outflow or underflow.

In the Mississippi River, during low flow, some authors note autochthonous nitrogen and phosphorus inputs from side arms and former channels to the main channel. During floods, the physicochemical composition of the dead arms and main channel are similar. Regulation mainly affects the chemical composition of the main channel, but, depending on the exchanges between this channel and the other floodplain waterbodies, either the water quality of the river will affect the water quality of the floodplain environments, or the latter will act as refuges for the river fauna during disturbances (chemical and toxic pollutions). An example is given for a reach of the Mississippi River contaminated by PCBs.

Beside localized short-term studies, there is a well-established network of stations to monitor the quality of the Danube water. The study by Iwanow (1982) shows a slow increase in time of dissolved organic and inorganic compounds in the Danube. This does not seem to affect the river's self-purifying capacity, which can be classified as ß-mesosaprobe. Due to the insufficient treatment of sewage effluents in some sections, there are local bacteriological problems. Nowadays the most acute problems are related to chemical pollution due to solvents, heavy metals, and radioactive waste, and especially to their accumulation in sediments.

Some localized work carried out in Czechoslovakia and Hungary shows the prominent role played by floodplain channels connected with the Danube in oxygenating the river water.

● NUTRIENT CYCLE ●

The complexity of the processes interacting in the floodplain makes it difficult to clearly define its role as a source or sink for mineral nutrients. In this respect the available data appear controversial, depending on the type of nutrient, the floodplain component and the relative position during the hydrological or seasonal cycle. However, it is agreed that flood waters entering the floodplain bring a substantial amount of nutrients with them, which are made available for plant growth and are partly responsible for the high nutrient level of alluvial ecosystems. The uptake of these nutrients by the floodplain vegetation represents a potential purification mechanism for the surface water of the river.

Through its flood waters or secondary arms, rivers provide a large quantity of mineral nutrients for the aquatic and terrestrial habitats of floodplains. Thanks to this supply, floodplains feature nutrient values which are always greater than or equal to those of temperate forests or non-fluvial humid zones.

In return, the assimilation of nutrients by the terrestrial and aquatic plants in the floodplains represents a means of purifying the river waters and the groundwater, i.e. of reducing the flow of nutrients which could increase eutrophication (nitrates, phosphates).

The effectiveness of this purification is a direct function of the type of plant life, i.e. it is linked to the diversity and organization of the plant formations. It has been shown that, on the Rhine, the terminal hardwood forest stage, which is the most complex and highly structured, is also the most efficient in purifying groundwater. In general, the quality of groundwater is improved when it circulates under a forest, and when it is separated from a polluted and/or eutrophic river by a strip of forest - the wider the better.

Purification efficiency also depends on the capacity of the water to circulate inside sediment. Here again, hydrologic fluctuations ensure sediment permeability by periodic scouring.

Surface waters, for their part, undergo optimum purification in areas where the side arms provide calm zones conducive to the development of

aquatic and semi-aquatic plants and/or phytoplankton which actively use the nutrients. This effect is greatly amplified if the complexity and meandering of the secondary arms increase the time during which the waters circulate through this biological filter.

In addition, floodplains play a regulating role in the organic matter cycle: by ensuring a staggered supply for rivers, floodplains contribute to the efficiency and regulation of the organic matter cycle.

1.3
ORGANIC MATTER CYCLE AND BIOMASS PRODUCTION

• FLOODPLAIN HABITATS: HIGH BIOMASS PRODUCTION •

Two features rank floodplain ecosystems among the most productive:

- In these systems, the land-water interface zones are graded. Yet the land-water interface is always the most productive zone per surface unit along the gradient ranging from land to open water.
- The fluctuating nature of these interfaces, linked to alternating phases of immersion and drying up - the "moving littoral" concept - promotes this high metabolism. The absence of stagnation allows rapid recycling of the organic matter and nutrients, thus enabling higher productivity than would be found under stable terrestrial or aquatic conditions.

High productivity has been clearly demonstrated in the aquatic habitat as regards plankton and fish farming production in the secondary arms.

Numerous research studies conducted on the Danube floodplains of Slovakia have demonstrated:

- The contribution of secondary habitats to the productivity of the main watercourse by exporting a large plankton biomass produced in the calm habitats of the floodplain.
- The positive and direct correlation between frequency and duration of floodplain submersion periods and fish farming productivity.

Here again, it is the connection between the components of the fluvial system and their fluctuating hydrological nature which enables the circulation of the organic matter produced, regulation of its flow, and optimum use.

• ORGANIC MATTER CYCLE AND PLANKTON PRODUCTION •

Fluvial wetlands appear to be among the most productive ecosystems. This can be related to:

- The increased in land-water interfaces which characterize these systems, these boundaries have been proved to be the most productive zone along the land-to-water gradient.
- The fluctuating nature of these boundaries (moving littoral), which encourages a very active mineralization and recycling of organic matter and hence a higher productivity than in more stable aquatic or terrestrial conditions.

Initial results obtained from forested floodplain systems on the southeast coast of the USA show:

- The quantitative importance of organic matter inputs from the floodplain into the river. These inputs outweigh the primary production of the river and are of the same order as inputs from the upstream watershed. They represent a substantial food source for river communities.
- The qualitative role of the floodplain as a buffering structure which regulates the organic matter cycle, either directly by providing snags which hold back the coarse organic particles and slow down losses caused by downstream exportation, or indirectly by postponing the major release of organic matter into the river (i.e. autumn litter) usually until the spring floods.

• BENTHIC INVERTEBRATES AND FISH PRODUCTION •

The production and the biomass of the main channel are greatly influenced by inputs of fauna (plankton, macro-invertebrates, fish juveniles) and nutrient inputs from side arms and former channels.

Studies in the Upper Mississippi River and the Rhone River show the role of producer, then distributor caused by the drift of these environments.

The fish production of the fluvial wetlands and floodplain waterbodies is highly correlated to periodic flooding. Numerous studies carried out in the braided side arms of the Slovakian Danube give figures and estimations on this subject. These studies show the dispersive role of the side arms into the river during high waters, and the reservoir role played by former channels and lentic waterbodies for fish which have not drifted.

It is important to maintain these connections because, if the waterbodies are too isolated and flooded too sporadically, their biomass and production will be low. Studies of temporary and permanently connected waterbodies in the Rhine and Rhone floodplains show the higher biomass and diversity of the latter.

• BIOMASS PRODUCTION IN THE DANUBE •

Research carried out in Hungary and Czechoslovakia especially provide quantitative data on the productivity of the Danubian aquatic ecosystems.

A number of measurements of the phyto- and zooplankton productions in the Danube side-arms provide quantitative evidence of the very high productivity of these biotopes and their contribution to the productivity of the main channel when the plankton is washed out of the floodplain channels during flood recession.

The high fish productivity of the Danube floodplains is related to periodical floodings. Several authors document the linear relationship between the duration of annual submersion and fish production in the floodplain. In the Slovakian stretch of the floodplain, an increase of 1 cm in the average water level induces an increase of 500 kg in the fish production that year and of 300 kg in subsequent years.

1.4
LIFE CYCLE OF AQUATIC SPECIES

• FLOODPLAINS: A VITAL HABITAT FOR NUMEROUS AQUATIC SPECIES •

For many species of fish and certain species of aquatic invertebrates, the aquatic habitat of the floodplain can play a triple role:

- A key role for the vital cycle of species which reproduce there: their alevins are later dispersed in the main channel during high waters, and as the result of connections between the main channel and secondary habitats.
- A feeding role, making it possible to exploit the abundant resources of the aquatic and terrestrial habitats flooded by river species.
- A role of refuge in the case of disturbances (heavy flooding, pollution) in the main channel: individuals seeking refuge in secondary habitats can later recolonize and reestablish populations in the main channel.

These functions are closely linked to the hydrologic variations in the system.

• LIFE CYCLE OF AQUATIC INVERTEBRATES •

As in the case of fish, the known migration patterns of two mayfly species (*Leptophlebia cupida* in Canada and *Parameletus chelifer* in Sweden) provide evidence that floodplain water bodies connected with the main channel can be vital stages in completion of the life cycle of some invertebrate species. In these two cases, the aquatic floodplain biotopes are known to provide either a temporary shelter from severe flow conditions in the main channel, or better temperature and food conditions, allowing faster growth.

When the whole biotic community is considered, side channels or temporary inundated areas provide potential sources for recolonization of the main channel after severe disturbances have occurred here, e.g. floods shifting the river bed sediment. This case is exemplified by a study of

post-flood invertebrate drift in a side channel of the Durance River, France.

● LIFE CYCLE OF FISH ●

If the diversity of aquatic and semi-aquatic habitats is necessary for completion of the life cycle of numerous fish species, it is also needed to provide a refuge during disturbing events such as floods, reductions in discharge and pollution inputs.

Periodic phenomena such as floods, low flows and physicochemical cycles are the keys to good biological functioning of the floodplain. These needs are exemplified by the study of fish migration in a sector of the Morava River floodplain.

● LIFE CYCLE OF AQUATIC SPECIES IN THE DANUBE ●

The importance of floodplain biotopes for the life cycle of fish species has been thoroughly studied in the Austrian and Slovakian sectors.

The side arms connected with the main channels act as dispersal outlets for fish during high water periods, whereas the more isolated water bodies can function as stock sites. The temporarily inundated zones can be used as reproduction and feeding grounds for some species which migrate to these zones during high water periods. There is a clear association between certain types of alluvial habitats and some groups of fish species, for both adults and juvenile stages.

1.5
BIODIVERSITY

● ALLUVIAL FLOODPLAIN AND BIODIVERSITY CONSERVATION ●

The fundamental biodiversity of floodplain ecosystems - terrestrial and aquatic - and their biocenoses mainly result from three types of dynamic forces:

- The intra-annual hydrological dynamics which results in alternating flooding and drying up.
- The geomorphological dynamics of the river, which on a scale of decades and centuries renew diversified terrestrial and aquatic biotopes.
- The dynamics of plant successions: in this case, they are largely triggered, directed or interrupted by the two previous forces.

The diversity of European floodplain forests is a telling illustration of the result of these dynamic forces. The plant density is reminiscent of some of the structural features of dense tropical forests. Their dendrological richness (50 species of trees and shrubs) and specific diversity are remarkable in comparison with non-floodplain temperate forests (diversity index of 0.6 to 0.8 for the latter, and greater than 3 for floodplain forests). This explains a number of remarkable features such as continuous flowering from January to October. The number of species flowering at the same time is twice as high as in non-floodplain forests.

The existence of sufficiently violent hydrological disturbances is what enables younger stages to be constantly renewed (softwood forests). In terminal hardwood forests, the juxtaposed mosaic of different phases (young plants), regeneration, maturity, senescence and death guarantees the biodiversity and long-term survival of the entire ecosystem.

In the aquatic habitat as well, the cohabitation or juxtaposition in small areas of animal populations with highly diversified ecological needs and biological strategies is made possible by the presence in the floodplain of diversified geomorphological forms and active hydrological dynamics.

Lastly, a few points should be emphasized concerning the value of floodplain systems with regard to preservation of biodiversity:

- In their original state, floodplain valleys were used as corridors or preferred paths for the migration and movement of animal and plant species (transportation provided by water, longitudinal continuity of wooded formations, warm and humid microclimate).
- The large floodplain valleys with their relatively warm and humid climate represented a refuge for a large number of tertiary plant species during the glaciations. That is why floodplain forests currently offer a wealth of tertiary relics.
- Under certain geomorphological and hydrological conditions, former river channels can comprise actual biotopes of mountains transposed in a plain. They ensure the survival of cold water fauna and plant life which is very pure, relics from the ice age. These are Salmonide biotopes of great biological value.
- According to recent research on the biology of Coleopteres Carabidae populations which are typical of land-water habitats, the river dynamics responsible for the constant creation of new habitats (gravel banks) could be one of the driving forces of the speciation processes within these populations.

● BIODIVERSITY OF BENTHIC INVERTEBRATES IN DIFFERENT AQUATIC ENVIRONMENTS ●

Floodplain aquatic and semi-aquatic ecosystems support rich and diverse communities, not only because they encompass the whole range of aquatic conditions from flowing to standing and semi-aquatic waters, but also because specific geomorphological or hydrological features create floodplain-specific gradient or boundary conditions which allow the overlap of otherwise distinct types of faunal assemblages. One example is the Rhone floodplain and its tributary, the Ain river, in France. The high amplitude of hydrological fluctuation in a set of former meanders of the Ain river provides optimum conditions for the coexistence over a short time period of ecologically highly contrasted aquatic beetle assemblages. We propose relating this type of diversity to the "intermediate disturbance hypothesis" which accounts for the high biodiversity of ecosystems undergoing intermediate levels of disturbance (here floods or drought conditions) enhancing the productivity of the system and the coexistence of otherwise competitive species. From the point of view of a whole floodplain sector, a more traditional example is given of how the diversity of former channel types supports a high range of invertebrate community types, not only in the surface water, but also in the groundwater component of the alluvial plain. The lack of objective, comparative methods to evaluate the biodiversity and functional diversity of floodplain systems is stressed, especially when relating this parameter to different taxonomical units or assessing it for different types of wetlands subject to various types of human alterations.

The physical factors are determinant, according to the quality, quantity and stability of the benthic invertebrate communities in a regulated hydrosystem. Different studies of the Missouri, Rhone, Mississippi and Volga rivers show that there is higher diversity of species in the unembanked parts of these rivers compared to the embanked ones. This is due to the reduced diversity of the substrates (habitats) of the latter. The banks, ecotones between terrestrial and aquatic (interstitial and potamic) environments, play a very important role in the colonization processes. The vegetal habitats (macrophytes) and mineral habitats of eroding environments connected permanently to the river (lotic side channels, wing dikes and embankments of the main channel) have higher numbers of individuals than mineral habitats in silting environments and vegetal semi-terrestrial habitats, which indicate the evolution of the waterbodies towards terrestrial stages by siltation (backwaters).

● BIODIVERSITY OF FISH IN DIFFERENT AQUATIC ENVIRONMENTS ●

The taxonomic diversity of fish increases from upstream to downstream as habitats become more diversified, that is, the floodplain increases. The positive correlation between the structure of fish communities and the increase in the stream order is a good indicator of geomorphological and hydrological changes along the longitudinal continuum. The structure of fish communities can also reflect the disruptions to which the hydrosystem is subjected (disappearance of backwaters and former channels, disappearance of islands and shingle shores). This is demonstrated by examples from highly regulated rivers in the USA such as the Missouri and the Mississippi rivers. In

these rivers, numerous original lotic species have been replaced by exotic species and the emergence of littoral and pelagic planktonophage species which usually constitute a minor share of fish assemblages in unmodified reaches.

In regulated European rivers, such as the Rhone, Rhine and German-Austrian Danube, fish communities are dominated by some species which represent 80% or more of the absolute abundance. The structure of these communities has shifted to communities of limnophilic cyprinids, and from phytophilous spawners (floodplain spawners) to mainly lithophil species (main channel spawners).

Thus, the diversity of fish species is highly correlated to habitat complexity. The higher the lateral dimension of a hydrosystem, that is, the more diversified and accessible the aquatic and semi-aquatic areas are, the more variable the community structure will be, that is, the richer the species will be. The same will be true for benthic invertebrates.

● BIODIVERSITY OF THE AQUATIC ECOSYSTEMS OF THE DANUBE ●

In 1967, 103 fish species were recorded in the Danube. This can be compared with 40 and 61 for the Rhone and the Rhine respectively. This taxonomic richness can be related to the number of endemic species and to the remaining high diversity of floodplain biotopes. However, the local structure and distribution of the fish communities reflect the impact of human modifications of the system, such as in the German-Austrian section. Furthermore, the Iron Gate plant has stopped the upstream movement of migratory species.

1.6
FLOODPLAINS: A FLOOD PROTECTION SYSTEM

Floodplains are natural systems for reducing the spread of floods and decreasing their strength. Two factors come into play: the roughness of the plant formations on the riverbanks, which slow water speed, and the room to expand provided by the floodplain areas connected to the river.

Conversely, concentration of the flow in a narrow channel increases the strength of the flooding river.

The consequences of the development of the Rhine are particularly eloquent. The "original" Rhine included 1,600 islands between Basel and Strasbourg. River training (1864-1876) carried out to protect the land from flooding, river regulation (1907-1939), designed to improve navigating conditions, and hydroelectric harnessing (1928-1977) shortened its channel (32 km between Basel and Lauterbourg) and triggered incision of the river bed (5 m at Rheinweiler and 7 m at Nuremberg in 1950). The faster flow and loss of 130 km² of retaining floodplains (60% of the initial flooding zone) increased the risk of flooding downstream. As a result, the frequency of a flood flow rate of 5,000 m^3s^{-1}, which was 1/200 years in Karlsruhe, is 1/60 years today. Furthermore, the flood front, which once took 65 hours to travel from Basel to Karlsruhe, now takes 30 hours. In addition, it cumulates its effects with those of the Neckar, Main and Moselle flood fronts, which used to run ahead of the Rhine flood front.

1.7
ECONOMIC VALUE OF THE ALLUVIAL FLOODPLAINS

The economic value of the alluvial floodplains is linked to their exceptional diversity and productivity. However, it is difficult to evaluate because the alluvial zones have vanished along the Western European countries, and in Eastern Europe, it is still impossible today to obtain reliable economic data from the past.

Nevertheless, communities of professional fishermen, which can no longer be encountered in the rest of Europe, still exist in the alluvial zones.

Forestry exploitation is particularly interesting in these highly productive alluvial zones. In the Gemenc, production in 1992 will amount to 115,000 m³.

Up until recently, commercial tourist hunting was a very important source of currency, especially in the Gemenc and the Kopacki Rit. The development of ecotourism along the same lines as that which is to be developed in the Danube delta Biosphere Reserve could replace advantageously hunting.

1.8
FLOODPLAIN ECOSYSTEMS: DISAPPEARING HABITATS

Due to successive land acquisitions, river training and dam construction over the past century, floodplains are currently a disappearing habitat on a European scale. The decrease in the surface area of the Rhine floodplain forest is spectacular: from an original surface estimated at 100,000 ha, only 20,000 ha remained in 1840, and 7,000 ha today, more than half of which consists of plantations.

The first to be affected are floodplain forests. The damage done by modern silviculture, which tends to simplify the forest structure by eliminating undergrowth, and whereby foreign varieties of trees are introduced and clear felling is practiced over vast surface areas, has greatly reduced the surface area of natural forests. The removal of senescent and dead trees has impoverished the fauna and flora, already weakened by the use of pesticides. The naturally structured forest's decreasing surface area (99% since 1800) considerably alters the overall functioning of the floodplain system. Forests older than 250 years are extremely rare in Europe, and floodplain forests of that age are even rarer. In Europe, only a few hectares remain on the banks of the Morava, a Czech and Austrian affluent of the Danube. In our latitudes, the loss of old forests has inestimable consequences for the forest's gene pool. The decrease in floodplain zones also affects areas which are flooded either temporarily or permanently.

When these types of habitats are not destroyed, they are greatly modified. One of the most classic examples is greater isolation of the larger part of the floodplain by dikes. This creates a "fossil" floodplain which is no longer in contact with the surface waters of the river. A reduced "active" portion remains, often very narrow along the river and greatly fragmented longitudinally. This situation is often encountered on the Rhine and the Danube.

Experience shows that regulation installations cause residual zones to disappear by disconnection and regulation of the water level in addition to direct destruction of the alluvial zones flooded by damming.

Development of rivers, and particularly damming of the minor river bed, cuts off the river from its alluvial plain.

Regulation of the river causes the alluvial floodplain ecosystem to dry out and die off downstream of the dam; upstream, it causes death by flooding.

Finally, and this is probably the most serious but also the most difficult impact to control, regulating the river causes it to subside in its bed, bringing about simultaneous deepening of the groundwater. This phenomenon, called incision, is particularly serious downstream of the Austrian dams on the Danube, where subsidence reaches 1,5 meter deep. The consequences are even more serious for the alluvial zones which are literally dried out and for drawing up drinking-water systems.

During the two years which Equipe Cousteau and its partners have spent studying on the Danube, the situation of the great alluvial plains suddenly worsened.

The violent drying out of the large alluvial zone of the Hungarian Szigetköz and the Slovakian Csalloköz (around 29,000 ha) caused by rerouting of the Danube in order to fill the Gabcikovo dam is a warning which the international community, for its own sake, must heed.

The Gemenc alluvial forest is now the last great alluvial zone of the Danube to have remained intact. It has recently been classified as a wet zone of international significance under the Ramsar Convention.

Nevertheless, the Gemenc is not totally unscathed. Quite the reverse, like all alluvial plains

along developed rivers it is gradually drying out.

What is more, the present developments of the Danube (not to mention the impact of the Gabcikovo dam) have cause an average subsidence of 1.5 meters. The groundwater level has also decreased by 1.5 meters and floodings are less frequent and less extensive than before.

Drying out must be stopped if we do not want the Gemenc alluvial forest to die.

RECOMMENDATIONS

The alluvial zones of the Danube basin constitute a unique heritage in Europe which is necessary to the life of the river and to the quantitative and qualitative upkeep of the groundwater tables, and consequently to the quality of drinking water. Today these alluvial zones are very seriously threatened and may be lost altogether if we do not take immediate action to conserve them. Such measures must be taken at both a local and international level.

• Study and restoration of an exemplary area: the Gemenc in Hungary

The Gemenc area is relatively simple from the viewpoint of its geomorphological history and its hydrological functioning, particularly when compared with the Szigetköz area, in Hungary, for example. Also, it does not feature any major facilities (hydroelectric dams, locks) nor cross any international borders.

Despite this simplicity, the area contains a wide diversity of aquatic, semi-aquatic and terrestrial habitats representing most of the floodplain habitats encountered in Middle European meander plains.

The ecological problems raised in this area are representative of situations encountered to varying degrees, not only in other Danubian areas, but also on the other large Middle European rivers, i.e. excessive exploitation of natural resources by humans, falling water line and resulting drying up of the floodplain.

There is a regional readiness to reach a compromise between socioeconomic and ecological constraints for integrated management of the Gemenc area. A detailed analysis of the area's hydrology and its changes since the beginning of the century has already been conducted. Furthermore, an initial program to study the physicochemical properties of the water at certain sites, and to install piezometers to study fluctuations in groundwater levels, has recently been undertaken at instigation of Equipe Cousteau and Pr. Zsuffa from the Baja University.

This study should be followed by a 4-phase long-term programme:

- Phase 1: analysis of current condition prior to intervention, provisional diagnosis (duration 1 year).
- Phase 2: development of an action plan and an ecological management plan.
- Phase 3: execution of reinstatement works.
- Phase 4: monitoring of reinstatement procedures (minimum duration 3 years).

The aim of this revitalization programme consists not only in understanding the mechanisms of water discharge in the alluvial plains but rather in restoring integrity of the ecosystem.

An inventory needs to be compiled of the fauna and flora in the region in order to understand how the current ecosystems function. This inventory may then be included in the larger programme launched by the IUCN in order to compile a biodiversity inventory of the Danube basin.

Given the piecemeal information currently available on the Danube alluvial ecosystems and fluvial incision problems in general, from both a geographic and thematic viewpoint, the Gemenc study and revitalization project offer the possibility of comprehensive research which would lead to a better understanding of the consequences of the phenomena involved to test solutions combining economic and socioeconomic factors.

• Creation of a green corridor

Protection of the Gemenc alluvial forest alone would not make it possible to preserve the genetic heritage of the vegetal species along the Danube in the long term. Genetic diversity is necessary for the survival of species.

RECOMMENDATIONS

For plants, the only way to maintain this diversity is to multiply intraspecific exchanges between natural zones.

To do this, we propose creating a diffusion corridor between currently isolated natural reserves. This is the necessary accompaniment to redevelopment of the Danube banks. A certain number of protective dikes must be moved further out, at least several hundred meters on either side of the minor bed, so that they are at least in line with the major bed which corresponds to the average annual flooding.

• All relations between the alluvial plain and the river bed must be maintained

No new channelization is needed, nor any rectification of the river bed; the connections between the secondary arms and the main channel of the river must be kept. It would be advisable to reinstate connections between the main river channel and the secondary channels by destroying certain groynes as part of our proposition for restoration of the Gemenc alluvial forest.

River flow irregularities must be maintained. High-low water alternations are vital. The construction of any new dam must therefore be shelved.

• Which management for these alluvial zones

Ecotourism can be a source of reserve financing. However, it must be strictly managed by natural reserve protection institutions. The type of management we have proposed for the Danube delta can serve as an example.

• International protection and world heritage

The wet zones of the Danube constitute a unique heritage for future generations, the responsibility of which is not merely of national interest but of international importance.

The patrimonial value of the alluvial ecosytems alone justifies their conservation by the international community.

The Convention on Biological Diversity signed in June 1992 at the Rio Conference clearly showed the need to preserve not only the plant and animal species as units of the biodiversity bases but also the ecosystems and their dynamics. It has also been admitted that the possible absence of scientific arguments is not a sufficient reason for postponing protective measure to conserve this patrimony. Thus conservation of the mid-European alluvial ecosystems and their restoration are a vital issue for Europe. These ecosystems are the most complex and most highly organized ever to be found in our climatic zone. The river must be given sufficient freedom to generate a mosaic of diverse ecosystems. The conditions for this freedom must be then consolidated, limits on lateral movement of the river reduced and hydrological fluctuations and sediment availability maintained.

The Danube alluvial zones must therefore benefit from classification by international institutions: Ramsar Convention for the wet zones of international importance, and UNESCO for Worldwide Heritage and Biosphere Reserve labels.

• International financing

Given the financial interests involved, particularly now that the Eastern European countries are opening up to the free market, these classifications need to be reinforced by international financial aid. This could be done by "swapping" foreign debt for alluvial zone protection. This type of financial aid has already saved a large number of threatened areas by having foreign trading partners swap part of the foreign debt for their protection.

2
THE DANUBE DELTA

Equipe Cousteau has been conducting its field studies in all the countries along the banks of the Danube, cooperating with scientists and officials as well as inhabitants, to address the issue of how the Danube should be utilized. The question is especially crucial in the delta as it is affected by all the disturbances to which the river and its tributaries have been subjected, and under pressure from totally diverging interests.

At the present, the Danube delta is an exceptionally rich natural zone, in spite of the sometimes severe changes that have occurred in places. The immense size and impenetrability of the reed beds, still intact, and the "plaur" (floating reed islands and decomposing vegetable matter) guarantee the best protection for the fauna, and in particular, the remarkably abundant birdlife.

The delta is the last European delta ecosystem of such scope and richness. It is essential for migratory birds. The migratory birds of Northern Europe fly over this area in tens of thousands on their way to Africa where they spend the winter. Birds from Africa come to the delta in the summer to breed. The pelicans' breeding ground must be designated as a strictly protected area.

The Danube delta records and concentrates all the disturbances that the river and its tributaries have endured. It is a privileged area for monitoring the evolution of the life of the river and the quality of the water.

The Equipe Cousteau teams spent several weeks in the heart of the delta, both in winter and in summer, to complete their study. They used all available means (helicopter, Zodiac, rowboat...), to explore those areas of the delta which are the hardest to reach. They had numerous meetings with local people and paid special attention to their vision of past and future changes in their region. The methodical grid-pattern helicopter survey of the delta played an essential part in the generalization of accurate but selective field-collected information. Through aerial observation we were finally able to ascertain the state of some areas which were either inaccessible or so remote that they could not be visited.

Equipe Cousteau has paid particular attention to proposing a management plan which will enable the inhabitants to have a decent standard of living by benefiting from the wealth of this exceptional patrimony recognized as such by the international community, while at the same time preserving it. The work has been carried out in close cooperation with the delta inhabitants, Professor Vadineanu, Secretary of State for the Environment, Romania, Mr. Gomoiu, Manager of the Biosphere Reserve, and IUCN representatives. The management plan was presented at the Bucharest conference organized by the Commission of the European Communities and the Romanian government on "Tourism and Conservation of Deltas." Our proposals are largely drawn from the final recommendations.

2.1
GEOGRAPHICAL CHARACTERISTICS

The Danube delta, which covers 591,200 ha, is the widest and the richest wet zone in Europe after the Volga delta. The delta and the banks of the Black Sea representing 679,000 ha were designated a "Biosphere Reserve" by UNESCO. In 1991, 312,440 ha, i.e. 53%, were designated "World Heritage;" the delta has been declared a "wet zone of international significance" under the Ramsar Convention.

2.2
HUMAN IMPACT

In 1990, the delta's population amounted to 15,600 inhabitants spread out over 28 villages. The density is 2.6 inhabitants per km^2. However, humanity has not altered the area uniformly: some zones have been greatly affected whereas others have remained untouched. On the other hand, the human impact has been very different whether it concerns food or quasi-industrial activity, therefore of national concern.

Food production activities, mainly agriculture and fishing but also traditional hunting, have not affected the delta ecology, not only because the density of the inhabitants is low and because these activities are not widespread, but also and above all, because their aim is not large-scale commercial development.

Development of the Sulina channel, in 1990, and the Saint George channel as well as the sinking of the transverse channels to connect the lakes to the main channels have considerably modified the natural water discharge. The sedimentation and the natural percolation of the water through the reed-beds have been greatly altered affecting not only the Danube delta but also the coastal area along the Black Sea.

The polder surface area altogether is about 36,000 ha, i.e. about 8% of the delta area.

- Sireasa to the west: 6,000 ha
- Pardina to the north: 27,000 ha
- Rusco: 3,000 ha
- Smaller agricultural zones are to be added to those above: Sulina and all those recovered to the south of the area upstream of the Saint George branch, from Tulcea to Dunavatu.

All the polder farms have gone bankrupt, not only because yields have never reached expected levels but because most polders become unproductive due to salinization problems.

The overall surface area which has been turned to pisciculture is similar to that of the polder area in that it is very difficult to estimate accurately as data vary considerably: there may be 32,000 ha in all, about 7% of the Romanian delta surface area. The following fish farms: Fortuna (2,500 ha), Grindul Stipoc, Chilia Veche, Caraorman, and the one to the north of Crisan (about 3,000 ha), seem to be still operating today but it is difficult to ascertain their results in any detail.

The large fish farms of Popina (8,000 ha) and Dranov (5,000 ha), however, seem to have been abandoned. Official reports confirm that these giant farms have failed and show a loss of several million lei per year (no further details are available).

Two zones are regularly cut: Uzlina Gorgova (2,500 ha) and the zone between the Sulina branch and the meander furthest upstream from the old Danube, around Obretinu Mare Lake. The present situation of the Periteasca zone which has been proposed as a strictly protected area is very poorly defined.

Reed exploitation reached its climax in 1963, when the yearly crop was about 226,000 tons. However the mechanical destruction of rhizomes by reapers and insufficient nutrient supplies in polders which are no longer flooded, have caused production to drop to 33,000 tons.

Industrial navigation stands apart because, although it does not directly involve local communities, it produces very pronounced changes, i.e. the rectification and channelization of branches. It also allows veiled threats to hang over the future of the Biosphere Reserve if it is further developed. The accident involving the Russian ship *Rostock* on September 3, 1991, in the Sulina Channel serves as a reminder. This accident occurred near the village of Partizani and could have caused an environmental catastrophe if it had been full of oil or had been carrying toxic substances. This warning must be taken into account in the legislation to preserve the Biosphere Reserve.

In 1989, 2,327 boats carried 5.2 million tons of cargo along the Sulina Channel. The port of Galati, the largest port on the Danube, deals with the majority of traffic (15.2 million tons). The Ukrainian port of Reni on the Chilia branch comes second with 12.6 million tons. Tulcea is far behind with 1.4 million tons (2/3 from the Black Sea). Traffic is mainly local, i.e. raw minerals, ferrous and non-ferrous metals. The outgoing freight (2.5 million tons on 1,205 boats) equals the incoming freight (2.7 million tons transported by 1,122 boats).

It is to be noted that more than half of cargoes (about 6 million tons) that are off-loaded at Galati goes through the Constanza - Cernavoda Canal.

RECOMMENDATIONS

The alluvial zones of the Danube basin constitute a unique heritage in Europe which is necessary to the life of the river and to the quantitative and qualitative upkeep of the groundwater tables, and consequently to the quality of drinking water. Today these alluvial zones are very seriously threatened and may be lost altogether if we do not take immediate action to conserve them. Such measures must be taken at both a local and international level.

• Political driving force and legal framework

The Biosphere Reserve Authority will have to ensure that relations between local people and all those involved in developing and managing the delta remain on a human scale, so that this unique European natural area will continue to develop harmoniously.

The delta is sufficiently large for the creation of strictly protected areas and inhabited zones for people interested in the development of the reserve. The inhabited and working zones should preferably be isolated by buffer zones in which traditional activities and crafts and moderate tourism would be possible, rather than protecting the natural zones by buffer zones. The philosophy is not the same for each approach: in one, man is tolerated in the reserve because he lives in a traditional way in the delta; in the other, the natural islands are protected against economic development and tourism that would otherwise threaten them with all kinds of pollution.

However, all the efforts made by the Romanian Environment Ministry and the international community to find the necessary balance between environment and development and enable the inhabitants of the delta to have a decent standard of living while preserving the wealth of the Biosphere Reserve, will be in vain if the Romanian government does not set up the necessary legal framework to apply the management recommendations.

• Strictly protected areas: passive protection

The Romanian government has suggested a certain number of zones that have been chosen for the diversity of habitats they cover and their abundant birdlife. These choices seem perfectly justified.

Nature is tough. She quickly takes back abandoned cultivated areas and fish farms. If a certain number of channels which provide access to bird breeding zones are no longer maintained, they will very quickly become impenetrable. Difficulty of penetration and inaccessibility to certain zones must be maintained. In this way the delta will recover a large part of its wealth and will protect itself without any unnecessary outlay.

Generally, apart from the pelican breeding area to the north of Lake Merhei, the suggested zones appear to be too easily accessible and, more importantly, are criss-crossed by numerous channels navigable by motorboat. This situation requires very strict control, which is much more difficult to enforce than if they were naturally inaccessible. Inaccessibility is the best guarantee of strict protection of these areas. Strictly protected areas should be placed under scientific control and the care of officially appointed wardens. Only scientists who are in charge of monitoring the ecosystem, and birds in particular, would be able to enter these zones occasionally for regular observation, according to a schedule that would be defined and monitored by the Danube Delta Biosphere Reserve Authority.

In addition to the zones suggested by the Romanian Government, we think it important for the Lake Dranov region to be considered a strictly protected area. Not only do pelicans go there to feed in peace, but it is also a well-protected area, since access to these zones is naturally difficult. And finally, as fish farming has failed, there is nothing to stand in the way of rehabilitating the entire area.

• Buffer zones

Buffer zones must surround the already existing inhabited and economic zones. They correspond to areas that are neither economic zones nor strict reserves. Only traditional activities and crafts as well as moderate tourism will be tolerated. Access will be by row-boats or low-power motorboats.

However, certain canals that link villages and remote economic zones cross the buffer zones. Only inhabitants who have a permit issued by the Danube Delta Biosphere Reserve Authority will have the right to travel on these canals by motorboat. Speed will be limited to 5 knots to avoid disturbance.

The only way of penetrating the delta is by river, and this must remain so. There must be no bridges and no new roads.

• Economic zone

All zones that are regularly served by motorboat carrying passengers and cargo must be considered economic zones.

RECOMMENDATIONS

Large-scale work has disturbed the delta. This is why we suggest setting a maximum limit on large-scale activities and buildings.

All new industrial economic activities must be forbidden. The present economic zones must be maintained but not expanded. Zones where there are economic activity and traffic at the present must be carefully delimited. They will not be able to extend beyond their present limits.

Moreover, fish farming and agricultural zones which are not viable should be rehabilitated. If large polder farming is not abandoned it must prove its profitability over a 5-year period (enough time for climatic variations not to interfere with the experiment).

It would seem very reasonable to rehabilitate these last two types of zones. Pelicans have already chosen the Dranov pisciculture region as a feeding zone because of its peacefulness.

The natural water flow must be reestablished by destroying the dikes surrounding the large-scale fish farms (those in Popina to the Northeast with a surface area of 8,000 ha and in Dranov - 5,000 ha) and the polders which have failed.

In any event, cutting new channels must be prevented and cutting channels parallel to the littoral must be stopped or the delta hydrology, which has already been sufficiently disturbed, will be altered even further.

Reinstating the natural flow of the water will have three beneficial results:

- Better distribution of the sediment and nutrients coming from too many fertilizers transported by the Danube and used in the polders, with the resulting reduction in eutrophication.
- Renewal of anoxic water in the closed, or slightly open branches and lakes which increasingly prevent life from developing.
- Opening up of zones conducive to delta fish breeding.

Reasonable reed cutting does not seem to harm the delta ecology. Reeds are a renewable resource which can be profitably harvested provided it does not extend beyond the two zones (Uzlina-Gorgova and Sulina) and that it is done without machines which are destructive to the ecosystem. A time limit for cutting should be defined so as not to disturb the first nesting species. Finally, the true advantages and consequences for the fauna of large-scale stubble burning at the end of winter should also be studied.

• Delta inhabitants

More importantly, the Biosphere Reserve cannot be created without the help of the delta inhabitants who must be directly involved in its development. In order to achieve this, their traditional activities must be preserved and they must also benefit from the tourism linked to the richness of the reserve. The inhabitants must therefore be offered training and the preferential status of tourist guide or officially appointed warden; above all, tourist accommodation in the inhabitants' homes must be encouraged.

A legal framework must be created which favors the life of the delta inhabitants while preventing any large-scale changes likely to disrupt the ecology of the delta.

The geographic extension of human activities must be prevented and construction in zones that have already been developed (main roads, existing villages) must be limited. The development of large tourist complexes that would go against the interests of the reserve and particularly those of the inhabitants, must be prevented.

The status of the delta inhabitants is essential if the classification into different zones is to be effective. Their ancestral property rights, their fishing rights, and, in general their traditional activities in the buffer zones must be preserved. To do this, the inhabitants must have a status that allows them to practice, within limits, activities which would be forbidden to non-residents.

With this aim in mind, everything must be done to interest the delta inhabitants and to involve them directly in the life of the delta. Traditional human activities have a negligible impact on the delta ecology. The inhabitants would more easily accept living in a Biosphere Reserve if they are directly concerned by compensatory measures: tourist accommodation, tourist guide or reserve warden jobs.

The economic activities in zones set aside for this purpose do not pose any real problem provided their extension does not threaten the buffer zones around them. The same cannot be applied to economic activities in the buffer zones. These buffer zones must be even more strictly controlled to promote improvement of the existing habitat, rather than new constructions.

This policy has all the advantages from an economic and environmental point of view: inhabitants who benefit from tourism (rented rooms, guides, etc.) will be the

RECOMMENDATIONS

most enthusiastic supporters of the protection of their reserve. On the contrary, large hotels would bring nothing to the delta inhabitants.

This improvement in the habitat must have two priorities:

- Drinking water. It may be necessary to install earthenware or porous stone filters so that water from the delta can be used. Setting up a local network for the distribution of drinking water must perhaps be considered.
- Waste water. The seasonal increase in the number of inhabitants is going to create a big sewage and plumbing problem as it does in all areas where tourism is developed. Sewage disposal and treatment for a greater number of inhabitants than today must be contemplated.

• Controlled tourism

Well-organized tourism tempered by lodging with the locals must be promoted if uncontrolled tourism is not to take over, as well as large structures which drain local resources without any profit for the delta inhabitants.

Tourists staying in the delta, be they Romanian or foreigners, could explore the buffer zones with a guide traveling in rowboats outside canals navigable by motorboat. Apart from special dispensation granted by the scientists in charge of reserve management, bivouacs and camping will not be authorized in the buffer zones, i.e. outside zones designated for economic activities. This means:

- Encouraging lodging with the locals. This entails financial incentives for home improvements so that the inhabitants can offer a minimum of comfort to tourists: comfortable rooms, sanitary facilities.
- Organizing lodging with the locals. This means setting up an organization to register rooms, check their condition, and allocate them according to availability. The information center or the tourist board in Tulcea could be made responsible for this, since all the tourists pass through there.
- Creating tourist circuits which channel the tourists and offer them choice observation points so that they can really take advantage of the abundant delta birdlife. Advantages: people cannot go just anywhere and they come back enthusiastic because they have seen the birds without having disturbed them, which is certainly not the case when they travel on the channels.
- Training guides and wardens. The guides and wardens who oversee the reserve must be trained in ecology. This will enable them to understand and notice any changes in the delta, guide the tourists, advise anybody caught committing an offense, etc. Obviously, the delta inhabitants would be given first choice as guides. They can be trained in the Uzlina center.

• Developments and investments: keeping things on a human scale

To improve local housing, local people must be able to borrow often moderate amounts at preferential rates. International banks (World Bank, EBRD, etc.), which because of their size, cannot provide direct services to private individuals, must put this in the hands of a local development bank, to be controlled by the Biosphere Reserve Management Agency.

• Long-term survey

The delta collects all the pollution slowly transported by the river. The Uzlina center could become a "field antenna," i.e. the monitoring center for the scientific center of Tulcea in the event of serious pollution. The purpose of the Uzlina center is threefold: a research center, educational and training center, and a reserve management center. The center will monitor the evolution of the delta ecosystem: pollution of the river water that flows into the Black Sea, eutrophication of the most stagnant delta water, coastal erosion, abundance in birdlife, etc. The center must also monitor the sturgeon population and no doubt take large-scale protective measures.

We have to bear in mind clearly that all the actions made by the inhabitants of the delta themselves, the Romanian government and authorities, international institutions and non-governmental organizations to allow a decent standard of living while preserving the exceptional wealth of the Danube delta will be vain if a new dam is built on the river and if we do not pay particular attention to reducing of the pollution of the river.

The delta is an indicator of the health of the river. But it would be ridiculous to consider it outside its economic, social and political context. Conservation of the delta can only be the result of deep international reflection concerning overall management of the river.

PART 2

NAVIGATION AND TRANSPORT

NAVIGATION AND TRANSPORT

The Danube, unlike other European or North American rivers, is little developed, especially downstream of Vienna. In Germany and Austria, twenty dams and eighteen hydroelectric plants regulate the upstream section of the river. However, downstream of the Altenworth and Greifenstein dams, located a few kilometers upstream of Vienna, there are no further dams before the two hydroelectric plants of Djerdap (Iron Gate) except the controversial Gabcikovo dam in Slovakia. This situation is exceptional for a large European river. Although the entire length of the Danube has been developed for navigation purposes, its low water bed has not been systematically diked.

The river's quasi-freedom, however, presents problems for navigation, which is hampered by some forty shoals during the low water periods and severely hindered by the irregular variations in the flow and thus the water depth - the variation between low and high waters is around 8 meters in Hungary.

These navigational difficulties compromise development of regular deep draft navigation. However, after the opening of the Rhine-Main-Danube channel on September 25, 1992, convoys of 3,500-ton-barges (one pusher and two Europe IIB class barges) can now carry goods from the North Sea to the Black Sea. Consequently, the Danube Commission, the international institution responsible for navigation on the Danube river, wishes to guarantee a minimum depth so that these "deep draft" convoys should be used throughout the year.

According to G. Balasoiu, the deputy director of the Danube Commission: "*The depths corresponding to the adopted recommendations can only be guaranteed by building hydraulic structures and installing locks on the Danube, thus creating an uninterrupted sequence of dammed sections.*" In order to do this, it has been proposed that eleven new dams be built.

Development of the Danube for deep draft navigation and the conservation of functional alluvial plains and forests are two contradictory objectives. The study of developed rivers in Western Europe and North America, and experience derived from Austrian dams, the Iron Gate dam and the more recent dam in Gabcikovo, have only emphasized their detrimental effects:

- gradual damage to alluvial areas and forests, leading to their complete destruction in the long run,
- contamination of groundwater and altered exchanges between river and groundwater,
- modification of the global fluvial balance (erosion, sedimentation).

Nevertheless, development of navigation on the Danube can reasonably be incorporated into an integrated transport policy, which alone is capable of combatting anarchical road transport development.

It is therefore essential to assess the economic soundness of facilitating navigation through development of the Danube. Equipe Cousteau was unable to find any economic or environmental study concerning these development projects, and has thus had to launch its own. This study was entrusted to Dr. Patrice Salini (Ph. D. in Economics and Spatial Development, specialized in transportation) and carried out in conjunction with the French National Institute for Research into Transportation and Transport Safety (INRETS), and consultants from each of the countries through which the Danube flows. It was based not only on the transport statistics within the former CMEA, but also on the economic development prospects of re-structuring and opening up the Eastern countries to the world economic market.

What is the future of navigation on the Danube? How is watercourse transportation to be incorporated into the overall scheme of transport development in the Central and Eastern European countries?

1
TRANSPORT IN EASTERN EUROPEAN COUNTRIES

Eastern European traffic features an oversized goods transportation industry and low mobility of inhabitants.

Structurally, goods transportation, which is 2 to 4 times the level found in Western Europe per GDP dollar, is mostly composed of heavy cargo carried by train. Moreover, the production of these countries features an extremely high energy (mostly oil) and steel output, at costs which are incompatible with world prices. At the same time, inhabitant mobility, which is 40 to 50% lower than in Western Europe, mainly depends on public transportation, used twice as much as in the West.

This situation coincides with the low density of the road networks, the extremely critical state of transportation infrastructures - and sometimes even the equipment.

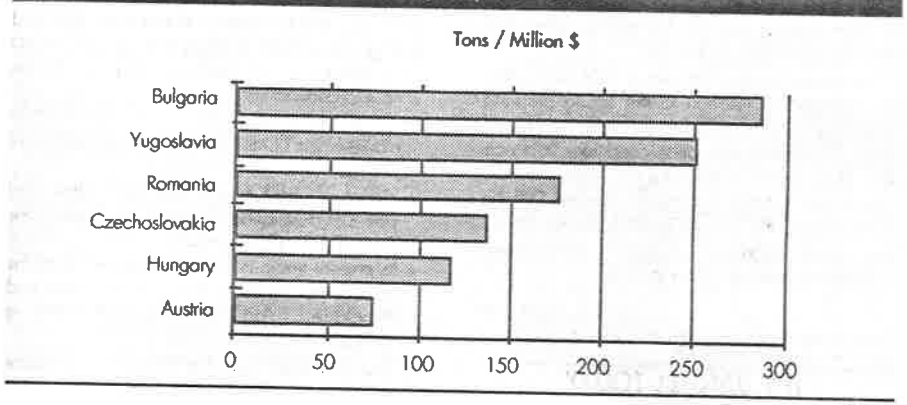
This hypertrophy of transportation is the consequence of three phenomena:

- The type of the production which is the basis of the economy of the ex-CMEA countries (heavy industry and mining) and which has undergone a shift in emphasis in Western Europe, together with the low share of services in economic activity.
- The systematic policy of specialization inside ex-CMEA countries where production facilities were set up without taking transport price into account and where worldwide quotation mechanisms for raw materials and commodities were largely ignored (absence of market prices for oil products for instance).
- A transport policy heavily based on railways and tariff practices explicitly encouraging heavy transport over medium and long distances, (note the use of a model for directing the choice of transport mode in Romania). Tariff practices concerning railway traffic have not yet become completely stabilized in spite of the emergence of a road transport sector obeying market laws.

In fact, the oil consumption per GDP unit is twice or three times greater in the Danube countries (*Figure 2.1*), with the exception of Hungary, better placed in the field of energy efficiency, in spite of the low development of road transport, and a high consumption of oil products. The absence of market prices for oil products explains the difference in efficiency, but it will also make the adaptation of high consumption industries difficult.

The major decline in production since 1989-1990 is indicative of these differences, though it is still difficult to evaluate precisely. Overall, however, the transition begun by anchoring Eastern Europe to the European Economic Community and the world market, has created two major trends:

Figure 2.1
Oil consumption per GDP unit



- The beginning of a profound modification in the production and trade structures which can now be clearly seen. It is now clearly noticeable. The end of "forced" relations in the ex-CMEA, and in particular, the imports from the ex-Soviet Union, has greatly changed major traffic flows. The reorientation of production towards consumer products with Western standards, and the injection of new technologies into basic industry have affected the core of the production structure, which has also been shaken by its more or less gradual insertion into the world economic market.

  The future of entire economic segments of these countries is now uncertain. Even agriculture is experiencing a fairly brutal transformation whose outcome is not clear.

  These factors have already induced a general heavy flow of goods traffic, and a booming East-West trade.
- The demand for mobility is being increasingly felt. A very strong link is being established between the aspiration for freedom and the demand for travel. Although at first this demand was mostly geared towards bus services and the use of existing motor vehicles, the number of vehicles is now increasing (used cars, then new cars).

In practice, these two trends have led to both a relative and absolute increase in the use of roads, whose critical situation (capacity, maintenance, etc.) is deteriorating even further. Congestion in and around cities is already a reality.

For travelers, the level of services provided by the infrastructures and equipment is poor.

Yet the ex-CMEA countries have clearly expressed two priorities:

- They want to interconnect, and, more importantly, connect with Western Europe (and, symbolically, CEC). And they want to do it quickly.
- They aspire to a type of consumption and standard of living comparable to those of Western Europe.

In this context, and despite the difficulties involved, it is clear that the road network will, in any case, be a factor in development even if the infrastructures have a hard time keeping pace. It is probably safe to assume that the increase in road traffic is inevitable, and that investing in this area (infrastructures and operators) will offer a high, immediate return.

Without ignoring the consequences of choosing this direction, it is precisely in the name of economic realism and the merits of a free market that road development is a priority, as it alone can

ensure new economic growth in these countries. For most observers, the roads are considered to be a way of increasing development. The growth of road traffic is unavoidable and investments in this area are highly profitable.

The potential development of river traffic must be assessed in relation to the strong demand which currently exists for the development of road traffic. Improving navigation conditions is a positive factor that may enhance the competitiveness of river transportation. According to the Danube Commission, this means building eleven dams, but the real economic advantages of the development required has to be studied.

2
THE DANUBE TODAY

Inland waterway transport in Europe is largely shaped by the importance of the Rhine axis and the Rotterdam-Antwerp area. It represents 8 to 9% of Community traffic, against 75% for road transport. Traffic volumes on all the inland waterways are largely dominated by so-called heavy goods, which are linked to the overland and harbor systems. Construction materials and crude ore generally predominate, followed by iron and steel goods, energy products and agricultural and food products (inputs and foodstuffs). The Danube is no exception to the rule.

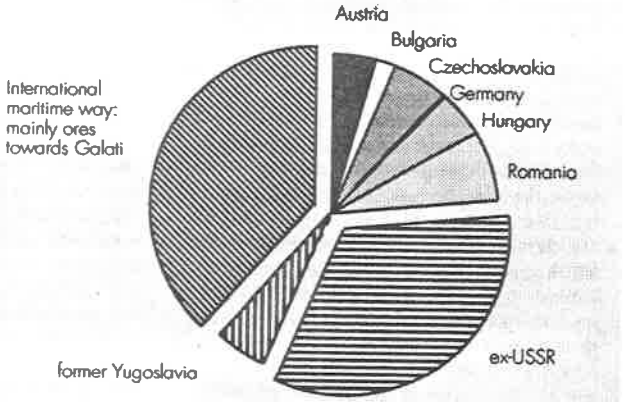
However, it comes up against a number of major obstacles:

- It does not pass through the major origin and points of destination of some traffic flows of the Central European countries.
- Its present traffic is dominated by the activities of delta ports (Galati, Braila, Reni, Izmail) and cabotage. Unfortunately, upstream traffic is stronger.
- The river does not offer optimum navigation conditions, particularly upstream from Budapest.

However, it is in a firm position to link the countries of Central Europe to the Black Sea, without the problem of borders, and to connect three major capitals.

Figure 2.2
Distribution of the traffic volume on the Danube in 1989 according to its origin

The main traffic comes from countries in the CIS and non-Danube countries



2.1
TRAFFIC ON THE DANUBE

The main traffic comes from countries in the CIS and non-Danube countries *(Figure 2.2)*. The destinations remain largely concentrated on the Romano-Ukrainian part of the river, and especially in the iron and steel centers near the delta. However, these destinations are more diversified and show not inconsiderable traffic flows to Austria. These are largely linked to the iron and steel activity in Linz.

This overall concentration of the traffic flow in the downstream region of the Danube is supplemented by the large local traffic in crude minerals, particularly sand and gravel, often taken from river beds such as that near Komarno.

In these tables, the traffic flow according to the main origins and destinations mixes cabotage and traffic between the different countries, based on Danube Commission figures *(Table 2.1)*.

Local navigation is extremely important. For example, it accounts for 73% of Slovak traffic with 5,874 million tons carried over a distance of less than 19 km. Bratislava, with 5,968 million tons, i.e. 4.3% of Danube traffic, is the fifth largest port. The same applies to Komarno. The importance of local navigation makes all-inclusive Danube traffic statistics unwieldy when establishing traffic forecasts.

Although national cabotage volumes, mainly sand and gravel, are considerable, the Danube

Table 2.1
1989 Country-to-country traffic estimated in thousands of tons

ORIGIN \ DESTINATION	AUT	BUL	SLOV	GER	HUN	ROM	CIS	ex-YUG	OTHERS	TOTAL
AUT	535	14		288			1089	63	206	2195
BUL	68	2	28	84	2		575	12		771
SLOV	624	89	5874	23		6	800	258	388	8062
GER	17	14		167	2	10	18	45		273
HUN	568		6	499	6980		829	69		8951
ROM	56		80	231	31	188087	26	138	2091	20740
CIS	2575	3040	1415	29	1362		6964	2697	2268	20350
ex-YUG	255		231	402	47		976	10627		12538
OTHERS	1691		126			10306	2969			15092
TOTAL	6389	3159	7760	1723	8424	28409	14206	13909	4953	88972

Local navigation is extremely important. For example, it accounts for 73% of Slovak traffic with 5,874 million tons carried over a distance of less than 19 km. Bratislava, with 5,968 million tons, i.e. 4.3% of Danube traffic, is the fifth largest port.

Table 2.2 - 1989 Country-to-country traffic estimated in ton-km

ORIGIN \ DESTINATION	AUT	BUL	SLOV	GER	HUN	ROM	CIS	ex-YUG	OTHERS	TOTAL
AUT	110 210	18 816	70 272				2 262 942	60 795	41 200	2564235
BUL	91 392	436	34 600	133 392	1 712		250 700	7 800		521832
SLOV	166 608	115 700	117 480	11 753	10 398	10 398	1 448 800	180 600	194 000	2245339
GER	4 148	22 232		4 175	1 464	22 440	41 796	54 405		150660
HUN	277 184		366	365 268	279 200		1 450 750	44 091		2416859
ROM	112 000		138 640	518 364	51 832	3 617 400	13 000	142 554	418 200	5011990
CIS	5 350 850	1 325 440	2 562 565	67 338	2 383 500		738 184	2 996 367	226 800	15651044
ex-YUG	246 075		161 700	486 018	30 033		1 084 336	1 370 883		3 379 045
OTHERS	338 200		63 000			2 061 200	296 900			2759300
TOTAL	6 696 667	1 482 624	3 080 151	1 656 580	2 747 741	5 711 438	7 587 408	4 857 495	880 200	34700304

Although national cabotage volumes, mainly sand and gravel, are considerable, the Danube trade is structured by certain long-distance traffic flows.

trade is structured by certain long-distance traffic flows. This can be seen when we analyze the traffic volumes expressed in ton-km *(Table 2.2)*.

2.2
NAVIGATING CONDITIONS ON THE DANUBE

Navigating conditions on the Danube are typical of those to be found on a river containing large free-current sections. Thresholds remain in unstable sectors because of the formation of sandbanks, settlement of alluvium or the presence of dangerous rocky beds. However, certain "unnatural" obstacles remain, such as the insufficient headroom of free-current bridges (Novi Sad Bridge: 6.07 m High Navigable Level; several bridges in Germany only have a High Navigable Level (HNL) of 4.4 to 5 m).

Moreover, the regulated or channelized sections of the mainstream of the Main or the Rhine and of the Rhine-Main-Danube canal do enable the same convoys to be used from the Black Sea to the North Sea (lock sizes, navigation channel widths, e.g. convoys of 2 barges and one pusher on the Rhine-Main-Danube, 9 barges and 3 pushers in Romania).

The Danube Commission in charge of issuing recommendations on navigation channel gauges and hydroelectric stations is drawing up a plan of major works.

The channel gauge recommended by the Danube Commission for the lowest possible Navigable Water and Regulating Level is generally 25 dm on the Danube. It is higher (73.2 dm) in the maritime part of the Danube. Commission records can be used to identify the most sensitive sectors over a long period.

A detailed analysis of statistics giving the number of days and sections where the river is less than 2.5 meters, i.e. the minimum recommended for navigation by deep draft barges, shows that the Nagymaros section in Hungary is the only part where frequent navigation problems occur *(Table 2.3)*.

It is thus unnecessary today to build the series of eleven dams recommended by the Danube Commission. The section comprised between Vienna and Budapest, a real bottleneck, including the highly controversial Gabcikovo dam, should undergo major works to guarantee the required depths. The work carried out between Vienna and Budapest would include a comprehensive project of four dams equipped with twin locks (Vienna, Hainburg, Wolfstahl and Nagymaros), based on studies carried out by the Danube Commission, and flooding of the Gabcikovo dam. The project can only be effective if all the dams are built; otherwise, navigating difficulties would be increased because of problems linked to incision of the river bed.

2.3
FLEET EFFICIENCY

The productivity of the Danube pusher fleet is lower than that of the Rhine's. While the productivity of barges seems to be comparable, this necessarily reflects problems of organization and navigation. It is difficult to determine the exact reasons for the lower level of efficiency.

It would seem that the scarcity of spare parts is responsible for the down time of some of the pushers. The productivity of barges, and the way it is dispersed, no doubt reflect another phenomenon, that of the specialization of fleets, i.e. their good adaptation to the river flow irregularity, and of their market areas.

Fleet renewal is indicative of the generally good state of repair of the vessels, of the deliberate policies of the states to maintain a high quality fleet in an internationally competitive market on which quotations are made in international prices (in dollars), as well as the presence of large shipyards on the Danube.

The size of the Romanian pusher fleet in spite of its remarkable youth, like that the Slovak, is indicative of a real overcapacity of transport. The traffic/power ratio for pusher trade in Romania is half as much as in Bulgaria and 30% less than of other flags in the East. The traffic/power output of

Table 2.3 - Occurence of navigating problems in 1989 Calculations based on hydrometry records

STATION \ MONTH	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC
Komarno											4	15
Nagymaros	7	20					2	5	14	17	22	21
Budapest											3	17
Giurgiu	2	28									3	13
Cernavoda		19	1									4

Depth < 25 dm - Number of days

The Nagymaros section in Hungary is the only part where frequent navigation problems occur, i.e. depth less than 2.5 meters, the minimum recommended for navigation by deep draft barges.

Austrian pushers is equal to 6 times that of the Romanian pushers. This difference in productivity is partly justified by the necessity of having an overcapacity to adapt to navigating conditions.

3
POTENTIAL DEVELOPMENT OF THE TRAFFIC

In order to ascertain whether it is necessary to develop the Danube for deep draft barges, traffic development on the Danube has to be forecast according to the new international market economy and the development of industry and any other activities which might justify the transport of raw material on the Danube using deep draft barges.

3.1
STRATEGIC CENTERS ON THE DANUBE

The economic future of some branches of activity in the Danube countries involves a certain number of strategic issues from the viewpoint of heavy traffic volumes, which are a source of potential business for the Danube. The maritime gateway of this region and its capacity to structure a hinterland will certainly play a decisive role in the geography of traffic flow.

In the West, there is the *Mitteleuropa polis*, between Linz and Budapest; in the center the Danube bottleneck, cutting across the fluvial axis between Budapest and Bratislava; and in the East, the Danube delta complex, Constanza and the Danube-Black Sea Channel with Bucharest's potential hinterland.

3.2
REGIONAL DEVELOPMENT PROSPECTS

Going down the Danube, these geographic centers are as follows:

• LINZ AND ITS IRON AND STEEL INDUSTRY •

There are two main scenarios for the future of the iron and steel industry in Central and Eastern Europe and thus for Voest-Alpine in Austria. Either it can survive by maintaining large-scale imports from the Ukraine and importing more ore from the southern hemisphere, in which case the Danube will play a leading role in making it competitive, or the iron and steel industry in Central Europe is condemned to give way to that of areas closer to the mines and ports.

The technological advantage of Voest (a cast iron percentage of nearly 100%) is considerable, but it must be consolidated in order to safeguard its iron and steel activity. For the books, this Austrian activity concerns 4 to 5 million tons of steel. At an optimistic estimate, the Danube's ore contribution could increase to 3 to 4 million tons per year.

When it comes to development, the port of Constanza is obviously a competitive factor, allowing the transport of Ukrainian or Australian or SouthAfrican ores, which Voest-Alpine has already integrated into its strategy for Constanza (modernization of the dry bulk wharf).

Other traffic can, of course, develop positively after the opening of the Rhine-Main-Danube canal. The forecasts made by the Dutch office, NEA, indicate a high potential but contain a substantial percentage of ore which can come both from the East and the West.

Most of present and future traffic in Linz is linked to the iron and steel industry and its energy supplies. However, in certain respects, uncertainties surround both competitors, and its Slovak and Hungarian partners could benefit Voest-Alpine. They can place the iron and steel industry in Linz in a very competitive position both on the Bratislava market and in its region. However, this hinterland is not very extensive and would be fiercely contested by the iron and steel industry in Dunaujvaros, which like that in Linz, is confronted with competition from waterside iron and steel activities.

However, if Voest were to penetrate the Slovak market, it would be dealing in semi-manufactured products, for which access is more difficult.

All in all, the decrease of the Slovak iron and steel industry should lead to the disappearance of ore transport on the Danube, and to the development of semi-manufactured rolled iron product import suitable for river transport (0.5 to 1 million tons).

The net balance for the Danube is thus extremely difficult to estimate.

At an optimistic estimate, with development of the port of Constanza and improvements to the Danube, the traffic volume could represent, under present economic conditions, 3 to 4 million tons of imports via Constanza. The traffic volume will be increased by about 500,000 tons of semi-manufactured iron and steel products on their way to Bratislava, whose transport is not affected by the Vienna-Budapest bottleneck. This traffic might totally disappear if Voest-Alpine decided to direct its traffic towards Rotterdam. Solving the Danube bottleneck would improve the Danube ore traffic to Linz of about 1 million tons. The most pessimistic scenario would result in the Austrian iron and steel industry simply disappearing.

• VIENNA AND ITS REGION •

The issues involved here for river traffic are quite different. It is first of all an urban center with nearly 2 million inhabitants. As such, it generates traditional traffic volumes of consumer and capital goods. The present port of Vienna is not used exclusively for fluvial harbor activities but as a vast warehousing, storage, bulking and break-bulking area.

The only structural traffic concerns the dispatching of metallurgical products to international transport (less than 200,000 tons), oil products refined after import (700,000 tons), cabotage to Linz (180,000 tons) and cement traffic from Linz (140,000 tons). It should be remembered that the refinery in Schwecat, near Vienna, has a capacity of 9.7 million tons (14 million tons in 1978), which represents the entire Austrian requirement in c olume.

The prospect of increased fluvial traffic can only result from with a deep-seated structural development of the traffic flows in the European countries. Otherwise, the prospect of a connection between the oil pipeline networks in the East and the West should make the Danube oil traffic in this region disappear altogether.

Projects for interconnection of the two major Western and Eastern oil pipeline networks, include the following:

- the liaison between Ingolstadt and the Litinov and Krapuly refineries, in the northwest of Czech Republic;
- the liaison between Schwecat and Bratislava connecting Bratislava to the two main AWP and TAL lines; a connection between Schwecat-Bratislava and the Hungarian refineries (Budapest).

To sum up the prospects for the Vienna area, it is assumed that there is little chance of traffic volumes for heavy goods increasing, outside a development in cement, cereals, wood and metals (estimated today at less than one million tons). An elasticity of 0.7 compared with Austrian economic growth can be assumed although it is optimistic. Certain traffic volumes, such as the transport of cars or containers on the Danube can be expected, both westward and eastward.

However, the main car manufacturing center in Austria is Graz (Steyr in the south of Austria) too far south to be linked to the Danube. What is more, container transport on the Danube no longer seems competitive today compared with a liaison with Trieste. It does not seem as though improving the navigating conditions would really change this state of facts.

• BRATISLAVA AND SLOVAKIA •

Danube traffic volumes in Slovakia represent about 8 million tons. Of these, only 2.5 million tons concern international traffic. The rest is made-up of short-distance sand and gravel transport and cabotage over an average distance of 19 km. Slovakia mainly uses the Danube to import ore and scrap iron from the CIS (probably Ukraine) via Killia and Reni, and to re-export scrap iron and metals to Reni, Izmail and especially Linz. Thus the present use of the Danube is

essentially concentrated on two market segments - building and public works (including river dredging) and the iron and steel sector (whose second customer is the building industry).

However, ore from the CIS still represents about 80% of raw materials for the Czech and Slovak iron and steel industry; about 1.3 million is transported by river. As we mentioned above, this situation should lead to an increase in iron ore imports by maritime transport (up to 3.25 million tons in 10 years according to the Ocean Shipping Consultants). What is more, only the iron and steel industry in Kosice (East Slovakia) seems to be competitive today. Industrial centers in Moravia (Ostrova, Victovice and Trinec) are in a very difficult situation and account for 75% of national production. The geographic situation of this area whose development (or maintaining of the status quo) is the most probable, excludes any formal use of the Danube.

The development of the car manufacturing sector however could open certain prospects.

In March 1991, the VAG group made an agreement with the Slovakian government to collaborate with Bratislavske Automotilové Zadovy (BAZ). This agreement concerns the production of gearboxes (1,300/day) and Passat passenger cars (30,000/year).

This reorientation of the BAZ group, which created 2,500 jobs in the short run, could create traffic flow on the Danube to Austria and Germany. It will be very low in terms of tonnage. Motor vehicle production in 1990 topped 240,000 units, and an increase in the total number of vehicles of 4% per annum is expected, due rises in both income and demography.

To conclude, for the Bratislava region, the decrease of the Slovak iron and steel industry should lead to the disappearance of ore transport on the Danube (-1.3 million tons) and an increase in semi-manufactured rolled-iron product imports suitable for river transport (0.5 to 1 million tons) and a low elasticity compared with growth (0.5). The increase in cabotage traffic volumes should continue as long as the work to regulate the Danube has not been completed in this area.

Nevertheless, they will have to be revised downwards when the ongoing works are finished. The transported volume (dredging and the supply of stones, sand and gravel) in the sector concerning Slovakia is estimated at about 20 million m^3 for the 10-year programme 1981-1990.

Whatever the prospects may be, the traffic volumes for miscellaneous products cannot be very great because of the small population of the Danube hinterland, with the exception of car transport.

• BUDAPEST AND HUNGARY •

One of the main features which sets Hungary apart is its monocenter spatial structure centered on Budapest. Although the Budapest region has 2 million inhabitants and specialized mainly in light industry, this industry and the food industry scarcely accounted for more than 39% of "socialist industry." Budapest accounted for 30% of all industrial jobs. Mining resources are generally situated far from the Danube, with the exception of the brown coal mines in Tatabanya and Oroziany, southeast of Komarom.

Two refineries operate along the Danube, one in Komarom, the other one in Szazhalombatta, southwest of Budapest. The most modern iron and steel activity is situated along the Danube at Dunaujvaros, south of Budapest. This location was originally chosen so that Soviet ore and coking coal from the Mecsek mines could be imported via the Danube. This factory, with a capacity of 1.5 million tons per year, was built midway between Budapest and Mecsek. However, the situation has changed because the factory is now fed with Indian pellets, and Australian, Swedish and Brazilian iron ores are to be imported. Coking coal comes not only from Mecsek, but also from Czech and Slovak Republics and the West (richer ore). The development of joint ventures with iron and steel industries in the West is ongoing. This factory remains the iron and steel center whose maintenance or even development is the most probable in the medium run.

Finally Hungary remains a large producer of cereals (wheat in particular), with good outputs, largely exported.

All Hungarian ports have a large cabotage traffic of crude minerals (about 6 to 7 million tons of sand, gravel, etc.), mainly off-loaded in Budapest and Mohacs-Baja. The expected figures for work on the Danube between Ipoly and the Croatian border for the period 1981-1990 were about 18 million m^3 of materials, neither brought in nor removed.

The main traffic volumes leaving the country concern cereals (about 300,000 tons via Baja and Dunaujvaros), crude oil (via Budapest 500,000 tons, Gyor 150,000 tons and Szöny-Amasfüzito 130,000 tons) and metallurgical products (660,000 tons including 370,000 tons from Budapest-Csepel and over 210,000 tons from Dunaujvaros). The main incoming traffic consists of iron ore and scrap iron (1,100,000 tons, 95% of which goes to the factory in Dunaujvaros).

Leaving aside the cabotage traffic of sand and gravel from the dredging of the Danube and regulating works, the traffic development prospects seem optimistic, in particular in the downstream section of the river (area south of Budapest). Cereal exports are likely to pick up after hesitations due to problems encountered by the CIS. The volumes on the Danube could increase considerably and transit via Constanza (1 to 3.5 million tons).

Although the iron and steel industry in Dunaujvaros is faced with the same geographic problem as that in Linz, it is the only area really likely to develop in Hungary. It would certainly benefit navigating difficulties upstream in the river if the recommended works were not carried out. Voest's interest in this site is perhaps extremely clear-sighted. The volume of ore imported by sea could thus reach almost 2 million tons in about the year 2000. However, this would require extensive changes to the port of Dunaujvaros, curiously built on a dead arm of the Danube, and requiring a 14 km railway shuttle service between the port and the rolling mills.

The prospects offered by the free port of Csepel-Budapest, which is the object of development projects, are of a different nature. If it is suitably incorporated into plans to improve and modernize the road and railway networks, Csepel could become Hungary's major logistic center. It could be one of the supporting points for container traffic, and even roll-on-roll-off truck shipping to the Black Sea, if the economic and social conditions are propitious to its development.

• VOJVODINE AND THE BELGRADE REGION •

Information presented here come from data collected before the war in former Yugoslavia. The area traversed by the Danube mainly consists of Vojvodine and the city of Belgrade (1.5 million inhabitants) in northwest Serbia. Vojvodine is mainly a developed agricultural region producing wheat and corn (2 million tons of each cereal), with high yields. Vojvodine has gas and oilfields (production of 1 million tons/year).

The Serbian capital, Belgrade, has a powerful agricultural and food industry (Privedni Kombinat). The iron and steel factory in Smederevo is the only one situated on the Danube. Serbia has important energy resources thanks to the Iron Gate complex and its coal production (35 million tons/year).

Once again, the traffic volume of the Danube ports is characterized by extensive cabotage of crude ore and oil (to Smederevo and Belgrade). The most typical international flows are imports of iron ore (670,000 tons mainly to Smederevo), coal (550,000 tons mainly to Vukovar before the war) and fertilizers (550,000 tons to Pahovo). They also involve cross trade in metallurgical products (exports 700,000 tons, imports 100,000 tons).

Description of the economy of ex-Yugoslavia makes traffic forecasts still more difficult. Present outputs from agricultural yields suggest a moderate growth in production levels in Vojvodine. New grain flows on the Danube will only be possible after the broken pieces of former Yugoslavia have been reorganized. The future of oil traffic is also a debatable question, and it is not impossible that Serbia will persist in obtaining

supplies via Romania instead of via Croatia, as it is doing at present.

The Danube could, at least for a certain time, have large oil traffic volumes. However, they will not stand up for long to competition from the oil pipelines that are to complete the European network. A diagnosis of the future of the iron and steel production in Smederevo is very difficult at present.

All in all, the only growth factor for traffic, and even that is very low, is the potential development of Belgrade and NoviSad but competition remains high.

● NORTHERN BULGARIA ●

Apart from the fact that Bulgaria has developed roll-on-roll-off truck shipping (Ro-Ro) on the Danube, from Germany and Austria, and that Somat (a State-owned road transport company) has been concentrating for several years on transport to the Middle Eastern countries, this country has little to do with the Danube economy.

Also, the ports of Varna (300,000 inhabitants) and Burgas (190,000 inhabitants) can hope to compete with Constanza and counterbalance the appeal of the Danube. Finally, the basic production centers are mainly set out around Sofia and Plovdiv, far from the Danube. The traffic volumes of the country's ports, put aside the habitual cabotage of crude minerals, mainly concern imports of scrap iron and iron ore (1.6 million tons in cabotage in Lom), metallurgical products (900,000 tons) and coal (1 million tons, 700,000 tons of which go via Ruse).

These traffic flows mainly originate from Reni, in the delta. They either feed metallurgical installations (Vidin-Ruse) or contribute to the activity of what is considered to be a poorly located iron and steel industry (Sofia, Kremitlovtzi, Pernik), which depends on iron ore and coal from the CIS. The failure to develop an iron and steel industry on the waterside in Burgas (Black Sea) leaves the experts puzzled about the future of this activity in Bulgaria. In fact, the metallurgical industries in Ruse and Vidin remain the only major openings in the North.

The agricultural production of the Danube plain is aimed at supplying towns in the south and exporting via the Bulgarian ports of the Black Sea. Low agricultural yields, in spite of extensive irrigation, indicate a potential production growth. The question is whether Bulgaria can choose to rely on the port of Constanza and the Danube for her agricultural exports. On this assumption, the long-term traffic on the Danube could reach 0.5 to 1 million tons. This should also result in increased fertilizer traffic on the river (200,000 tons).

To sum up, the main traffic between Bulgaria and the CIS at present is largely artificial. However, if the transformation industries in Vidin and Ruse are to be maintained, the combination of the delta and Constanza could encourage a diversification of ore sources and, in particular, semi-manufactured articles.

New agricultural product and fertilizer traffic could use the Danube in the future. These traffic volumes combined could represent a new flow of about 1 million tons. To these figures we can add Ro-Ro transport in transit to the Middle East via Ruse and Varna, which can only be competitive if the Bulgarian haulers are controlled.

● ROMANIA ●

The Romanian economy is characterized by:

- a very high agricultural potential, offered by the Wolachian plain;
- a powerful iron and steel industry, situated for the most part along the Danube;
- cement works, the largest of which were designed to execute the major works policy of the former regime, such as the Cernavoda Channel;
- a powerful but obsolete chemical industry.

Thus, the Danube plays, or could play, a specific role in the Romanian economy, particularly since building the Danube-Black Sea Channel (Cernavoda-Constanza) has created a new type of relationship between the port of Constanza and its hinterland.

In fact, this port forms one of the centers around which numerous traffic flows can be structured. This is the Southern Port, or "free port" strategy

aimed at securing an important position in traffic flows between Europe and Asia. At present, the smallness of its hinterland restricts what could be spectacular development.

The rise in agriculture, the improvement of the road transport network, the building of the Bucharest-Constanza motorway and reinforcement of the Bulgaria - Giurgiu - Braila - Galati - Ukraine connection can help strengthen the role of this port, and this can only encourage the use of the Danube waterway.

An analysis of the present traffic flows of Romanian ports reflects the high quantity of dredging in proportion to the length of the Romanian section of the river. Further away, current traffic volume mainly consists of imports of iron ore (6 million tons to Galati) and coal (3 million tons to Galati). This is the source of the main metal exports from Braila. This port imports about 300,000 tons of grains. Nonferrous ores are imported via Tulcea (800,000 tons). Galati also exports wood (500,000 tons). Turnu-Magurele sends almost 100,000 tons of fertilizers in cabotage. As we can see, these traffic flows are mostly imports and mainly linked to the Danube delta.

The Romanian iron and steel industry in Galati and Calarasi is considered to be profitable and well located. In fact, it has been the country's main source of supply since the collapse of production from facilities in the western part of the country near the iron mines of Ghelariand Teluc. Production fell from 14.4 million tons in 1989 to 7.5 million tons in 1991.

Traffic flows linked to the activity of iron and steel centers in the East of the country are mainly confined to the maritime section of the Danube, and between these centers and Constanza.

One may question the long-term benefits to be gained from developing iron and steel activities directly on the coast, so that they can be shipped by sea directly from the works. Transport by mixed fluvial/maritime vessels (at best) does not enable the highest maritime quotations to be obtained. If it were restructured along the coast, the Romanian iron and steel industry would be in an excellent position to be redeveloped.

However, it would generate little raw materials traffic on the Danube. On the other hand, it could produce upstream traffic in finished products. All in all, the prospects opened up by Voest (Austria) in the port of Constanza, and those of the iron and steel industry in Galati and Calarasi could mean heavy traffic in ore and finished products. The order of magnitude of Romanian industries alone could be more than 10 million tons of iron ore (+ 4 million tons).

Agriculture is one of Romania's potential source of wealth. The Romanian plain benefits from excellent conditions, including large-scale irrigation. At present, production levels are very much below what they should be. It is generally estimated that yields could be doubled. If this happened, Romania would become a granary again and thus structurally an exporter. It would then use its own fertilizer production. Traffic potentialities would be considerable, probably several million tons.

Chemistry, which needs to be technologically upgraded could be a source of exports, perhaps fertilizers, to Germany and Central Europe. At present, railway transport plays a predominant role on this market.

Finally, Romania has a large refining capacity, as well as a high cement potential as we mentioned earlier. However, the potential export sites are situated near Constanza and will thus use the sea.

The conclusions to be drawn from this analysis of Romanian potentialities can be summed up very simply. There is certainly an additional potential of 10 to 21 million tons, but directed very much towards the Black Sea and the ports of Constanza and Galati. Certain traffic could pass through the Iron Gate, in particular to compete with the iron and steel industries of Central Europe, which are at a disadvantage due to their distance from harbor sites.

In reality, as we already said, the future of this part of the Danube as a main transport route will depend on the development of Romanian agriculture and the industrial harbor complex of Constanza, Braila and Galati. Colossal as it may seem, building a channel between Cernavoda and Constanza and developing a southern (free) port, by excavating the channel, will open up otherwise impossible prospects. It should be emphasized that most of the traffic flows are rarely held up by variations in the water level.

3.3
TRAFFIC FORECAST FOR 2020

The development potential of the Danube artery is directed towards the Black Sea, although it is somewhat uncertain.

Thanks to the port of Constanza, the increase in traffic volume in Romania could reach roughly 25 million tons by the year 2020, only 1.8 million tons of which would have to go through the Vienna-Budapest Danube bottleneck.

Although this potential exists, it cannot be taken for granted. The railway crisis will inevitably increase competition, particularly when it comes to tariffs. Traffic transfers and even induced traffic are therefore fragile. On the other hand, insufficient infrastructures and difficulties in crossing borders are so many points in the Danube's favor, both for heavy traffic and Ro-Ro transport. Ultimately comfortable, although slow, the river offers an extraordinary reserve capacity which is relatively inexpensive.

Under these circumstances, improving navigating conditions can only have a limited effect.

The need is mainly confined to the Vienna-Budapest Danube bottleneck, which is rather small compared to traffic flows. Nevertheless, in the long run, it would not be absurd to imagine that this fluvial route could play a more important role in the economy of Central Europe, with the expansion of trade between major urban centers such as Linz, Vienna, Bratislava and Budapest.

A highly optimistic scenario (assuming that the economy will recover in 1994 or 1995) will give the following navigation origin/destination matrix for the year 2020 (Table 2.4), based on traffic volumes and a calculation of the benefits for navigation. Concurrently, the development of three iron and steel industries (Austria, Slovakia, Hungary) does not appear realistic after the Danube has been improved. Our hypothesis will therefore not be based on an accumulation of these three industries but rather on the disappearance of the Slovakian iron and steel industry.

Table 2.4 - Traffic forecast on the horizon 2020 (Billion ton-km)

ORIGIN	DESTINATION									TOTAL
	AUS	BUL	SLOV	GER	HUN	ROM	CIS	SERBIA	OTHERS	
AUS	0.1		0.6	0.6			2.3	0.1		3.2
BUL	0.1			0.1		0.4	0.3			0.9
SLOV	0.2	0.1	0.1			0.5	1.4	0.2	0.2	2.7
GER	0.5							0.1		0.6
HUN	0.3			0.4	0.3	5.5	1.5			8
ROM	3.1			0.5	6	5.1		2.1	0.4	17.2
CIS	5.4	1.3		0.1	2.4		0.7	3	0.2	13.1
SERBIA	0.2		0.2	0.5		3.6	1.1	1.4		7
OTHERS	0.3		0.1			2.1	0.3			2.8
TOTAL	10.2	1.4	0.5	2.2	8.7	17.2	7.6	6.9	0.8	55.5

4
ECONOMIC EVALUATION OF IMPROVEMENTS TO THE DANUBE

4.1
YEARLY EARNINGS FOR NAVIGATION IN 2020

Thus traffic volumes would be about 55.5 billion ton-km including 11 billion ton-km traffic which has been induced or transferred from other forms of transport. The remaining traffic gains would be the result of economic development and independent of improvements to the Danube.

The aggregate traffic can be broken down into three categories:

- The first consists of traffic flows which would benefit very little from improvements to the Danube between Vienna and Budapest.
- The second consists of traffic flows which would use the Danube in any case, but which would not, in the case of improvements, gain any advantage from the possibility of using heavier and more regular convoys (drop in unemployment). Estimation of this advantage is based on the difference in cost between using 2,500 ton transport services and 8,000 ton pusher convoys. This difference should be comparable to the total costs including all the cost components for the entire transport chain *(See Figure 2.3)*.

Table 2.5
Yearly earnings for navigation in 2020
Estimated cost differences applied to expected traffic ($ Million)

ORIGIN	DESTINATION								TOTAL
	AUS	BUL	CZEC	HUN	ROM	CIS	SERBIA	OTHERS	
AUS	0.3		0.2			5.8	0.2	0.1	6.6
BUL	0.2	0.1							0.3
CZEC	0.4	0.3			0.7	3.7	0.5	0.5	6.4
HUN	0.7			0.7	7.1	3.7	0.1		12.3
ROM	4.2			7.8			2.9	1.1	16
CIS	13.8		0.2	6.1			7.7	0.6	28.4
SERBIA	0.6		0.40	0.1					1.1
OTHERS	0.9		0.2		5.3	0.8			7.2
TOTAL	21.1	0.3	1.4	14.7	13.1	14	11.4	2.3	78.3

Benefits linked to the improvements in $ million taking into account the percentage of induced traffic:

Improvement of the bottleneck	33.2
Fleet productivity	45.1
Total benefits	78.3

It results from this table that the benefits for navigation fall between $ 33 and 78 million by the year 2020.

- The last category includes traffic which has been induced and that transferred from other transport modes. It is usual to consider that the advantage is equal to half the product of the difference in overheads between the basic rate and that of types of transport being considered. We must not confuse the cost difference with the different modes of transport.

It is possible to calculate the total amount to be gained from a complete theoretical improvement of the Danube bottleneck.

Yearly earnings are nearly $ 80 million for the reference year 2020 if we include all the benefits (improvements and better productivity) and $ 33 million if we limit ourselves to the direct effects of improving the bottleneck. *(Table 2.5)*.

Investments would exclusively concern the section between Vienna and Budapest. They would consist of 4 dam/lock series near Vienna, Hainburg, Wolfstahl and Nagymaros. The cost of these works, excluding Gabcikovo and investments in electricity production, would be about $ 1 billion or an 8% updated value of $ 700 million.

These costs have been calculated for locks with a 23 x 24 m gauge and dams with the characteristics defined by the Danube Commission using simple estimation formulae used to make similar calculations in France for previous project evaluations in 1990 French francs. (N.B. We have assumed that all the improvements will be completed by 2000, and there will be a gradual rise in traffic volume from this date forth).

These direct costs for the improvements are to be compared (restricted balance) with benefits to be gained for navigation only. These are estimated at $ 180 million (updated value) if only the direct benefits from improvements on the Vienna-Budapest section are taken into account. If all the benefits are considered, the figure is $ 360 million.

The percentage of induced or new traffic volumes directly linked to these improvements is low. It is less than $ 30 million. It would be $ 120 million at an optimistic estimate. Consequently, by the year 2020, the net earnings for navigation can be expected to be at best, about 50% of the cost of the works. However, taking only direct benefits into account on the improved section only, brings this percentage down to 25%.

It is obvious that this does not include either the cost of the Gabcikovo complex or the investment costs and margins for the hydroelectric installations.

The net earnings for navigation do not compensate for the cost of improvements.

4.2
OVERALL ASSESSMENT

The benefits to be expected from improving the Vienna-Budapest section do not affect all the Danube countries. There are in fact two main areas which will reap the benefits of river transport.

The first, for exports, consists of the CIS (probably Ukraine and Moldavia) and Romania. After these two centres, the Hungarian and Serbian economies can expect to reap part of the benefits.

Most of the benefits are related to improving what is known as the Danube bottleneck between Budapest and Vienna. The strategical argument for the work only seems to apply to the Austrian iron and steel industry in Linz, which is perhaps banking on it to assert its position on the central European markets, and maybe even for its survival as well.

Possible improvements to the river clearly play a less strategic role for the other Danube economic centers.

As far as Romania is concerned, although the port of Constanza will obviously benefit from greater competitiveness on the Danube, it is clear that its hinterland will depend on Romanian development, and on the overall quality of the transport and distribution systems. Generally speaking, it should be pointed out that the bottleneck is too far from Constanza for its elimination to have much effect.

Overall estimation, as we saw earlier, limits the increase in traffic volumes by the year 2020, due to induced or transferred traffic, to 20% or 11 billion ton-km. The induced traffic, disregarding the overall improvement in the productivity of transport vessels is very low.

However, our estimation of Danube traffic for the reference year is far from ridiculous. Whatever may be the scenario, more than 55 billion ton-km constitutes a large amount of freight in this area, and comparable in terms of volume (ton-km), to that of the Rhine, although lower in tonnage.

The negative impact of the improvement work on the environment will be immediate, and probably irreversible, while the positive impact is uncertain and somewhat remote. If it is possible to imagine that this route will one day offer a substitute transport capacity, an investment in this direction does not require any improvement work.

It seems difficult to consider, as a priority, an investment on Hungarian or Slovakian territory which will only benefit Austria, and could hasten floundering of the iron and steel industry in these countries.

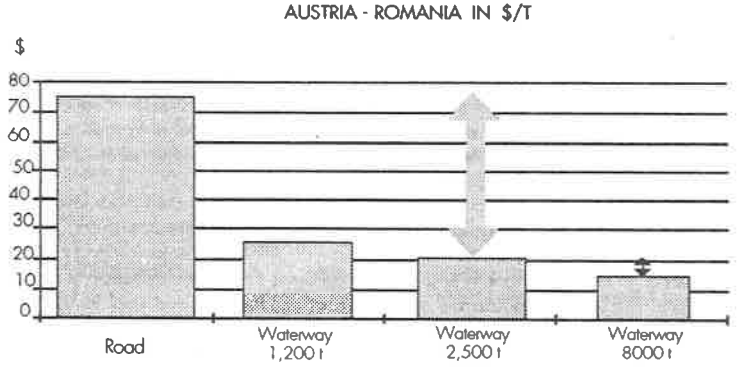
4.3
ROLE OF THE RHINE-MAIN-DANUBE CANAL

If we take a look westward, we are struck by the fact that the traffic potential announced for the Rhine-Main-Danube channel is also largely linked to the potentialities of the Voest group. The investment for building 170 km of canal would be over DM 5 billion. The channel is of medium capacity (pushed convoys of about 3,500 tons), but it will nevertheless give the Austrian iron and steel industry two competitive transport routes by September. Transport prospects to the East and to the West cannot be added together. The traffic volume is divided between the East and the West, except if we consider a very strong induction.

Traffic prospects on the Rhine-Main-Danube route comprise between 6 and 10 million tons per year.

Thus, the value of opening up the historical route between the North Sea and the Black Sea and the work undertaken by Germany 38 years ago lies more in the cost and symbolic value than in the traffic it will carry.

***Figure 2.3* - Example of quotations - $/ton**



The difference in cost between large-gauge transport (8,500 t) and 2,500 ton transport is slight when compared with the difference in the cost between water and road and it should in no way result in a transfer to this mode.

Austria will be the first to benefit from opening up this route, with Hungary a distant runner-up, and the two ports of Rotterdam and Constanza, rivals but beneficiaries of possible induced traffic.

• TRAFFIC TRANSFER FROM THE ROAD TO OTHER MODES OF TRANSPORTATION •

There is little likelihood of transfer from roads to waterways, whatever developments occur.

If a transfer from roads to waterways results from the development of the Danube, the advantages of road and rail transport are, at most, equal to the cost difference between river transport before and after development, i.e. between a 2,500 ton waterway and a 8,000-ton-large-gauge waterway.

Clearly, the advantages for navigation do not balance out development costs and if a transfer from roads to waterways were going to happen, it would already have done so, considering the very high difference in costs. *(Figure 2.3).*

The development of the Danube will probably fail to induce any transfer from one mode of transportation to another.

An overall economic analysis of the Danube area shows that navigation should develop around two major economic centers: the modern steel industry in Linz (Austria), and the port of Constanza, on the Black Sea. Most of the increase in traffic between now and 2020 will occur downstream from the Danube bottleneck between Vienna and Budapest, i.e. 20.7 million tons more than the current traffic will thus transit between the Black Sea and the ports downstream from Budapest, whereas the traffic increase through the Danube bottleneck will only amount to 1.8 million tons if the river is developed.

On this hypothesis, the section including the very controversial Gabcikovo dam, in Slovakia, would have to undergo extensive work to ensure the required depth. The works to be carried out between Vienna and Budapest would include a complete series of four dams equipped with double locks according to the recommendations of the Danube Commission. These are the only works that can be considered as priorities for navigation.

However, the lock gauges and the radii of bends in the upstream section limit the productivity gains to be expected from the works after Vienna.

There are no direct profits to be gained for navigation from improvement of the Vienna-Budapest sector (a negative internal profitability rate).

The impact of these investments on the overall productivity of the transport vessels is not inconsiderable, but it will not produce any significant profitability. It would be about 2.5% at the maximum.

The first to benefit from these investments will, of course, be the fleet operators, and thus their clients. Although Romanian and Hungarian agriculture is the indirect beneficiary of the fleet productivity, the iron and steel industry in Linz will be the only direct beneficiary of the improvement to the Danube bottleneck.

The negative impact of the works on the environment will be immediate, and probably irreversible, while the positive impact remains uncertain and somewhat remote.

RECOMMENDATIONS.

Better organization of transportation has a price: that of anticipating and overinvesting as part of a planned approach. This is why, in the final analysis, it is a political question...

• Limitation of development of the Danube

- Turning the Danube into a deep-draft channel must be prevented. It seems greatly preferable and far less expensive to use barges and fleets suited to the river's irregularity. Ukrainian and Romanian fleets, with their typical overcapacity are highly suitable in this respect.

- Nothing at this stage justifies building the eleven dams planned by the Danube Commission.

• Equipping the ports, linking them to their hinterlands and encouraging the installation of transport operators experienced in the techniques of bulking and break-bulking can be more important than investments in the river. In any case, these investments are necessary for the development of fluvial transport, which is basically modern and remarkably well located compared with the Danube urban system. Investments in facilities along the Danube and harbors should be considered strategic. International financing should therefore be directed towards a selective programme of this type.

• Developing a strategic master plan for transport

The priority given to developing and constantly looking for solutions which encourage multiple modes of transport has made road transport or the automobile the focal point around which the transport system is organized. The policies in question are based on three main considerations:

- For goods, the development of a competitive, combined rail/road, waterway/road and sea/road transportation system. In general, this policy requires specific investments in infrastructures and ports, and price policies.

- For medium- and long-distance travelers, the re-instigation of competitive railroad prices and services compared with those offered by road.
- In urban areas, better control of automobile traffic and a fresh boost to the development of public transport.

A structural policy cannot be envisaged without a master plan for transport, i.e. a strategic master plan.

The value placed on traveling time in our society, and the consideration of all the costs for each component of each transportation chain, has lead to the organization of a transport system in which the road network is the structural entity. To have any significant effect on the breakdown of the different types of transport, or to lessen the domination of road transport, in Eastern Europe as well, a period of scheduled overinvestment will need to be included in any strategic plan.

• Promoting multiple modes of transport now

Multiple modes of transport should be effectively encouraged. This means large-scale public investment (port infrastructures, combined rail/road transport centers, interconnecting passenger networks, railroad gauges, etc.). However, multiple modes of transport cannot be developed if it is not part of the strategy of river, rail, airline and sea operators. Giving priority to multiple modes of transport, which is only possible through a more rational use of different systems and modes of transport, requires that great attention be paid to the effective conditions under which they can be accessed, and to the interconnection of networks in time and space.

• Land development, urban planning and land control: three factors for better organization of the transport system

The development of traffic in Western Europe shows that congestion threatens the most developed hubs. The need for infrastructures is concentrated in rich, densely populated, polluted areas. This is not only due to an increase in trade. It results from the increasing concentration of the population, and the production of wealth. Yet it is precisely in these areas that the cost of adapting to demand is the highest, environmental constraints the heaviest

RECOMMENDATIONS

and the price to pay for a supply which is poorly suited to demand is the highest.

In other words, everything works to camper the system to become more deeply embroiled in a vicious cycle. Even with exceptional determination in terms of urban transport policy, it will be difficult to counteract the effects of this growing concentration.

Land control, urban planning and land development are the three most reliable factors in a more intelligent organization of the transport system. But it is impossible to have a transport policy without managing space and the way it used.

• Investing in the infrastructure network

• Making the investments needed for economic recovery and thus bringing about immediate change seems to be an important objective. These investments therefore mainly concern the road network, which suffers from a strong undercapacity. But it will not be enough to invest in linear infrastructures (roads and bridges). A special effort must be made to promote efficient transportation chains, which necessarily involves the main communication nodes, the logistics and distribution platforms, and the systems for interconnecting modes of transport (people and goods, collectively and individually). The transfer of technology and experience in the field of transport organization and logistics (mainly distribution) should be encouraged.

The development of traffic volume on the Danube, as well as the increase in the flow of manufactured articles, trade between countries in the region, and between these countries and the rest of Europe, require important investments in infrastructure networks. The scarcity of bridges, appropriate road transport infrastructures and railway lines which are compatible with western technical standards is such that the immediate priority is to establish a suitable connection between the ex-Soviet bloc countries and Western Europe.

This priority in relation to freight transport requires large-scale organizational investments, particularly in distribution, bulking and break-bulking infrastructures. It means that a large number of harbor facilities (fluvial, overland, etc.) whose operation is either inefficient or deficient need to be redesigned.

• Investing in traffic monitoring facilities

Another aim should be to invest in a means of obtaining statistics on passenger and goods traffic. This is a *sine qua non* for a rational approach to future investments, their location and their amount. To be effective, these need to be coordinated on a European level, by a transport monitoring organization. Initiatives already taken in this area should be expanded.

PART 3

ENERGY IN THE DANUBIAN COUNTRIES

ENERGY IN THE DANUBIAN COUNTRIES

Historically, the development of affluent countries occurred in parallel with the increase in the production and consumption of energy resources. The energy factor takes place in all the economic fields and represents an industrial sector into itself.

Energy plays a crucial role in citizens' daily life. It is one of the most exchanged commodities in the world market, which induces complex relations between producing countries and consuming countries. Finally, energy has a considerable impact, sometimes non-reversible, on local, regional and worldwide environments.

Some international institutes foresee that, according to the current trend, energy consumption in 2020 could be between 14 and 20 billion toe, as compared with the 8 billion toe consumed today. The social and ecological impacts from such an energy consumption would be considerable and difficult to cope with.

Moreover, exploitable fossil fuels, today estimated at 1,400 billion toe, could be consumed in less than a century. For oil and gas, the duration of exploitation would be even shorter. If consumption goes on doubling every 25 to 30 years as has been the case for a century, 80% of the exploitable reserves, estimated today to be 140 billion tons, will have disappeared within 50 years.

Such forecasts are incompatible with lasting and fair development. For economic, physical and environmental reasons, energy consumption must be stabilized as quickly as possible at a level close to current consumption.

The stabilization of worldwide energy consumption supposes that consumption in developed countries be halved to reach an average rate of 2 to 2.5 toe per capita per year, allowing an increase in the developing countries' consumption which would thus amount to 1 toe per inhabitant.

In order to stabilize worldwide energy consumption, energy sources must be varied but, most of all, they must be used rationally.

The efficient use of energy can be concomitant with economic development. Between 1973 and 1988 in the OECD countries, energy consumption increased by 5% while the GDP increased by 36%.

It is important to notice that the most globally energy-efficient countries are leading the GDP race. Western Germany and Japan are both typical, with an energy intensity twice as low as that of the United States.

Nuclear energy has shown its limits. After the first very serious alert at Three Mile Island in

1979 and the accident at Chernobyl in 1986, it is impossible to consider the development of this energy source under conditions acceptable to the public. The investments necessary to develop nuclear energy according the highest safety standards possible today are considerable and out of reach for practically all countries. The only 450 operative nuclear reactors in the world in 1990 show how wrong the planning authorities were in the 70s when they forecasted more than 2,000 of them by 1990.

A modern energy policy which paves the way for the 21st century must have nothing to do with the past so as to avoid repeating mistakes made in Western as well as in Eastern countries. This new energy policy must first rely on energy efficiency, the economical use of other fossil fuels, renewable energies and the growing recourse to natural gas and biomass.

The work which has been completed by Equipe Cousteau and International Consulting on Energy, directed by Bernard Laponche, in the field of energy in the Danubian countries is an analysis of the political, economic, institutional and structural barriers and a reflection on the setting up of new rules in order to succeed in the transition towards an environment-respectful development improving the quality of people's living conditions. After an in-depth study of the current energy situation in Danubian countries, we propose different scenarios for a new energy policy and measures to take for its setting up. More in-depth studies have evaluated the role that renewable energies must play in this new energy policy.

1
CURRENT SITUATION

1.1
GLOBAL INDICATORS

The five countries studied — the former Republic of Czechoslovakia, Hungary, the former Republic of Yugoslavia, Bulgaria and Romania — are characterized by a high level of energy consumption compared with their economic activity level.

The following table *(3.1)* gives general information and known global indicators from 1989 for energy consumption in each country studied.

GDP is calculated with purchasing power parities and is expressed in 1980 US$. The choice of currency unit is purely a matter of convention with no effect on comparison between countries.

To complete the comparisons, we have represented Western European countries by an average European country "EUR" which is obtained by dividing the figures for the European Community by twelve.

The final energy intensity of these countries - i.e., the ratio of primary or final annual energy consumption to the gross domestic product of the same year - is two to three times higher than that of Western European countries such as Austria and Italy. Only former Yugoslavia has a final energy intensity similar to Western European levels, while Hungary is nearer than Bulgaria, Romania and ex-Czechoslovakia to the overall Western energy intensity level.

The intensity of per-unit-of-GDP electricity consumption is high in Danubian countries, where figures range from 0.56 for Hungary to 0.92 for ex-Czechoslovakia. In the average European country that we have taken as our reference, value stands at 0.47.

Further, electricity is consumed primarily by industry in Danubian countries. In Bulgaria, space heating with electricity is a source of difficult problems with the supply of electricity to the population at peak hours and in winter time.

This high level of energy consumption is due to:

- Historical economic development in which priority has been given to heavy industries (iron and steel, petrochemicals) which are high energy consumers.
- Low efficiency in the production, transformation, transport and distribution of energy products, in particular for electricity generation and the transport of heat.
- Obsolete and poorly maintained industrial installations and, in general, inefficient consumption or end-use systems (badly insulated houses, non-regulated space heating, etc.).

Table 3.1 - General information and known global indicators (1989) for energy consumption in each studied country.

	EUR	AUS	ITA	ex-CSFR	HUN	ex-YUG	BUL	ROM
Area (1000 km²)	197	83.9	301.3	127.9	93.0	255.8	110.9	237.5
Population (million)	27	7.5	57.3	15.9	10.8	23.8	9.08	23.7
GDP (billion $) (Gross domestic product)	261	70.3	57.4	92.5	57.4	91.1	42.9	87.7
GDP/capita. (10,000 US$)	9.7	9.4	10.0	5.8	5.3	3.8	4.7	3.7
PEC Mtoe (Primary Energy Consumption)	92	21.5	151.7	73.7	31.5	44.1	37.5	72.6
PEC/capita	3.4	2.87	2.65	4.64	2.91	1.85	4.14	3.06
FEC (Final Energy Consumption)	66	18.4	117.1	49.8	21.4	24.1	24.2	46.3
FEC/capita	2.4	2.46	2.04	3.13	1.98	1.0	2.66	1.95
FEC/PEC		0.86	0.77	0.68	0.68	0.55	0.65	0.64
PEI (Primary Energy Intensity PEC/GDP)	0.35	0.31	0.26	0.80	0.55	0.48	0.87	0.83
FEI (Final Energy Intensity FEC/GDP)	0.25	0.26	0.20	0.54	0.37	0.26	0.56	0.53
Electricity, final consumption TWh	124	41	207	85	32	65	39	71
Electricity, final consumption per capita kWh/c	4590	5530	3610	5320	2970	2750	4310	3010
Electricity, final consumption per GDP unit kWh/$	0.47	0.58	0.36	0.92	0.56	0.71	0.91	0.81

* GDP is calculated with purchasing power parities and is expressed in 1980 US$.
** "EUR" is an average European country which is obtained by dividing by twelve the figures for the European Community.
*** Italy is given as the lowest intensity consumer.

For all the Danubian countries, this high level of energy consumption and correspondingly high production is a source of enormous economic waste (investments, hard currencies) and of environmental pollution and hazards.

Overcapacity of electricity production is a considerable burden for Danubian countries. It is risky (nuclear accident, nuclear waste), it pollutes the environment (non-efficient burning of low-quality coal) and it is not viable in economic terms (production investment, operating costs, fuel cost). The high level of electricity consumption compared to domestic product points to a considerable potential for electricity savings and the rational use of electricity. In order to reduce consumption levels while raising service quality, the effective use of electricity must become the number one priority of any energy policy in these countries.

1.2
FINAL ENERGY CONSUMPTION BY PRODUCTS

Coal tends to be used more than in Western countries while oil products are used less, primarily as a result of low consumption by the transportation sector (See Table 3.2).

Another interesting characteristic of energy systems in Danubian countries is the importance of heat networks for industrial use and, above all, district heating.

Former Czechoslovakia based its energy development on coal and lignite, which also occupy key positions in the ex-Yugoslavian, Bulgarian and Romanian energy balances. Hungary uses more hydrocarbons than the other Danubian countries and its primary energy balance is therefore closest to that of western European countries.

Bulgaria and Romania are in totally different positions. Bulgaria is almost totally lacking in energy resources and has given preference to oil, which is easily importable, and nuclear power energy, while Romania is drawing upon its natural gas resources.

Natural gas is of minor importance in ex-Czechoslovakia, ex-Yugoslavia and Bulgaria but it occupies first place jointly with oil in the Hungarian energy balance and it is the dominant energy source in Romania.

Nuclear energy plays an important role in electricity production in ex-Czechoslovakia, Hungary and Bulgaria.

Table 3.2 - **Final energy consumption by products in the Danubian countries and comparison with European standards**

PRODUCTS	EUR	AUS	ITA	ex-CSFR	HUN	ex-YUG	BUL	ROM
solid fuels (%)	7	10	3	23	15	12	13	21
oil products (%)	54	51	56	21	31	47	32	24
gas (%)	22	16	26	16	23	12	10	32
electricity (%)	16	20	15	15	13	23	17	13
heat (%)	1	3	0	25	18	6	28	10
non comm* (%)	-	11.6	0.7	0.8	1.8	0	1.7	2.5
TOTAL CONSUMPTION (Mtoe)	66	18.4	117.1	49.8	21.4	24.1	24.2	46.3

* non commercial energies: rural, urban and industrial waste, wood

Renewable energy sources are not widely used in Danubian countries although significant resources are available, particularly in terms of biomass (Romania is particularly rich in this respect). The one exception is hydroelectric power, which is particularly developed in former Yugoslavia.

1.3
FINAL ENERGY CONSUMPTION BY SECTORS

In Danubian countries, energy consumption is marked primarily by the distinctive pattern of sectorial distribution, which is totally different from the Western European model *(Table 3.3)*.

In Western Europe, final energy consumption is shared equally by industry, transportation and the domestic-tertiary sector, which each consume some 30% of the total (37% for industry since we include the non-energy uses for statistical reasons).

The predominance of industry in consumption structures in Eastern countries can be explained by the mode of development pursued in these countries. Development strategies were based on heavy industry and the extensive exploitation of natural resources; the development of the tertiary sector was largely ignored.

2
SCENARIOS FOR A FUTURE ENERGY POLICY

One of the main energy resources in the Danubian countries today, and for the next two decades is improved energy efficiency, the other one concerns renewable energies. This improvement is also a necessary condition for economic and social development, and improved environmental quality including reduced health risk. Improving energy efficiency is the cheapest of all energy policies for the Danubian countries.

In 1989, the Directorate for Energy of the Commission of the European Community issued several credible hypotheses on the evolution of energy efficiency in the twelve countries of the European Community. The highest energy consumption scenario indicates a 32% decrease in energy intensity between 1989 and 2010 while the highest energy efficiency scenario indicates a decrease of 48%.

The assumption made in our study on economic growth for the Danubian countries is the following:

- The GDP value for 1995 will be at its 1989 level.
- Then it will grow at a 3% per year rate from 1995 to 2010, i.e. an increase of 55% GDP in 15 years.

Table 3.3 - **Final commercial energy consumption, by sector (1989)**

SECTOR	EUR	AUS	ITA	ex-CSFR	HUN	ex-YUG	BUL	ROM
Industry* (%)	37	37	39	55	42	53	65	67
Transport (%)	29	30	29	6	13	24	8	7
Others** (%)	34	33	32	39	45	23	27	26
TOTAL CONSUMPTION (Mtoe)	66	18.4	117.1	49.8	21.4	24.1	24.2	46.3

* *Including non energy uses*

** *Others: residential + tertiary and commercial + agriculture*

The assumption on energy intensities will be that the values for the Danubian countries will fall in line with the value for the western European countries during the period from now to 2010. This assumption is the key to our forecasting exercise for each country.

We shall therefore envisage two possible scenarios for trends in final energy intensity in each country, associated with economic scenarios indicating relatively low economic growth in the 1990s and steadier growth between 2000 and 2010.

In the first scenario, final energy intensity improves over the twenty years to attain a value of 0.25 in the year 2010 and final electricity intensity reaches 0.47. This figure is that of the average Western European country (EUR) in 1989.

In the above scenario, energy efficiency in the year 2010 would still be higher in Danubian countries than in western Europe where energy intensity is expected to decrease significantly over the same period.

Final energy and final electricity consumption will decrease in most of the countries.

In the second scenario, final energy intensity improves over the twenty years to attain a value of 0.17 in the year 2010 and 0.41 for final electricity consumption. This is the target figure for Western European countries as indicated in the highest CEC energy consumption. In this scenario, the Danubian countries would be more or less in line with other European countries with respect to the overall energy efficiency of their economies.

The cautiousness of both of the above scenarios should be noted. In the first scenario, we assume that Danubian countries will take twenty years to reach the overall energy intensity observed today in Western Europe. In the second scenario, we assume Danubian countries will attain the European average by the year 2010, based on the highest energy consumption figure in the CEC scenario.

Actually, environmental constraints will force Europe to work even harder to increase energy efficiency, which will be further improved by the impact of new technology on the end uses of energy.

These two scenarios have been applied to the five Danubian countries and are further explained in the document "Energy in the Danubian Countries," September 1992 (second edition December 1992), prepared by Equipe Cousteau and International Consulting on Energy.

3
IMPLEMENTATION OF A NEW ENERGY POLICY

Energy planning is the bedrock of any coherent energy policy. Energy planning must take into account energy enduse and also the services that energy must provide.

3.1
PRINCIPLES OF A NEW ENERGY POLICY

The consequences of energy waste at all stages of energy production, transformation, distribution and consumption are very serious:

- For the economy: high investment costs to increase energy production and high production costs due to the inefficient energy system, expensive and sometimes unnecessary energy imports.
- For the environment: high level of pollution linked to energy production, transformation and consumption.
- For the public's quality of life: due, in particular, to environmental degradation and to poor levels of services linked to energy consumption.

If the Danubian countries want to achieve the transition from central planning to a market economy while securing a better quality of life for their citizens, it is necessary that they reach the overall level of economic efficiency already achieved in the Western European countries.

Energy efficiency must be the focal point of energy and economic policy in Danubian countries:

- in the energy sector itself (production, transformation, distribution);
- in all energy enduses.

Considering the present situation of Danubian countries, energy efficiency is the main factor in economic development and environmental improvement.

Enduse energy efficiency has the potential of saving enormous amounts of money (which would be otherwise devoted to energy production or energy imports) and reducing the profound environmental stresses facing these countries, central Europe and the world at large (global climate change or nuclear hazards for instance).

For the necessary impetus to energy efficiency policies and programmes, three main steps must be taken:

- The introduction of energy practices and investment strategies at national and international levels that deal equally with the expenses and capital requirement for energy efficiency and energy supply (global leastcost planning), and the incorporation of these strategies in the programmes of bilateral and multilateral funding agencies.
- The creation of institutions at the highest level of national and local governments, with appropriate financial and human resources, to define and implement energy conservation programmes in all sectors of social and economic activities. The support of these programmes, including - as a necessary preliminary phase - the building of such institutions, must be included as a priority of international cooperation.
- The establishment of prices of energy products at the consumer level which reflect the real cost of energy supply, both in terms of capital requirements and of energy prices on the international market.

Energy efficiency and energy demand perspectives are not issues limited to the energy sector but concern the national economy and perspectives as a whole: all sectors of activity and all economic agents are involved.

3.2
ENERGY DEMAND PERSPECTIVES

To launch a vigorous policy for energy efficiency, the government must have a clear view of the potential of such a policy. This will require that governments assume their responsibility for the specific and detailed studies that must be undertaken in order to explore the perspectives of energy demand in the Danubian countries, in accordance with the degree of implementation of energy efficiency measures and programmes.

Tools and methods have been developed in the western countries to carry out such an exercise: they are based on detailed analyses of the final energy consumption of all the economic agents coupled with assumptions on the economic and social development of the country studied and the evolution of the efficiency of each enduse in accordance with the evolution of technical factors (for instance: insulation of houses, more efficient equipment and appliances). These technical factors improve under the pressure of a number of factors: energy prices, technical progress, regulations, incentives, etc. This improvement is then a consequence of the level of energy efficiency measures, initiatives and programmes which are implemented in all sectors of social and economic activities.

To perform such an exercise, which has to be an ongoing process, we recommend that Danubian countries' governments set up a permanent working group under the technical leadership of the institution responsible for energy efficiency policy implementation, gathering experts from various energy and non-energy sectors: representatives of the energy companies and insti-

tutes, and also from the building industry, the various industrial branches, the transportation companies, financial experts, representatives from cities, etc. The permanent group (fewer ten persons) can be small, but it must work with partners from various fields.

The work of this group can be facilitated by experts who have already done the same exercise in their own country or other countries.

The results of this work must be regularly reported to a steering committee under the responsibility of the Prime Minister.

Terms of reference of the working group will be:

Phase 1: Evaluating the total final energy consumption in 2010 with the assumption that, over a period of 20 years, Danubian countries raise the global efficiency of their economies to the present level of Western European countries.

Phase 2: Evaluating the final energy consumption for each sector in 2010 in accordance with the assumption detailed below.

Phase 3: Establishing programmes and standards of energy efficiency in all sectors and for all equipment in order to obtain, over the twenty-year period of their implementation, the results mentioned above.

Each of these measures and programmes must be described in terms of government decisions (energy prices, regulations, institution building), incentives to the consumers or the equipment manufacturers, financing methods.

One then has to compare various scenarios with or without the implementation of these energy efficiency programmes in terms of the supplementary energy supply (production or imports) necessary to provide the final energy output of each scenario and to evaluate the costs of these supplies and their environmental impact.

Eventually, the exercise will lead to a comparison between several economic and energy policies, with their associated costs (economic and environmental) and risks. From this comparison, appropriate political decisions for today can be made.

Phase I takes as a political goal the reduction of energy intensities to levels comparable to those in Western European countries. The results of Phase I have already demonstrated that no additional capacity of energy supply is needed in Danubian countries: the present capacity, in particular for power production, is largely in excess. The problem is then to upgrade the present facilities (and to close those which are too dangerous or desperately inefficient) and to gradually improve the techniques (clean coal technologies) and to shift, over time, to more use of natural gas (for which continuity of supply can be insured).

3.3
COST PRICING IS NECESSARY BUT NOT SUFFICIENT

Cost pricing is required not solely to promote the rational use of energy but also to establish a sound basis for running the economy. Moreover, to take the process to its logical conclusion, one must move beyond the concepts of economic cost and set energy prices to take into account the external cost generated, for example, by damage to the environment.

In almost all western countries, the state draws considerable revenue from heavy taxes placed on certain energy products, particularly gasoline. The pricing system introduced must therefore take into account a wide range of financial, budgetary, environmental and economic considerations.

The transition from a context of low, subsidized energy prices to a context of highly taxed prices clearly incites the consumer to use less energy and thereby to save money. The price effect created encourages the consumer to control his energy consumption.

However, the price effect alone is not sufficient to promote the rational use of energy in all sectors of activity, particularly if the economic situation demands that the changes in direction of an energy efficient economy be made rapidly, as it is the case in Danubian countries.

THREE REASONS WHY ENERGY COST PRICING ALONE IS NOT SUFFICIENT

Price adjustment is a slow process, which needs to be accompanied by moves to introduce salary adjustments and to change the production system.

For example, it is not acceptable to make a consumer pay the economic cost of obsolete and ineffective district heating. Only when the heating system has been brought into compliance with standards of rational operation must the consumer be asked to pay the full price. The same is true for electricity prices: they must reflect the cost of quality service and not the cost of overcapacity with poor efficiency, which is presently the case in Danubian countries.

During the period of adaptation, which may be extended according to social or political considerations, the state will continue to pay subsidies to energy producers or, alternatively, to companies and local authorities, to prevent their financial collapse. In this context, it is the state rather than the end user who is encouraged to save energy: when the state is disbursing subsidies to keep energy prices low for the consumer, it is in the treasury's own and direct interest to implement programmes that encourage rational energy use.

In the case of Danubian countries, the immediate implementation of such programmes would cut costs for the national or local budgets and pave the way for the introduction of prices that are more realistic and more acceptable to the consumer.

Even when prices are set to reflect costs and additional taxes, consumers generally lack the resources to further the rational use of energy and therefore require external assistance.

This fact has been amply demonstrated in western industrialized countries.

After the first oil crisis of 1973, the western industrialized countries (most of the OECD countries) achieved a decoupling of energy consumption and economic growth: during the following fifteen years, energy consumption per capita was roughly stabilized while the GDP grew by more than 30%.

Many examples in Japan, the United States and western Europe show the technical feasibility and cost effectiveness of energy conservation policies and programmes based on the implementation of new efficient technologies and practices. These efforts were strongly supported by an important commitment of governments, in terms of legislation (regulations, standards), creation of institutions (agencies for energy conservation in various forms), research and development programmes (with high budgets: the "Moonshine" project for example in Japan), financial incentives (grants, loans), information and training programmes, human resources devoted to implementation, etc.

In a context of fierce international competition, the modernization of their industrial processes to achieve greater energy efficiency is mandatory to increase competitiveness of the major industrial consumers (steel, paper, aluminum, etc.).

But in all other sectors of activity, industrial and non-industrial, energy expenditure is very high at the national level, in particular in hard currencies, but is not sufficient to force the consumer to take immediate action, other than through a possible short-term reduction in consumption, which is not the same as an increase in energy efficiency.

THREE EXAMPLES OF COMPLEMENTARY STEPS TO ENERGY COST PRICING

Let's take three examples to illustrate the necessity of means other than energy pricing to ensure the improvement of energy efficiency.

● HOUSING ●

Inadequate insulation, inefficient heating systems and the absence of heat supply controls make the heating of existing houses (and buildings in the tertiary sector) highly problematic and energy- and money-consuming. Consumers do not have the technical or financial capacity to manage programmes for rehabilitation of buildings and heating systems. Local authorities or housing organizations must program or coordinate initiatives (which does not preclude the eventual passing on of investment costs to the consumer).

New housing and heating systems must be energy efficient. It will therefore be necessary to define new construction methods (building codes)

and regulations and to use new building materials, equipment, etc. Virtually all western countries have made decisive progress in this area (slashing expenditures by more than 50% in the process) through the introduction of national regulations backed by information campaigns and extensive negotiations with prime contractors and customers.

• ELECTRICITY IN HOUSING AND TERTIARY SECTOR •

With the rise in the standard of living and the development of the tertiary sector, the amount of electricity consumed by lighting and household appliances in the housing and tertiary sectors will increase rapidly with economic growth.

The increased production and distribution of electricity made necessary by this growth in demand, which tends to be most apparent at peak periods, is a source of considerable financial problems. The expenditure of individual consumers remains low however and is not a sufficient incentive for rational use of electricity in this sector, even if the prices reflect the costs.

The consumer purchases the appliances that are most easily available on the market. He will frequently buy the cheapest appliance, even if it consumes more than the others, because his overriding concern is the immediate cost rather than the total expenditure throughout the service life of the appliance.

In this context, it is the interest of the state and the electricity company to moderate consumption by encouraging manufacturers to sell energy-efficient appliances and by helping consumers to purchase them. This can only be achieved, as the example of California has shown, by the introduction of a wide-ranging initiative that links regulations (ceilings set on the consumption by appliances for a given service) to financial incentives (for the manufacturer and possibly for the consumer) and information (for the consumer).

• TRANSPORTATION •

Petroleum products consumed by urban and interurban transport, and by cars and trucks absorb foreign currency, pollute the environment and cause accidents.

Even when prices are set to reflect costs and are further bolstered by heavy taxes (as in Western Europe), they are rarely high enough to curb a steady increase in consumption whose long-term consequences will be catastrophic.

The only effective and viable solution in the long term is to enforce strict regulations on the above modes of transport and to offer the consumer a convenient, efficient, economical and clean alternative: urban transportation (trams, subway, buses) and interurban transportation for the public and rail transportation for goods.

This is a field in which national and local authorities have a key role to play in orienting policy and in making the principal structural investments required.

If energy prices are high at the consumer level, the majority of sectors will probably undergo a process of medium- and long-term adjustment that will ultimately increase energy efficiency but:

- ***The process will be long and involve prohibitive costs unless an outside body steps in to direct and organize the process in a rational manner.***
- ***The current context points to the emergence of situations that will be extremely difficult and costly to rectify if allowed to become established. That is particularly true in the case of housing and transportation, which have long service lives.***

3.4
REGULATIONS

The definition and followup of regulations and standards are the responsibility of the state administration. The objective is not solely to define appropriate regulations - in limited numbers - but also to insure that they are implemented. The introduction of any new regulations must be preceded by an explanatory phase in which discussions will be organized with the partners concerned. In this way, the regulations will be clearly understood, the resources required for implementation will be made available and the partners will perceive both the need for the regulation and the benefits that it can be expected to bring.

Regulations have proved their effectiveness in manufacturing electric appliances and new passenger cars:

- *Building codes*: to upgrade the efficiency of new building stock. Implemented in all OECD countries, these regulations have been maintained even in periods of declining energy prices. They are very cost effective in the long term due to the improvement of building techniques and materials. For example, in France, there were three updatings of the building code, in 1974, 1982 and 1989. A building in accordance with the 1989 code consumes 40% less energy for heating than the same building consumed under the pre-1974 code, and it is not more expensive to build it.
- *Appliance efficiency standards*: in particular for electric appliances. Standards have been implemented in Japan and United States. Most countries are more interested in appliance labelling programmes than efficiency standards. Standards can be very effective if they are accompanied by negotiations with and incentives to the appliance manufacturers in order to help them modify their production in favor of greater product efficiency. It is particularly important in Danubian countries to avoid importing all energy-efficient equipment. In this case, energy-efficiency policy encourages new industries to manufacture high quality products which can be exported, especially to western countries, where not all appliances are efficient.
- *Fuel economy standards for new passenger cars:* these standards are directed toward manufacturers and importers and work in parallel with transportation information programmes.
  It is also important that imported cars, whether new or old, be controlled: some countries, Thailand for instance, have established very high import taxes for high fuel-consuming cars.

3.5
ENERGY EFFICIENCY PROGRAMMES

The Danubian countries must establish consistent energy-efficiency programmes for all sectors of their social and economic activities.

- The two main objectives of a national energy-efficiency programme which must be dealt with simultaneously are:
  - To cure the present situation: upgrading of the heating systems, insulation of buildings, reshaping of industrial enterprises, etc.
  - To prepare immediately for the future: build efficient and clean heating systems, build well insulated houses, provide the market with high-efficiency light bulbs and electric appliances, introduce clean and efficient processes and equipment in new industries, establish clean and low-consuming transport systems.

The main elements of such a national energy efficiency programme are the following:

- New regulations, particularly in the construction and household appliances sectors.
- Information programmes for all consumers able to undertake energy management initiatives, particularly businesses and local authorities.
- Energy audit programmes and demonstration operations in all sectors of activity, and particularly in state companies and buildings, to convey the skills necessary for the subsequent implementation of techniques.
- Assistance for research and development institutes and industry in their efforts to develop, produce and disseminate energy-efficient equipment and appliances.
- Training programmes for engineers and facility managers to encourage energy management initiatives and promote sound energy management.
- Assistance for the creation of consulting and engineering firms that are able to design and implement projects for the rational use of energy in both existing and new installations.

- Assistance to enable companies, local authorities and consumers to obtain the funds necessary to undertake energy management programmes and projects.

This programme will accompany and help to promote economic reform and must therefore be implemented as rapidly as possible.

One must never forget that the programmes for energy efficiency will provide, in all sectors and in all regions and towns, new activities and jobs, which is of enormous importance in Danubian countries where the rate of unemployment is very high.

3.6
INSTITUTIONS AND THEIR TASKS

The implementation of consistent policy and programmes for energy end-use efficiency faces in Danubian countries, as in many countries, numerous obstacles:

- The energy prices at consumer level do not reflect the cost of energy supply and distribution due to government subsidies.
- There is a lack of information and economic training of political authorities as well as technical staffs on the potential and practices of implementation of energy-efficiency programmes, in particular in the field of efficient equipment. Often, the most elementary information, such as statistics on energy consumption by various activities, is not available.
- There is not enough local production of measuring devices, regulation devices, efficient equipment, nor local expertise and engineering firms able to implement energy-efficiency projects.
- The general lack of capital for new investment is aggravated by the choice of increasing energy supply capacities instead of directing sufficient financial resources to energy-efficiency programmes.

To modify this situation, it is necessary to understand that:

- Even in the western industrialized countries where the energy prices at consumer level reflect the cost of supply and where the market economy is the foundation of the economic system, energy-efficiency policies have been supported by the governments through regulatory measures, research and development programmes, financial incentives and important human resources. To take only the examples of the Federal Republic of Germany, France and Japan, each of these countries has devoted about 1 billion dollars per year of public funds to support and promote energy-efficiency policies.
- Whatever the economic conditions may be, an energy-efficiency policy cannot succeed without intervention.

Hence the need for public institutions in charge of defining and implementing energy-efficiency programmes in all sectors of social and economic activities.

An institution responsible for energy-efficiency policy implementation is needed, not to conduct projects, but rather to create the conditions necessary to maximize these projects' impacts in terms of technical, economic and environmental effectiveness. In other words, to facilitate the implementation by all the economic agents of the national energy-efficiency program.

Facilitation is a new function of public service whose role is particularly vital in the transition that is under way in Central and Eastern European countries.

The objective of facilitation is to help consumers promote the rational use of energy in their sector of activity by providing information, training, advice, programming, access to technical and financial engineering, etc.

The above tasks demand considerable flexibility to the part of the institution in charge, which will be required to tailor its approach to each partner and situation.

The experience already gained throughout the world suggest that the best solution is to:

- Create autonomous and decentralized regional organizations whose field of operation will be small enough to maintain continuous contact with consumers, companies and local authorities for the definition of common plans of action.
- Create a national body with full support of the government at the highest level.

The tasks of that national body will be to:

- Programme the overall energy conservation policy.
- Propose national initiatives: regulations, research and development, industrial policy (high performance equipment).
- Coordinate international cooperation in the field of energy conservation.
- Integrate energy-efficiency goals into the definition of the country's overall energy policy.
- Organize, coordinate and technically control the incentives given to the consumers or the equipment manufacturers.

In order to prevent the above organizations from becoming bureaucratic:

- They will be of modest size.
- The relations between the national and the regional organizations will be defined contractually on the basis of negotiated cooperation programmes.
- The human resource managers of these organizations will endeavor to build bridges with partners in order to promote mobility between organizations, companies, universities, local authorities.

Organizers, facilitators and catalysts of the ongoing process, the role of the organizations above will be to offer a public service and to mobilize the network of economic agents with the objective of increasing the energy efficiency of all social and economic activities.

The solution which is at present the best adapted for most countries is the setting-up by the government of an Agency for Energy Efficiency, autonomous from the traditional administration and under the responsibility of a high authority of the government dealing with general economic policy (prime minister or minister of economy).

From the very beginning, the implementation of energy conservation programmes must be decentralized, to be as near as possible to the consumer. That means the creation of regional agencies for energy efficiency must be implemented at the same time as the creation of the national agency. This must include a consumer advisory board with consumers who are not passive agents but active partners in an energy-efficiency policy: specific programmes will have to be set up, not only with major industries, but also with towns (buildings and transportation), chambers of commerce (small and medium industry, commercial sector, etc.), regional authorities (in particular to stimulate rural development through energy-efficiency and the development of renewable energies, especially biomass).

3.7
THE FUNDING OF ENERGY-EFFICIENCY ACTIONS

The first funding problem therefore concerns the funding of these institutions.

The organization will ordinarily receive its operating budget from the state, but there are very strong arguments in favor of additional support from the international community, which will find its own interest served by having a well identified partner for energy-efficiency programmes in each country.

The basic budget will also include the financing required for funding initiatives that are specific to the institution: economic studies, information, communication, training

The largest funding requirements are needed to support the initiatives seeking to improve energy efficiency in actual activities through energy conservation investments.

A distinction must be made between two main categories of actions:

- Initiatives to make high-performance equipment widely available on the market; their targets are designers, manufacturers and sellers of this type of equipment or appliance.

- Initiatives to improve energy consumption by consumers: companies, local authorities, households.

The creation of partnerships will be essential in the funding of these initiatives and each funding mechanism will have to be tailored to the sector of activities, the partner, the nature of the equipment.

To launch, in all countries, the large energy conservation programmes which are an urgent necessity both for the economy and the environment, it is appropriate to create a fund, from taxes on the energy products and subsidies or loans from the international agencies or banks, to provide impetus to the investments at consumer or manufacturer level.

One proposal is that 1% of total energy bills paid by the consumer be placed in a national Fund for Energy Efficiency to provide:

- Direct funding of the Agency, which will then be financially independent of the state budget and will be able to pay its staff correctly and attract high quality people.
- Incentives to the consumers and the equipment manufacturers, through the national development bank (or other) as financial partner and the Agency for Energy Efficiency as technical partner.
- Financing of a national training programme for energy efficiency.

3.8

EXAMPLES OF ACTIONS AND FUNDING MECHANISMS

The variety of funding sources for energy-efficiency programmes is shown in the following examples concerning major sectors or items of equipment.

• IMPORTING AND PRODUCING HIGH-PERFORMANCE EQUIPMENT AND APPLIANCES •

Taxes on imported high-efficiency equipment will be significantly reduced or eliminated. This process will rely upon a list of equipment or, for more complex situations, a case-by-case study by the Agency or, preferably, by consulting firms working for the Agency.

Conversely, heavy taxes must be placed upon equipment that consumes inefficiently large amounts of energy, certain vehicles for e. .ple.

If the market broadens (which is immediately true for the main household appliances or common equipment in industry), imports must be replaced by domestic equipment.

It then becomes necessary to seek partners and to supply aid for industrial agreements (purchase of patents or joint ventures) by using industrial development funds or the Fund for Energy Efficiency.

The Agency for Energy Efficiency will act as technical advisor for these agreements but will not necessarily be the main source of funding (Bank for Development or Industrial Development Bank).

However, resources must be made available to the Agency for the creation of a database on high-efficiency equipment and appliances.

• ELECTRICITY SAVINGS IN HOUSING AND TERTIARY SECTOR •

If the economic situation improves, the demand for electricity can be expected to increase in housing and tertiary sector. It is therefore in the common interest, including that of the electricity company, to save electricity without reducing the level of service offered. In this way, the utility will be able to increase customer satisfaction without increasing expenditures (peak-period savings will be particularly valuable).

A joint programme involving both the Agency for Energy Efficiency and the utility must be set up to bring high-performance equipment or appliances into general use.

A simple solution can be implemented for lighting: the utility will purchase high-performance bulbs (fluo-compact) for public buildings, commercial premises (hotels, shops), households. By buying in bulk, it will be able to acquire the bulbs for far less than the market price.

The utility will install the bulbs free of charge and add the cost, or part of the cost (since the utility itself stands to benefit in this operation) on the electricity bills over a period of one year.

A simple calculation shows that both the utility and the consumer gain from the arrangement (provided that the bulbs are used for a sufficient period of time daily).

The first campaign will rely on imported bulbs but it will be rapidly necessary to consider domestic manufacturing of some or all of the quantities required. If a regional market emerges in the Central European countries, the countries involved could sign agreements to limit the number of manufacturers.

The situation is slightly different for household appliances. The heaviest-consumption appliances - refrigerators (because they equip almost all house-holds) - tend to be manufactured inside the country and are not energy efficient. Better appliances are available elsewhere.

The first step will be to accurately assess the performance of local appliances. The work will be carried out either by a laboratory attached to the electricity company or by a laboratory working specifically in the field of energy consumption. The next step will be for the Agency to identify the best appliances available on the world market. Finally, the Agency for Energy Efficiency will undertake negotiations with a local entrepreneur (who may or may not already manufacture refrigerators) for the creation of an assistance contract, which will involve purchasing a patent or setting up a joint venture for the manufacture of high-performance refrigerators.

This new industrial development will be accompanied by:

- regulations on refrigerator consumption;
- financial assistance from the Fund for Energy Efficiency to the consumers (or to the manufacturer), if the price of the new, efficient refrigerator is too high.

• ENERGY EFFICIENCY IN INDUSTRY •

A distinction must be made between new facilities and existing facilities.

The design of new facilities is a crucial factor of energy efficiency improvement. An appropriate design could offer considerable energy savings during the service life of the installation without necessarily pushing up costs.

A regulation - which is already applied in Tunisia for instance - must impose the consultation of the energy-efficiency Agency for new projects whose energy consumption exceeds a certain level (the same regulation can be applied to companies in the tertiary and transportation sectors).

The Agency will propose more efficient solutions, with the assistance of engineering consulting firms whose work it finances.

This activity emphasizes the advisory role of the Agency, linked to the establishment of a database of high-performance equipment.

A three-stage plan will be implemented for existing facilities: energy audit / action plan / investment incentives.

Energy audits alone are not sufficient. The Agency for Energy Efficiency and the approved consulting firms must be able to offer a full range of services whose scope encompasses the requisite investment.

In this case, when an action plan is established, the financial incentive to the enterprise will come from the Fund for Energy Efficiency through grants and, or low-interest loans managed by the National Bank for Development, or other banks, helped by the Agency and the approved consulting firms acting as technical experts.

The financial incentives will be distributed in two ways:

- a rapidly available and systematic incentive targeting a list of selected efficient equipment;
- a negotiated incentive for more complicated projects.

The same procedure can be applied to the tertiary sector.

• THE TRANSPORTATION SECTOR •

The transportation sector is the most difficult area to address but it is also one of the most important in that it maximizes the benefits of energy efficiency actions by simultaneously reducing energy expenditure (petroleum products), pollution and accidents.

The main partners are:

- the government for land use planning and the development of rail transportation;

- local authorities for city planning and the development of public urban transportation;
- goods transportation companies.

Investments in major infrastructures extend beyond the framework of energy efficiency alone. Central and Eastern European countries must realize that they still have time, though not for long if economic growth is resumed, to limit the number of private cars in cities and trucks on the road and to develop public and rail transportation. If they do not take the necessary drastic measures, their large cities will find themselves with the same impossible traffic conditions found in the major western capitals.

The Agencies for Energy Efficiency can play a decisive role in informing local and national authorities of initiatives that have been successful elsewhere and in helping them to take the necessary steps to implement them in Danubian countries.

More specifically, it seems necessary to:

- introduce taxes on imported vehicles that are not energy efficient;
- set up framework agreements with transportation companies (passengers and goods) for the improvement of their fleets and their operation (management, maintenance, choice of equipment, training of drivers and management staff).

The Fund for Energy Efficiency will be used on a similar basis as in industry. However, we must recognize that the only long-term solution for the transportation sector lies in the development of clean, low-consumption modes of transportation for both goods (trains) and passengers (public vehicles).

4

NUCLEAR ENERGY IN EASTERN AND CENTRAL EUROPEAN COUNTRIES

Since 1989, alarming information has been circulating about the state of the nuclear reactors VVER (pressurized water) and RBMK (Chernobyl's type). The experts follow one another in the eastern nuclear power plants and their report is always the same: the situation must be taken seriously. According to some of them, 33 reactors should be closed: 15 RBMK (11 in Russia, 2 in Lithuania, 2 in the Ukraine); 10 VVER 440/230 (4 in Bulgaria, 4 in Russia, 2 in Czechoslovakia); 8 VVER 440/213, more recent but dangerous (6 in Czechoslovakia, 2 in Hungary).

Other experts deny the emergency and propose a three-phase programme: first closing the most dangerous ones within 2 to 3 years; repairing some of them to be operative within less than 5 years; bringing the most recent reactors up to western safety standards. The cost of such a programme is enormous: more than 10 billion dollars according to the most optimistic experts.

Table 3.4 - Nuclear power plants in Danubian countries

Country	Type	Nuclear plant/Reactor	Power (MW)	Exploitation starting
Bulgaria	V-230	Kozloduy 1-4	440	1974/75/80/82
	V-1000	Kozloduy 5-6	1000	1988/91
Hungary	V-213	Paks 1	440	1982
		Paks 2	450	1984
		Paks 3-4	460	1986/87
ex-Czechoslovakia	V-230	Bohunice 1-2	430	1978/80
	V-213	Bohunice 3-4	430	1984/85
	V-213	Dukovany 1-4	440	1985/86/86/87

Three Danubian countries have developed activity in the domain of nuclear energy: ex-Czechoslovakia, Hungary and Bulgaria. In those three countries, the reactors are of the VVER type, pressurized water, of Soviet technology. *(Table 3.4).*

Alerted by the Bulgarian authorities about the situation of the nuclear power plant of Kozloduy, Equipe Cousteau organized a scientific appraisal mission to analyze its safety. The group of experts included Raymond Sené, from the Groupement des Scientifiques pour l'Information sur le Nucléaire (France), and Robert Pollard, from the Union of Concerned Scientists (United States).

The Kozloduy plant, located 200 km northeast of Sofia on the Danube, contains six Soviet-made VVER pressurized-water reactors. Two of them, with a power of 1,000 MW, are recently built. The four other 440-MW reactors, which were designed at the end of the 1960's, no longer meet current safety standards.

The experts' report draws up a long list of design flaws in both the reactors and the safety systems: the steel of the reactor vessels is deteriorating, the reactor containment is just a steel dome, the electric wiring is poorly protected and the backup circuits are poorly or not at all isolated from the main circuit. If the pipes should break, the water injection systems would be insufficient or not work at all. There is no backup control room for units 1 and 2, and the backup control room for units 3 and 4 is not well isolated from the main room, etc. In addition, the plant as a whole is dilapidated and it is difficult to obtain spare parts. Several Bulgarian reports emphasize the deplorable psychological state of the personnel.

Robert Pollard and Raymond Sené consider that the *"repairs would not remove the possibility of an accident including the discharge of radioactive substances at least as serious as that of Chernobyl."*

On March 1, 1992, a helicopter chartered by Equipe Cousteau, with an on-board measurement device developed by the French Atomic Energy Commission, flew over the areas surrounding the plant to search for any radioactive contamination of the environment. Two contaminated areas were detected. The pollution is said to come from leaks in the reactors' primary circuit.

Experts from the IAEA (International Atomic Energy Agency) and the WANO (World Association of Nuclear Operators) have estimated the repairs at 6 billion French francs.

In accordance with the experts' opinion, and as early as April 1992, Equipe Cousteau has been firmly insisting on the urgent need for the international community to assist Bulgaria in bringing the two 1,000 MW VVER reactors recently taken out of production up to current safety standards and in shutting down the four oldest reactors. The Russian companies in charge of their operation are leaving Kozloduy little by little, the Bulgarian authorities not being able to pay them in dollars. Without any special assistance, the Bulgarians have managed to get along on their own but on September 22, 1992, the electrical equipment which controls these two reactors caught fire. The repairs will take months. In the meantime, electricity shortages will be suffered throughout the country. It has even been proposed to restart units 1 and 2 which had been "definitively" closed down for more than one year.

The studies we carried out on energy in Central and Eastern Europe demonstrate that in pursuing a different energy policy based on energy efficiency and use of renewable energies, these countries can do without nuclear energy.

There is no question of asserting that all Soviet nuclear power plants must be closed down, but the Central and Eastern European countries have to be convinced that the most dangerous nuclear reactors must be closed down permanently and rapidly. Closing some nuclear plants and improving the safety in other plants can only be made possible through the development of a new alternative energy policy and international financial support.

Money not yet invested in obsolete and dangerous reactors should be available by now for productive investments which could be of great help to the country.

The situation of the nuclear power plant of Kozloduy is typical. The blackmail which consists of playing with the safety of Bulgarian citizens first, and then that of other Europeans, in exchange for providing them with energy, is unacceptable.

Major energy savings are feasible in Bulgaria, in other Danubian countries, and of course, in Lithuania, Russia and the Ukraine.

Even in highly industrialized and politically stable countries, the use of nuclear energy is very problematic and has in most countries been considerably limited, if not cancelled. In Eastern Europe, nuclear energy is dangerous, too expensive and moreover unnecessary. Protection of citizens all over Europe from a nuclear accident risk must be dealt with by the international community without any consideration of profit.

5
HYDROELECTRICITY AND OTHER RENEWABLE ENERGY SOURCES

5.1
HYDROELECTRICITY AND SMALL HYDROELECTRIC POWER PLANTS

Large hydroelectricity (power of more than 10 MW) represents an important potential resource in the Danube countries, but its intensive exploitation entails very serious consequences for the environment. This is the case particularly when dams located in the Danube plain regions - or the plain regions of the largest tributaries - are concerned. The Gabcikovo dam, in Slovakia, is a perfect example. *(See Table 3.5).*

Conversely, small hydroelectric power plants (power of less than 10 MW) do not represent a major challenge for the Danube countries. They might nevertheless contribute to diversification of production sources and the use of derived renewable energy sources. The impact of small hydroelectric power plants (SHPPs) on the environment, though not negligible, can be controlled more easily.

Overall, economically operable hydraulic potential represents 196 TWh, i.e. 16.9 Mtoe (1 TWh = 0.086 Mtoe) for all the six Danube countries researched (Austria, ex-Czechoslovakia, Hungary, ex-Yugoslavia, Romania and Bulgaria). This potential is greater or smaller depending on the particular country *(Table 3.5)*. In Austria or the former Yugoslavia, hydroelectricity could theoretically cover 100% of electricity consumption while in Czechoslovakia it could only take a 6% share, the figures for the other countries totalling between 12% and 54%.

Only 40.5% of this total hydroelectric potential is currently being exploited (79.4 TWh).

Of this total potential, the economically operable potential for SHPPs represents around 7%, equalling 13.4 TWh. This represents an average of 3% to 5% of current electricity consumption in the countries in question. Actual production of SHPPs (1991) is 3.7 TWh, equalling less than 1% on average of consumption, except for Austria where its share is 4.5%.

The vast survey which was carried out in the context of the Cousteau Danube programme enables an appraisal to be made of the situation where SHPPs are concerned, in each of the Danube countries. The main points of the study are detailed below. Annie Rousseau and Lucien Monition of Ademe (Agence de l'Environnement et de la Maîtrise de l'Energie), and consultants from eastern countries were in charge of this comprehensive investigation.

• CZECH REPUBLIC •

There is no obvious political driving force behind the development of SHPPs, but there are over 700 re-certification and new construction applications under way. A total of 250 MW producing 873 GWh is projected for 2005, which will bring the exploited proportion of the economically operable potential from 27% in 1992 up to 81% in 2005 (representing 2.4% of 1991 electricity consumption).

There is no specific legislation on SHPPs.

Large-scale hydroelectricity should experience moderate development, rising from 1.4 TWh to 2 TWh in 2000, equalling approximately 60% of the total potential.

Table 3.5 - Hydroelectric power in the Danube countries (Twh)

	AUS	CZECH	SLOV	HUN	ex-YUG	ROM	BUL	TOTAL
Electricity consumption	43.5 (1990)	56.7 (1990)	29.3 (1990)	37 (1991)	70.7 (1988)	74 (1990)	48.6 (1990)	360
Electricity production	44 (1990)	65.2 (1990)	21.4 (1990)	27.4 (1991)	78.4 (1988)	64 (1990)	44.2 (1990)	345
Economically operable hydraulic potential	53.7	3.5	7.3	4.6	71.8	40	15.3	196
% consumption	>100	6.1	24.9	12	>100	54	31.4	
Total hydroelectricity production (1991)	30.5	1.4	2.2	0.178	24	16.5	4.6	79.4
% consumption	70	2.4	7.5	0.4	34	22.2	9.5	
Economically operable SHPP potential	>4	1.66	1.2	0.032	?	4	>2.5	13.4
% consumption	>9.2	3	4	0.09	?	5.4	>5.1	
Small hydroelectricity production (1991)	2	0.476	0.25	0.015	?	0.4	0.62	3.7
% consumption	4.5	0.8	0.8	0.04	?	0.5	1.3	

• REPUBLIC OF SLOVAKIA •

There is a real political driving force behind the development of SHPPs, particularly in the sensitive zones or zones where there is an electricity deficit. Four hundred potential sites have been listed and it is projected that 70 MW be installed by 2005, which should produce 382 GWh. The exploited proportion of potential would rise from 21.5% in 1992 to 53.7% in 2005 (i.e. 2.2% of 1991 consumption).

There is no specific legislation on SHPPs, but project impact studies are required. The Republic of Slovakia also displays development targets for large-scale hydroelectricity, the production of which should almost triple by 2015 (from 2.2 to 5.8 TWh). The Gabcikovo dam (2.2 TWh), the numerous and serious environmental consequences of which are now well known, is an essential component of this growth. 80% of the economically operable potential would then be achieved.

• HUNGARY •

Political drive measures up to the production potential of SHPPs in this country, i.e. very slight.

For the 70 potential sites that have been identified, there are no real projects beyond SHPPs currently being built. 50% of the SHPP potential was already being exploited as of 1991 and this represents only 0.04% of electricity consumption. There is no specific legislation on SHPPs, but impact studies are required and have to determine a restricted flow and to guarantee suitable insertion into the landscape. The only large-scale dam project, Nagymaros, has been abandoned.

• FORMER YUGOSLAVIA •

No data because of the war raging in this country. Hydroelectricity, however, is abundant in this country and is widely exploited.

• ROMANIA •

Political drive is mixed where SHPPs are concerned because their development is one of the major recurring questions of energy policy in the country, though no projects have been clearly scheduled. Only 10% (0.4 TWh) of the economically operable potential for SHPPs (4 TWh) has been installed to date, and more than 100 potential sites have been listed.

There is no specific legislation on SHPPs, but impact studies are obligatory. Romania has great ambitions where large-scale hydroelectric plants are concerned, since exploitation of 100% of the economically operable potential is planned by 2005.

• BULGARIA •

The SHPP development policy has been clearly announced, particularly in order to supply the zones in the north of the country which are deficient, and manifests itself in the form of numerous economic feasibility studies. The list of potential sites nevertheless seems rather overestimated and should be reevaluated taking economic criteria into account in a more satisfactory manner. By the year 2000 horizon, 87% of the economically operable potential should be installed (2.2 TWh) by comparison with 25% today (0.6 TWh).

There is no specific legislation on SHPPs, but regulations are ruled on by the Energy Council. Impact studies have to be carried out.

Large-scale hydroelectricity is also to be developed, with production rising from 4.6 TWh in 1991 to 14.1 TWh in 2005. 92% of the economically operable potential would then be installed and would carry out production equivalent to 29% of current electricity consumption. However, the dams on the Danube at Nikopol and Silistra are among these projects. Building of these is highly improbable and in any case could not be recommended.

It seems that the countries in which SHPPs represent an interesting potential (Slovakia, Romania, Bulgaria) have a very marked will to develop them and numerous projects are under study. From this point of view, cooperation and possible aid from Western countries really only comprise a feature accompanying a well-known and self-sufficient development policy.

It is also noticeable that no specific legislation exists in these countries and that impact studies are rarely mandatory. Setting up of a legislative framework which stipulates electrical production re-sale conditions and the specification of consequence studies prior to installation of the SHPPs must be a mandatory step on the road to SHPP development in these countries.

These countries have undeniable hydraulic skills. Nevertheless, the large state companies which had the monopoly on SHPPs are being dismantled or have ceased involvement in this sector of activity. Skills are thus now dispersed among craftsmen in workshops which are too small and not very profitable, if at all.

The future of SHPPs in Eastern countries clearly lies in the private sector, but some time will be required so that the latter can adopt structural and organizational systems capable of allowing it to develop.

5.2

EVALUATION OF THE ECONOMICALLY OPERABLE POTENTIAL OF RENEWABLE ENERGIES

The role that renewable energies could play in the Danube regional energy balance is not a trivial issue. Reliable information is available on the different technologies and their economic costs. But, as the commercial development of these renewable energies is generally very weak, the arguments for postponing their real possible development are frequently confused with short term market type considerations.

To overcome that difficulty it has been proposed to undertake a comprehensive analysis, region by region, of the actually accessible renewable energies over a given time period. This estimate could then be divided into "proven renewable reserves" and "renewable energy resources" using the same methodology used to derive "proven fossil energy reserves" from "energy resources" on the basis of quantitative information on physical potential, taking into account technical and economical accessibility.

Apart from the unique character of renewable reserves, going from "resources" to "reserves" in renewable energy raises specific problems: first these resources fluctuate with time; and second, they are distributed and dispersed in space and not readily storable or transportable. In addition to physical and economic considerations, it is necessary to take into account the presence of populations or activities near enough to be able to benefit from these distributed and somewhat volatile energies.

Five fields have been considered in this study:

- Small hydraulic power.
- Solar-water-energy heating.
- Energy from wood.
- Energy from urban waste.
- Energy from rural waste.

Wind energy and solar electricity have not been taken into account due to the lack of information.

The values of the following table illustrate that renewable energy sources as a whole constitute a great potential. They could represent close to 11% of consumption of primary energy for all the Danube countries combined. Some countries such as the former Yugoslavia or Romania are particularly fortunate since these sources represent a potential of 15 to 17% of total primary energy consumption *(Table 3.6)*.

Table 3.6 - Renewable energy resources in the Danube countries (ktoe)

Country	Pot. SHPP <10 MW	Solar Therm.	Wood	Rural waste	Urban waste	Total	% of primary energy consumption
Austria	344	20	880	670	150	2064	9%
ex-Czechoslovakia	246	40	1000	1905	220	3410	4,6%
Hungary	3	30	1050	2415	85	3583	11%
ex-Yugoslavia	-	610	4100	2840	120	7670	17%
Romania	344	550	2500	7580	160	11134	15%
Bulgaria	215	240	1600	2425	90	4570	12%
Total Danubian countries	1 152	1490	11 130	17 835	825	32 430	11,7%

The major resources rest in the exploitation for energy of rural waste or of wood originating from forest operations. For all the Danube countries combined, these two types of energy represent close to 90% of all reserves *(Figure 3.1)*.

Exploitation of some of these renewable energy sources may provide additional advantages in addition to energy production:

- The use of wood waste originating from forest operation or wood industries comprises an additional financial resource.
- Exploitation for energy of rural and urban waste contributes to solving environmental problems. This applies for example to those associated with contamination of groundwater resources by agricultural liquid manure or with processing and elimination of domestic waste the volume of which will increase alongside the standard of living.

The technology implemented is well known and can be relied upon in Western European countries. Its development in the east constitutes an opportunity for the private sector.

The four technologies considered are well known throughout Europe:

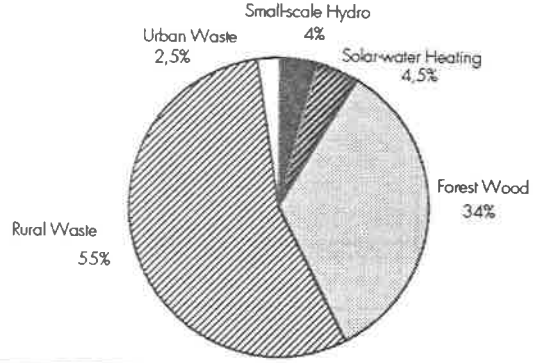
- Solar heaters are used widely in countries like Greece, Cyprus and Turkey; they are technically and economically mature.
- District heating or electricity production from urban waste, and gas production from composting are common technologies in Western European countries.
- Modern and efficient use of wood (logs, briquets, pellets or wood gas) in boilers, steam generators (efficiency up to 70%) or gas turbines for domestic, industrial or energy-supply purposes has been fully demonstrated in Northern European countries, in Austria and in France.
- Transformation of rural waste (burning or biogas) has been technically demonstrated; now that large installations are competitive, improvements are necessary to achieve the same goal for small remote biogas production plants right on the farm.

All these technologies can be implemented in the industrial framework of each of these countries since they are mainly classical mechanical industries.

Development of the exploitation of these renewable energy sources constitutes a service rendered to the countries involved, as they enable significant savings in energy imports, construction or re-certification of hydroelectric plants to be carried out. It is because of this that such development merits the support of public authorities.

***Figure 3.1* - Relative importance of the different renewable energy sources for all the Danube countries combined**

The major resources rest in the exploitation for energy of rural waste or of wood originating from forest operations. For all the Danube countries combined, these two types of energy represent close to 90% of all reserves.



Experience has shown that incentives were required in order for these energy sources to gain a foothold in the energy market and become an attractive proposition for users. The following measures are required:

- The creation of a legislative framework enabling these new energy sources to be integrated.
- Assistance for the startup of new technology by means of public investment. Public authorities (schools, hospitals, town councils, etc.) could thus use these new energy sources and create an initial market for the companies developing them.

Development of renewable energy sources is one of the components of a modern energy policy, as well as the improvement of energy efficiency. It must therefore form an integral part of reflection concerning the matter and be included in the field of competence of the authority (which in some cases has yet to be created) which is responsible for promoting new policy.

6

MEETING OF CONCERNED CITIZENS FOR AN ENERGY-EFFICIENT AND ENVIRONMENT-RESPECTFUL SOCIETY

Following the different studies led by Equipe Cousteau and its partners in the domain of energy and nuclear safety, it has been decided to intensify our action in this domain in Bulgaria. These studies have been presented to the highest authorities in Bulgaria, discussed in the different committees and administrations in charge of the production and the distribution of energy.

Equipe Cousteau and the Ecoglasnost movement in accordance with and under the high patronage of the Prime Minister, have organized a conference on the theme of energy efficiency and environmental protection.

This meeting gathered most of the ministers of the Bulgarian Government, parliament members, environmental organizations, energy experts, trade unions, academics, members of the administration and international institutions. More than 150 concerned citizens took part in the conference.

6.1

FINAL DOCUMENTS OF THE MEETING

Debates were lively and fruitful, and as a result, it has been possible to identify new and original orientations towards a modern energy policy.

Although its gross domestic product (per capita) stands at under half that in Western European countries such as Germany, Italy or France, Bulgaria's energy consumption is in the same range or slightly superior: 4.1 toe per capita. Energy intensity, the ratio of primary energy consumption to gross domestic product, is double that in Western countries. Final consumption of electricity per GDP unit is also double that in Western countries. Electricity consumption is high in industry (60%) and in housing (heating, cooking, hot water).

This abnormally high energy consumption arises from past energy policies exclusively centered on production growth and resulting in:

- energy-wasting facilities,
- obsolete industrial processes,
- a misguided utilization of electricity in housing,
- subsidized energy prices.

This leads to:

- non-satisfaction of the basic needs of Bulgarians,
- exceedingly costly investments in new means of production or the importation of energy,
- serious environmental damage: air and water pollution due to mining operations, oil refineries, power plants,
- serious danger to the population of nuclear accident,
- the lack of democratic processes in energy policy.

Starting from this situation, one can define the aims of a new energy policy:

- that Bulgaria catch up with European countries as soon as possible in the area of energy efficiency,
- that consumption and supply of energy should be better balanced,
- that energy efficiency be a priority,
- that a fair place be allotted to renewable energies: solar, biomass, wind power. The energy potential of renewable resources amounts to 12% of primary energy consumption,
- that fossil fuels such as coal or oil should be used in a rational and limited way,
- that natural gas sources be explored and brought into production.

The importance and potential of an appropriate energy policy integrating an energy-efficient approach has been quite clearly demonstrated by describing the achievements in three countries: France, Portugal, Tunisia. It was of special interest to note similarities between the situation in Bulgaria and in Portugal. The evolution of this last country could be instructive with regards to the Bulgarian energy policy.

The evidence presented, in addition to the more general international experience also reported, show that:

- an energy-efficient policy is absolutely necessary to the quality of development and environment,
- it must be clearly defined as a government priority and be steadfastly supported by the government and parliament,
- it must be accompanied by decisions concerning the true cost of energy and by an adequate set of laws and rules,
- it must benefit from public outlays, considering the importance of economic advantages for the nation,
- above all, an agency in charge of this energy-efficient policy should be established, not to take action by itself, but to create the conditions favorable to implementation by consumers, facilitate generalization and promote this new way of conceiving the rational utilization of energy in the service of sustainable development.

The relevance of this approach and its crucial necessity in Central and Eastern European countries has been highlighted by contributions concerning Romania, already endowed with an energy-efficiency agency, and Poland, that has as yet been unable to make the necessary institutional decisions in spite of the efforts and the actions undertaken by a number of teams.

During the conference, speeches by participants repeatedly demonstrated what a remarkable scientific and technological potential exists in Bulgaria.

In the past, as in the current period, many people have worked towards an energy-efficient policy, as an alternative to the policy followed up to now which only led to increasing the means of production.

Contributions by the EcoEnergetica group have been very important: they helped in defining more precisely what a Bulgarian agency for energy efficiency should be.

Converging efforts resulted in a first decision, a genuine symbol of the success of this conference: the government stated that it was most interested in the energy-efficient policy and announced the creation of a Bulgarian Agency for Energy Efficiency, in charge of implementing this policy. Parliament has also created an energy committee that strongly supports the energy-efficient policy and the creation of this Agency.

The Agency must now be as dynamic as possible to mobilize active partners and agents in the economy and the citizens. It must be endowed with human resources and financial means enabling it to deal with all its tasks, and ensuring its development.

An essential asset linked to the creation of the Agency and its development will be the display of effective and well-organized international cooperation.

The Agence de l'Environnement et de la Maîtrise de l'Energie (Ademe), the French agency for environment and energy management, with a past record of support for Bulgarian efforts, was well to the fore during the seminar and committed itself through a message from its President to continuing cooperation. Other similar bodies in the European network are to join this venture. The United Nations programme, Energy Efficiency 2000, will support initiatives and encourage exchanges. The Commission of European Communities, which has already demonstrated its commitment with the PHARE programme, will undertake to continue its cooperation in the field of energy efficiency. The European Bank for Reconstruction and Development is also ready to take steps in this respect.

The Bulgarian Agency for Energy Efficiency must act quickly by setting up a plan, defining priorities, suggesting projects, raising funds...

Rational and efficient use of energy is an essential component of a modern energy policy preparing for the 21st century.

Contributions by several participants emphasized that the government must develop a new energy policy integrating long-term considerations and that institutional structures must be reorganized in order to carry out this policy.

Such a dynamic policy can only be implemented through a reinforcement of democracy and by bringing together all the actors in the political and social spheres: Parliament, NGO's, trade unions. Democracy, in the area of energy as in many other fields, requires transparency of decisions and information, clear distribution of responsibilities, democratic supervision, systematic funding and implementation of second expert assessments.

Democratic practices such as these can best ensure the circulation of ideas, and cooperation within and between nations. It will open the way to an energy-efficient, environment-respectful society, furthering individual and collective advancement.

The development of democracy in Bulgaria depends very strongly on the success of an energy-efficiency policy.

6.2
EXTRACTS FROM THE PRESENTATIONS

The presentations of the participants will be gathered in a document to be published in 1993. We are presenting two of the most political presentations of these meetings: those of Mr. Filip Dimitrov, the Bulgarian Prime Minister, and of Mr. Dimitar Korudjiev, Honorary Chairman of the Ecoglasnost movement.

• INAUGURATION SPEECH OF MR. FILIP DIMITROV, PRIME MINISTER OF THE REPUBLIC OF BULGARIA •

«... I would not repeat what we all understand, that for Bulgaria as for the majority of the countries of the former communist camp in which the principles of the absurd, chaos and wasteful were the basic principles of the economy. It is extremely necessary to take steps to raise the efficiency of power generation and the Cabinet is ready to take such steps but we are aware of the fact that the results will not be tangible without a broad support in the country and outside it.

Parallel with this, however, I hope that discussing matters of principle and the problems of the long-term strategy, you all will have the opportunity to reckon with the situation Bulgaria is in.

This real situation is connected with a multitude of problems, with serious difficulties on the threshold of the coming winter, with the practical impossibility for this country to shrug off all existing traps set in the overall development of Bulgarian power generation relating, of course, to the way the Bulgarian power generation is structured, the way in which the nuclear power station and other stations has been built and functioning and, certainly, relating to the whole political complexity of the situation in which this country's first democratic government is fighting the natural attempts during the period of such a huge transformation of society to reverse the process.

All these are realities and I am convinced that you will take them into consideration not just as an element of your assessment of the situation and of the necessary future activities, but also as a message which I expect all of you to take to your countries so that needs and difficulties Bulgaria is faced with now may be clear to the people around you, to the institutions connected with you, to the states and our guests.

Consequently, without disturbing you with this, I cannot but think about this conference also as a scientific and theoretical forum and as a means of having direct impressions of what I may call

personal experience on your part, which, I hope, will motivate you as supporters of the cause we have been fighting for.

Therefore, I would like to wish you successful work and practical results from your discussion and, certainly, success in the defense of the Bulgarian cause in the sphere of the resolution of this country's ecological problems...»

• INAUGURATION SPEECH OF MR. DIMITAR KORUDJIEV, HONORARY CHAIRMAN OF THE ECOGLASNOST MOVEMENT •

«... My work as recent Chairman and now as Honorary Chairman of the major Bulgarian ecological movement Ecoglasnost has brought me in a direct contact with the problem of the so-called modern society progress. Who is in favor of progress?

Our activists, who organized rallies both at the Kozloduy power plant demanding its closing down or the employees at the plant wanting it to operate. It was not difficult to find out that the nuclear holocaust fears of the recent past and those of an ecological disaster today make many people reconsider that notion.

The time is long past of the blind faith in science and technology. This process started with the dropping of the A-bomb over Hiroshima and Einstein's words: "I am the greatest criminal in human history." Gradually, we have realized that our progress has been a self-hating necrophilia. The respect for the artificial, for what causes death or which is itself dead, generally speaking for the machines. In the early 80s, our doubts turned into something very bad, into a renunciation of our wish to live. The control of nuclear missile systems was given in the hands of robots. The cult for the dead made us powerless.

Actually, what is the difference between a nuclear war and a breakdown at a nuclear power station? Today the problem with the Kozloduy plant in Bulgaria shows that death is above all a capacity to view a problem from a different angle. The reasons behind this paralysis of conscience, irrationality and prejudice determined by it. Currently prejudices are fully materialistic and the notion progress is among them. People who used to have faith in material progress only could not realize how their convictions are sometimes harmful and conservative.

This is one of the most significant U-turns of the last two decades. The increasing technical perfection, the rising productivity are no longer an indication of progress. They cannot be such a measure if life is threatened. Humanity is gradually getting convinced that there is just one safe and eternal measure for the good and evil and it is the protection of life.

I said a measure for the good and the evil, and not already for progress, because this word does not mean good only. Our struggle with the nuclear plant at Kozloduy is a struggle with an absurd conscience and the threat of a demise is not frightening to it. What is actually frightening is the thought that we can abandon nuclear power generation and go back.

Going back is a spell invented by materialistic philosophers and means an act which renders senseless the existence of people in their view. This is a conscience which does not assume that life was given to be lived. Or even less that calm and happiness should be sought in it. This is a conscience which has assumed once and for all that life is a chanceful opportunity that we have to use to stride forward. It is not important if we are in a state of stress, of depression, if we dream nightmares. The most important thing is not to wash our dishes ourselves but to make machines do it and to make our life cozier with nuclear atomic piles. The important thing is to live not for ourselves but for the sake of progress.

Here in Bulgaria and in all Eastern Europe the people know very well this way of thinking due to another of its versions. The red dictatorship tried to make us believe that it would be better if we all die in a nuclear war than if communism disappears.

The Bulgarian nuclear lobby does not make secret plans I suppose. It wants to get much money. It is by far not accidental that the leaders of our power generation did nothing to develop alternative power generation and energy saving.

That is why the establishment of the national

Energy Efficiency Agency is a great achievement which should be supported. I am convinced that this is the beginning of a new road for Bulgaria if, of course, our democratically elected Government remains in office. In general, when receiving money from the West, the Bulgarian nuclear lobby is, I repeat, a symptomatic loan process of linking interests which will pose the most serious problem in the coming decade.»

6.3
COMMENTS

The Prime Minister clearly stated that a new policy for energy should take into account its rational utilization. The presence during this conference of Mr. V. Vassilev, Minister of Environment, Mr. Karadimov, Minister of National and Regional Development and of Housing, Mr. Alexandrov, Minister of Transportation, Mr. Bikov, Minister of Industry, Mr. Kostov, Minister of Finance, Mr. Stoianov, Minister of Agriculture, Mrs Constantinova, Minister of Cultural Affairs, Mr. N. Vassilev, Minister of Education, Mr. Eskenazy, Deputy Minister, Counselor to the Prime Minister and of numerous members of Parliament, including the President of the new Committee for Energy, Mr. Krassimir Chernev, demonstrates the awareness gained by members of the Bulgarian government and their determination to get out of the current deadend.

National and international institutions supported the newly created Bulgarian Agency for Energy Efficiency. The Agency must be endowed with human and financial means enabling it to run properly. The trying economic situation in which Bulgaria is plunged must urge the west to emphasize its assistance in the domain of energy efficiency.

R E C O M M E N D A T I O N S

Rational energy use, the cornerstone of any strategy for a sustainable future, has a positive impact on the environment and the well-being of the citizens who dwell there. It is the responsibility of the international community, especially of Western Europe, to share in the efforts and sacrifices, of which the Danube countries will bear the brunt, in making the successful transition to an energy-efficient and environment-respectful society.

It is broadly acknowledged that the development of energy efficiency is the only way in which the world can pursue a process of sustainable development that will respect the environment and keep the world fit for future generations to live in.

The different studies concerning energy in the Danube countries have established the fact of the important energy consumption and the very high energy intensity which prevails in Central and Eastern European countries.

For all these countries it is a source of enormous economic waste (investments, hard currencies) and of environmental pollution and hazards.

• Another energy policy

Under these conditions, it is then necessary to define a new energy policy based on energy efficiency and the renewable energies which are the primary energy resources in Eastern and Central European countries.

- The objective of this new energy policy is to reach a level of energy intensity in these countries close to those in the Western European countries in 2010. Under these conditions, it is easy to see that energy consumption will then be 20 to 50% less important than today. This inversion of the overall tendency to consume ever more energy in order to meet the requirements of the citizens will come through a change in mentality rather than through technological upheaval.
- Energy-efficiency policies should be developed in all Danubian countries through:
- Planning of energy supply and demand.
- The creation of an expert group subordinate to the Prime Minister of each state, which will be in charge of defining and following up on the energy efficiency policy.
- The creation of institutions at the national and the local levels to establish programmes for improving energy efficiency in the various sectors of activity and to

RECOMMENDATIONS

help the appropriate partners and economic agents implement them.
- A system of regulations to promote the rational use of energy, in particular for new buildings and electric appliances.
- An appropriate system of incentives to stimulate and promote energy-efficiency improvements, initiatives, and projects, and corresponding mechanisms to facilitate financing of investments and programmes.
- National training programmes for energy efficiency for technicians and engineers, managers, architects, local and municipal officials.

International cooperation should also be provided to help the Danubian countries achieve these policy objectives.

This assistance should include:

- Training in energy planning methods
- Creation of a "Danubian Center for Energy Planning" in one of the countries as a center for common training and to support needed applied research and technology innovation and adaptation.
- Institution- and capacity-building programmes for energy efficiency.
- Natural gas development, in particular through the laying of the Iran-Europe pipeline.
- Renewable and decentralized energy development.

• **Funding energy-efficiency policy**

- Improving final utilization of energy provides a significant opportunity for financial savings. As a first step, we recommend the creation of a National Fund for Energy Efficiency financed by 1% of the bills paid by energy consumers on final energy consumption. This fund will finance national energy-efficiency programmes.

• **Exemplary actions**

- Exemplary actions must be carried out in the following fields:
- Domestic, urban and tertiary lighting, using economical solutions such as compact fluorescent bulbs which consume five times less than incandescent bulbs and last eight times longer.
- Household appliances, particularly refrigerators and TVs. It is now possible to obtain models that consume half as much as models currently on the market in western countries.

• **Hydroelectricty**

- The hydroelectric potential is great in most of the Danube countries and these do possess recognized hydraulic skills which are exported throughout the world. As a result, hydroelectricity is relatively well advanced in the Danube countries and some of the latter (Slovakia, Rumania, Bulgaria) plan to develop it very widely in the coming years.

However, hydraulic constructions have serious effects both on the general equilibrium of fluvial ecosystems and on the drinking water resources associated with them (groundwater tables), effects which are not always reversible

This is why:

- Exploitation of 100% of the economically operable hydroelectric potential is not a reasonable objective. Development of hydroelectricity must be limited and moderated.

RECOMMENDATIONS

- Installation of new plants must be the object of strict and full prior impact studies which take the ecological, technical and economic aspects into account along with the possibility of alternative solutions.
- The building of dams in the plains regions must be prohibited.
- No new dams must be built on the Danube.
- New ways of exploiting the existing dams must be envisaged. These must incorporate moderation of their consequences (sediment and output management in particular).

Small Hydroelectric Power Plants also have the support of governments in the countries where their potential is sufficiently great. They have consequences which are more easily controlled as they are smaller in size and do not for the most part create water retention. However, these consequences must not be neglected. The multiplication of SHPPs along a watercourse would create problems identical to those of a large plant.
This is why we recommend:
- That the legislative framework which must be put in place to accompany their development strictly imposes consideration of the consequences on rivers both at construction design level and at output management level.
- That the re-certification of old SHPPs or the installation of turbines on existing constructions which fulfill other functions (e.g. water tapping for irrigation) be favored over the building of new constructions, even if this leads to additional cost. It is broadly acknowledged that the development of energy efficiency is the only way in which the world can pursue a process of sustainable development that will respect the environment and keep the world fit for future generations to live in.

• **Renewable energies**

- The estimate of the renewable potential of the Danubian countries, around 12% of primary energy consumption, shows that interests at stake for energy, environment and development are significant. In this case it is necessary:
- that the exploitation of renewable energies be a priority goal of energy policies currently in the process of being redefined in Danubian countries
- to prepare a comprehensive evaluation of the potential of the main renewable technologies really accessible,
- to set up a general survey of the industrial capacities which would be necessary for the technologies,
- to make an analysis of the institutional and financial framework necessary to develop such policies.

Answering these questions will allow these countries to identify priority actions, to prepare government decisions, to convince investors of the interest of such policies for local development, population welfare and protection of local and global environment.

• **The end of nuclear energy**

- The application of this new energy policy is aimed at balancing the energy assessments from all the Danubian countries without resorting to nuclear energy. Giving it up therefore takes the lead for the obvious reason of individual safety and above all because it is not necessary.

PART 4

EVALUATION OF THE POLLUTION OF THE DANUBE

EVALUATION OF THE POLLUTION OF THE DANUBE

Research carried out by Equipe Cousteau and its partners in evaluating the pollution of the Danube followed two main directions. The first concerns resources assessment which is of critical importance for the wise and rational management of resources. The second concerns the tools for data analysis and environmental management available for decision-makers.

In order to save time and to minimize costs, it is important to select the main parameters which should be measured, to specify the analytical processes and to share information and data. In order to fully assess the situation of Danube pollution, Equipe Cousteau has set out a programme of chemical analysis of sediments and mussels collected all along the river. The database thus constituted reflects the status of the river's contamination by pesticides, PCBs, oil combustion products, industrial chemicals and sewage.

Europe as a whole was exposed to radioactive fallout as a result of the Chernobyl accident on April 26, 1986; the Danube and its tributaries cool nuclear plants in Hungary and Bulgaria; the power industry produces radioactive waste; undetected random discharges sometimes contain radioactive waste. For all the above reasons, we developed an aerial gamma-spectrometry programme in order to study natural and man-made radioactivity along 2,200 km of the Danube's banks and at and around nine selected nuclear and non-nuclear industrial sites.

Modern environmental management requires the development of highly productive decision-making tools. In the case of the Danube basin, in which there is a population of nearly 76 million people and where the Danube river passes through ten nations, state-of-the-art data analysis and management techniques, including cartographic representations, must be implemented. The Geographical Information System thus seems to be a tool well suited to environmental management.

The holistic approach which inspires our Danube programme tends toward an upstream approach which favors analysis of data concerning human activities generating pollutants rather than water quality measurement, to evaluate pollution and high-risk zones. The results of this upstream approach perfectly complement field analyses. Through this approach, priority actions, required in order to stop environmental deterioration, can be identified with a high degree of certainty and without requiring pollution measurements to be taken everywhere and in all sectors.

This new approach was presented, discussed and compared with other techniques during an international symposium in Budapest. Exchanges between the participants enabled the foundation of real international cooperation to be laid with respect to developing tools for environmental management. A skills network is currently being formed around the creation of an Environmental Decision Support System for the Danube river basin.

ENVIRONMENTAL RESOURCES ASSESSMENT

1
CONCENTRATION OF CHEMICAL POLLUTANTS IN SEDIMENTS AND MUSSELS ALONG THE DANUBE

1.1
PRESENTATION

As with all major rivers, the Danube provides an effective means of transporting waste from human activities, within its basin, to their ultimate repository in the sea. This use conflicts broadly with other, more productive functions of the river as a source of drinking and irrigation water (artificial irrigation or by natural replenishment of the water table), as the supporting medium for biotic resources, or as a recreational asset for the inhabitants of the riparian countries. At an early stage in the development of an environmental management plan for the Danube basin, it will be necessary to review the current status of pollution of the river in its entirety and assess the needs for urgent responsive or preventive actions as well as the design of a comprehensive monitoring programme.

In order to answer the need for quality, efficiency and international cooperation, this study has been given to the Marine Environmental Laboratory of the International Atomic Energy Agency (MEL) in Monaco directed by Dr. Lawrence Mee and the Institute for Water Pollution Control of VITUKI, in Budapest, directed by Dr. Peter Literathy.

Scientific supervision was ensured by Pr. Jean-Marie Martin, head researcher in CNRS, head of the Marine Bio-geochemistry Laboratory of the Ecole Normale Supérieure in Paris.

The Department of Marine Geology and Sedimentology (Institute of Geology and Geophysics of Romania, Bucharest), directed by Dr. Panin, is in charge of the completion and precision of the measures done between the Iron Gate and the Black Sea, this area happening to be the most polluted of all.

It is recognized that a single set of measurements of water quality would yield data reflecting a momentary situation in the river and might be unrepresentative of the average conditions. It would add little to the efforts being made in this direction by institutions responsible for implementing the Bucharest Declaration or by the excellent studies of independent organizations such as the International Center for Water Studies of the Netherlands. On the other hand, it is also recognized that the list of parameters currently being measured for the Bucharest Declaration is an extremely limited one and may not cover many of the chemical contaminants likely to pollute the Danube. For this reason, it was decided to follow an entirely different strategy and focus upon measurements of contaminants in sediments and sentinel organisms along the entire length of the river. Providing the sampling sites are selected carefully (undisturbed sites where there is a net deposition of fine sediments), sediment concentrations of many contaminants reflect the quality of the overlying water integrated over relatively long periods of time. Biomonitoring should achieve the same objective and reflect the possible passage of contaminants through the food chain. Of course, sediment or biota concentrations are not a quantitative measure of water quality but they enable the detection of spatial trends, pollution "hot spots" and the comparative importance of individual pollutants. As a preliminary investigative tool, they enable the correct placement of water quality stations for follow-up measurements of contaminants in solution or associated with suspended solids. They also permit the detection of "chemical time bombs" - sites where pollutants gradually build up in sediments until critical concentrations are attained.

The study focused on a broad range of contaminants - over 100 parameters in total. Even these represent a relatively small fraction of the total of potentially harmful substances which may be introduced to the waters of the Danube, mostly through industrial, municipal and agricultural effluents. The parameters selected for study fall into the following general classes:

- Chlorinated hydrocarbons: persistent pesticides and their residues and PCBs from industrial and municipal sources.
- Petroleum hydrocarbons: from the spillage or intentional discharge of oil or oil products.
- Polycyclic aromatic hydrocarbons, PAHs: principally combustion products of fossil fuels and as components in oil.
- Organophosphorous compounds: mostly pesticides and some industrial compounds.
- Trace metals: including heavy metals, mostly from industrial or municipal sources.
- Sewage pollution indicators: fecal sterols characteristic of domestic sewage.

The presentation of primary results does not pretend to make a full scientific analysis of the data set obtained, rather it selects some of the parameters as "model compounds" in order to describe the current status of contamination in the Danube and provides a brief overview of the initial results of the study. It draws upon a data set consisting of over ten thousand individual measurements. A full and systematic review of the data set will be published jointly by IAEA-MEL (Monaco) and VITUKI (Budapest), with support from Equipe Cousteau, in early 1993. The data set by Dr. Panin will be published in a separate report.

1.2
FIELD STUDIES AND ANALYSIS

Equipe Cousteau and the VITUKI experts were in charge of an on-site sample collection. The team collected:

- Sediment samples for analysis of organic and inorganic pollutants.
- Mussel samples for studying bioconcentration of chemical pollutants in biological indicators.
- Benthos samples for analysis of diversity of benthic organisms which are a qualitative indicator of the stress undergone by an ecosystem exposed to pollution.

Sediment and mussel samples were maintained frozen during transport to the laboratories. Samples were treated according to internationally accepted procedures (e.g. UNEP Reference Methods for Marine Pollution Studies).

Fifty locations from the source of the Danube to its delta were determined by the scientific coordinators in accordance with local observations *(See Figure 4.1)*.

Three types of sites were selected:

- Bucharest Declaration sites.
- Hot-spot areas associated with cities, big industrial complexes, dams or nuclear power plants.
- Confluences of main tributaries of the Danube except in Yugoslavia.

The number of mussel sampling sites is limited to 10. Some of the samples were selected for a comparison between the different laboratories.

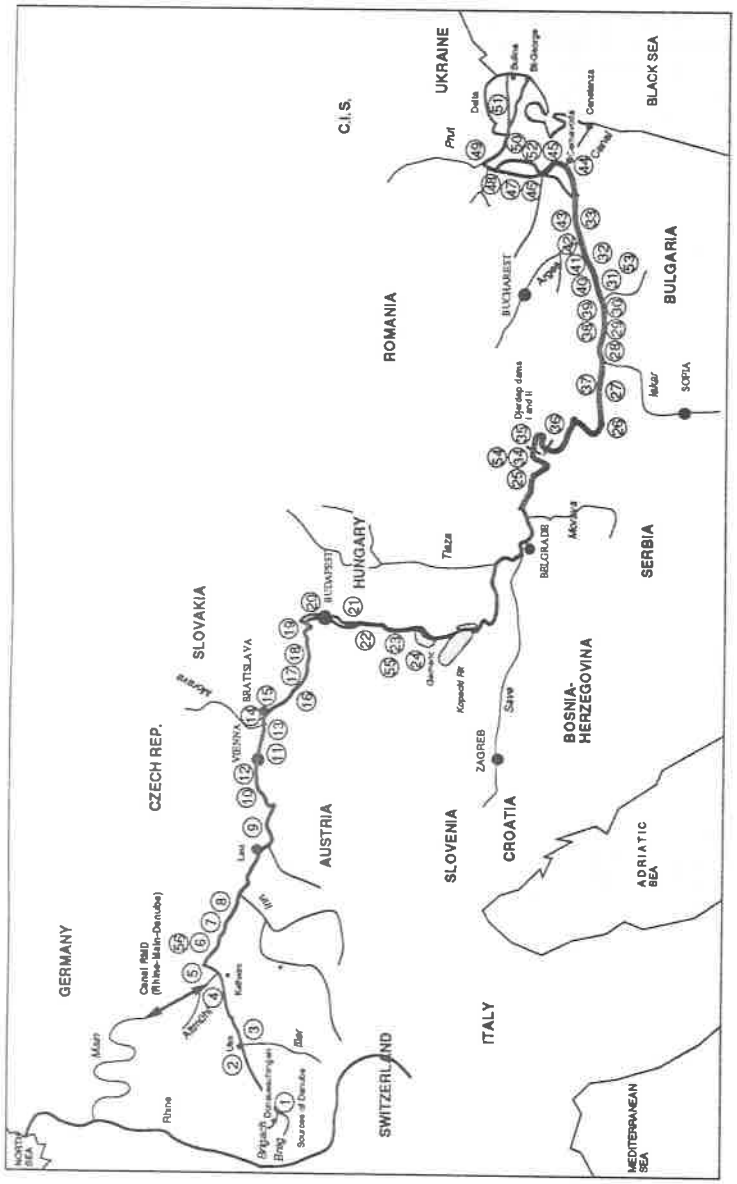


Figure 4.1 - Location of the sediment, mussels, and macrozoobenthos sampling sites.
Three types of sites were selected: Bucharest Declaration sites; hot-spot areas associated with cities, industrial complexes, dams or nuclear power plants; confluence of the main tributaries (except former Yugoslavia).

1.3
COMPARATIVE LEVELS OF CONTAMINANTS

The simplest approach to analyzing the data from the present study is to compare the levels of selected contaminants in the Danube with those in other rivers, particularly major European rivers, and other well studied contaminated regions of the world.

● CHLORINATED HYDROCARBONS ●

The range of concentrations from the Danube compared with those observed in the lower Rhine (the section flowing through the Netherlands) and some other areas such as the Rhone and the region around the Mississippi delta *(Table 4.1)*, shows that, with the possible exception of lindane, the levels of chlorinated hydrocarbons are inferior to those measured in the comparator rivers. This, at first sight, is somewhat surprising. For example, the sedimentary ratio of "new" DDT to its degradation product DDE (DDT is often as much as 30% of the total of DDT and its degradation products), suggests that even this pesticide, banned in most western countries, has been employed until recently in the Eastern European part of the Danube basin, but in quantities insufficient to cause serious contamination of the river. In the case of PCBs (carcinogenic industrial products used principally as transformer fluids), levels are well below those found in rivers in the more industrialized western countries.

Table 4.1 - Comparative contamination levels of chlorinated hydrocarbons in sediments

Compound	Danube (range) ng/g (dry wt)	Lower Rhine (range) ng/g (dry wt)	Other comparators ng/g (dry wt)	Concentration limit for N. Sea dumping (Neth.) ng/g (dry wt)
Lindane	0.033 - 6.4	up to 4	0.02 - 1.74 (1)	20
HCB	0.036 - 35	12- 72	32 (average) (2)	20
DDT	<0.01 - 24	up to 8	<0.02 - 2240 (1)	?
DDE	0.03 - 16.9	5 - 17	<0.02 - 195 (1)	100
Dieldrin	<0.002 - 0.26	up to 2	<0.02 - 9.5 (1)	20
Endosulfan-I	<0.002- 0.35	up to 2		?
PCB 101 (3)	<0.002 - 4.1	8 - 30		20
PCB 138 (3)	0.021 - 6.3	14 - 55		20
PCB as Aroclor 1254	0.22 - 11.4		<0.02 - 3730 (1)	

(1) Gulf of Mexico coast including the Mississippi delta
(2) Rhone Delta
(3) IUPAC numbers for identifying individual PCB congeners

With the possible exception of lindane, the levels of chlorinated hydrocarbons are inferior to those measured in some comparative western rivers.

Table 4.2 - Comparative contamination levels of Petroleum Hydrocarbons and PAHs in sediments

Compound	Danube (range) µg/g (dry wt)	Lower Rhine (range) µg/g (dry wt)	Other comparators µg/g (dry wt)	Concentration limit for N. Sea dumping (Neth.) µg/g (dry wt)
sigma n-alkanes (1)	1 - 40		16 - 94 (3)	
UCM (2)	4 - 530		104 (average) (4)	
			250 - 1100 (3)	
Phenanthrene	0.004 - 0.58	1 - 7.5	0.75 (average) (4)	1.6
Fluoranthrene	0.006 - 1.4	0.1 - 2.4	1.01 (average) (4)	3.1
Benz(a)anthracene	<0.001 - 0.73	0.1 - 1.0	0.33 (average) (4)	1.2
Benzo(a)pyrene	0.002 - 1.0	up to 1.3	0.51 (average) (4)	1.6

(1) "sigma n-alkanes" refers to the sum of n-alkanes with carbon numbers from 14 to 36. This is a measure of relatively fresh inputs of oil.
(2) "UCM" refers to the chromatographically unresolved complex mixture. This is a measure of degraded forms of petroleum hydrocarbons (principally degraded oil).
(3) Data from the relatively polluted Tama river in Japan.
(4) Data from the relatively polluted Mersey estuary (Liverpool) in the UK.

Despite some rather high values in certain hot spots, the levels of oil and oil residues are inferior to those of chronically polluted Western rivers and estuaries.

● PETROLEUM HYDROCARBONS AND PAH COMPOUNDS ●

Levels of oil and oil residues are rather high in certain hot spots but are generally inferior to those of chronically polluted rivers and estuaries *(See Table 4.2)*.

It is interesting to note that in no case have the PAH concentrations exceeded values which would, in the case of the North Sea, constitute unacceptable levels for sea disposal following dredging.

● HEAVY METALS ●

The comparators have been selected in order to illustrate the case of European rivers with "background" levels (the river Loire) and the highly polluted Vestre river as well as the lower Rhine. It is clear that the Danube sediments span a wide range of concentrations which overlaps those of "uncontaminated" and "polluted" rivers *(See Table 4.3)*.

Of particular concern are the levels of mercury which, in some hot-spot areas are well above the highest levels observed in the lower Rhine and, in one case, exceed the limits for North Sea dumping by a factor of seven. It should be noted that considerable care was taken to re-check these high values by conducting triplicate determinations of the hot spot values. Levels of most of the other metals (copper, lead, zinc, chromium and arsenic) also exceed those registered for the lower Rhine, but, as will be illustrated later, this occurs at well-defined hot spots associated with identifiable sources of pollution. This situation reflects the preliminary results of Bucharest Declaration monitoring which tended to indicate elevated concentrations of some trace metals. Clearly this situation warrants further detailed study and control and remedial actions.

Table 4.3 - Comparative contamination levels of trace metals in sediments from the Danube

Metal	Danube (range) µg/g (dry wt) (1)	Lower Rhine (range) µg/g (dry wt)	Other comparators µg/g (dry wt)	Concentration limit for N. Sea dumping (Neth.) µg/g (dry wt) (2)
Cadmium	0.35 - 4.7	0.0 - 5.2	0.01 - 0.8 (3)	3.5
			16 - 195 (4)	
Mercury	0.11 - 5.55	0.4 - 1.8		0.8
Copper	19 - 290	65 - 158	1.6 - 45 (3)	55
			107 - 580 (4)	
Nickel	17 - 70	38 - 68	15 - 56 (3)	40
Lead	23 - 420	81 - 238	13 - 81 (3)	100
Zinc	73 - 2000	377 - 770	14 - 279 (3)	340
			1629 - 4806 (4)	
Chromium	35 - 310	79 - 123	18 - 125 (3)	100
Arsenic	9 - 48	16 - 27		30

(1) Data for the fraction of sediments less than 63 microns.
(2) For Rotterdam harbor sludge, calculated on the basis of a "standard bottom".
(3) The river Loire, which is one of the least contaminated European rivers.
(4) The Vestre river in Belgium, the samples were from a section 6 km downstream from a zinc factory

The heavy metal concentrations in Danube sediments are very high. In some hot spots the level of mercury can exceed the limits for North Sea dumping by a factor of seven.

● SEWAGE CONTAMINATION ●

A comparative analysis is presented for coprostanol, a parameter indicative of sewage contamination. The levels of coprostanol in Danube sediments are highly variable and appear to be related to the proximity of major areas of human settlement (see next section). From the comparative table, it can be appreciated that the Danube sediments are often heavily polluted with sewage, some of the highest environmental concentrations of coprostanol yet recorded. Measurements of this kind may serve as a useful tool in future detailed studies of sewage dispersion in the river *(See Table 4.4)*.

Table 4.4 - Comparative sediment concentrations of fecal sterols (as indicators of sewage pollution)

Danube sediments are often heavily polluted with sewage pollutants: some of the highest environmental concentrations of coprostanol yet recorded have been measured in the Danube sediments. They are related to the proximity of major cities.

Compound	Danube (range) µg/g (dry wt)	Sewage sludge µg/g (dry wt)	Comparators µg/g (dry wt)
Coprostanol	0.15 - 56	910 - 7800	9 (average) (1) 0.1 - 14 (2) 1.0 - 24 (3)

(1) Mersey estuary at Liverpool, UK. (2) Clyde estuary, Scotland, UK. (3) Lower Rhone (France).

1.4
GEOGRAPHICAL TRENDS

One of the goals of the present study is to illustrate geographical trends in the selected model contaminants.

Some distance references (from the delta):

The Danube sources:	2,880 km
Vienna	1,930
Bratislava	1,860
Gabcikovo	1,820
Budapest	1,650
Belgrade	1,170
Iron Gate	960
Kozloduy	700
Arges river (confluent)	420
Braila	175
Sulina (delta)	0

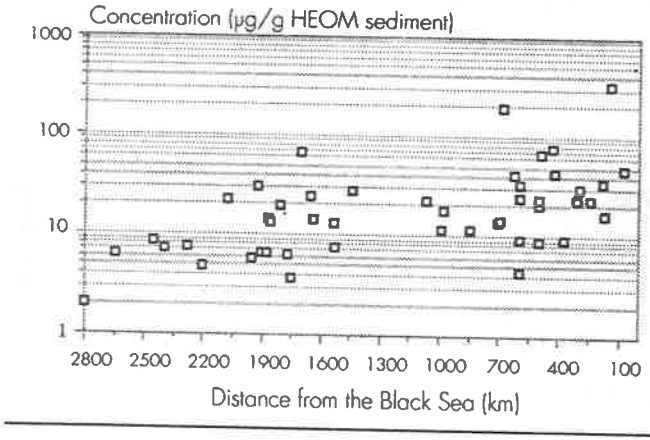
In order to study trends in pesticide concentrations and PCBs, the data can be "normalized" by expressing it in terms of concentration per gram of HEOM (hexane extractable organic material - largely a measure of lipids). This method compensates for natural variations in the system: proportion of lipids in sediments and organisms, mineral composition and grain size in sediments.

● PESTICIDES ●

Figures 4.2 show the results of sediment and biomonitoring for total DDT. The data for sediments span two orders of magnitude and is illustrated on a logarithmic scale for clarity. There is a trend towards increasing values of total DDT (over a ten-fold increase along the trend line) from the source to the mouth of the river. The concentrations at individual sites vary about tenfold from the trend line showing the presence of a number of hot spots. The same general trend is apparent from the results of biomonitoring. Interestingly, measurements made in different bivalve species at the same site produced virtually identical results when normalized to HEOM. For those stations where bivalves and sediments were collected (not always in exactly the same location), there was a

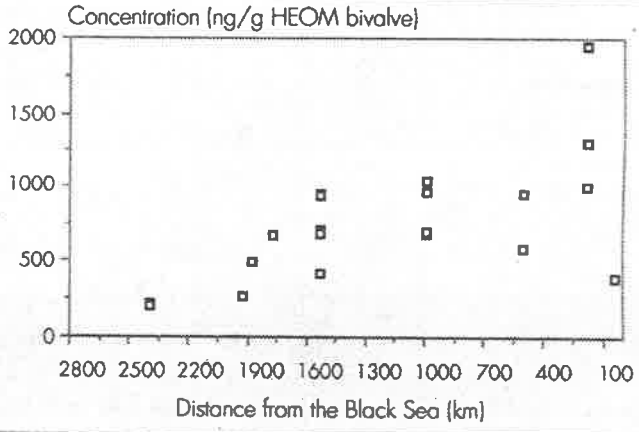
There is a trend towards increasing values of DDT from the source to the mouth of the river, and variations of the concentrations at individual sites from the trend line show the presence of a number of hot spots.

Figure 4.2
The distribution of "total DDTs" in samples from the river Danube
4.2a - Distribution of "total DDTs" in Danube sediments



Biomonitoring shows the same general trend of DDT concentrations as sediment analysis.

Figure 4.2
The distribution of "total DDTs" in samples from the river Danube
4.2b - Distribution of "total DDTs" in Danube bivalves



The good linear correlation between DDT levels in sediment and mussels shows the compatibility of the two approaches to pollution assessment for such pesticides.

Figure 4.2
The distribution of "total DDTs" in samples from the river Danube
4.2c - Correlation between "Total DDTs" concentration in sediments and bivalves

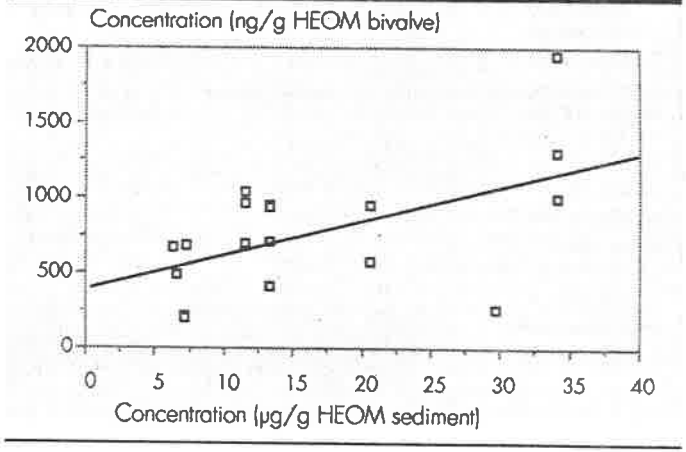


Figure 4.3 - Distribution of lindane pesticide in samples from the river Danube.
4.3a - Distribution of lindane in Danube sediments

The net increase of lindane concentration down the river is about 20 fold, with very large hot spots in the section downstream from the Iron Gate.

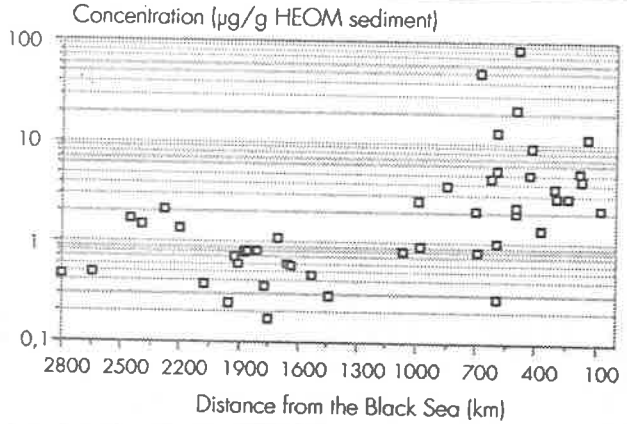


Figure 4.3 - Distribution of lindane pesticide in samples from the river Danube.
4.3b - Distribution of lindane in Danube bivalves

The general trend is also of increasing lindane concentration with distance down the river, but there is only a threefold increase in concentration. It should be noted that lindane is much more soluble that DDT and is less efficiently concentrated by bivalve molluscs.

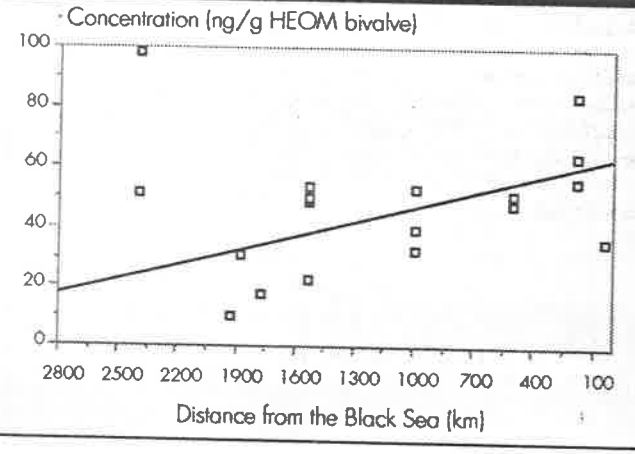
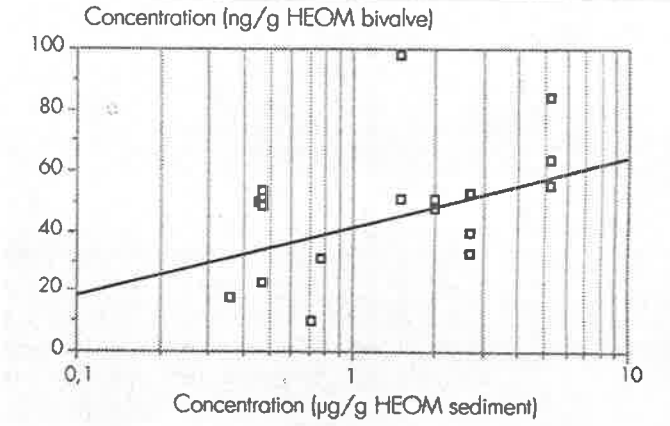


Figure 4.3 - Distribution of lindane pesticide in samples from the river Danube.
4.3c - Correlation between lindane concentration in sediments and bivalves

The log-linear plot reveals the existence of a relationship between sediment and bivalve lindane concentrations.



surprisingly good linear correlation between DDT levels in the two matrices. This shows the compatibility of the two approaches to pollution assessment for such pesticides.

In the case of lindane, the general trend is also of increasing concentrations with distance down the river, apart from somewhat elevated values near the Austria/Germany border *(see Figures 4.3)*. The net increase down the river is about 20 fold, with very large hot spots in the section downstream from the Iron Gate. The entire range of concentrations covers nearly three orders of magnitude. The magnitude of this trend is not reflected in the bivalves where only a threefold increase in concentration was observed.

A log-linear plot reveals the existence of a relationship between sediment and bivalve concentrations. It should be noted that lindane is much more soluble than DDT and is less efficiently concentrated by bivalve mollusks. The sedimentary levels in the lower reaches of the river however, appear to reflect sporadic contamination which may be serious in some places.

● PCBs ●

Unlike the pesticides, PCBs expressed as Arochlor "equivalents" decrease from the upper to the lower reaches of the river *(Figures 4.4 and 4.5)*. This reflects the association of these contaminants with high-technology industrial activities. The gradient in sediments from the upper to lower reaches of the river is about one order of magnitude along the trend line. Additionally, there is clear evidence of hot spots associated with tributaries flowing from the major cities in the region of the lower Danube. Concentrations of PCBs in biota vary comparatively little along the length of the river with the exception of a notable hot spot in the region of Vienna. There is a complete lack of correlation between the biota and sediment concentrations, suggesting that, in the case of the PCBs, bivalves are rather poor sentinel organisms. This may also reflect limited bioconcentration of PCBs through the food chain. As was mentioned earlier, the levels of PCBs are rather low in all of the samples studied and cannot be considered to represent a major environmental threat.

Figure 4.4 - Distribution of arochlor 1254 "equivalents", PCB, in samples from the river Danube.
4.4a - Distribution of arochlor 1254 "equivalents" in Danube sediments

Unlike the pesticides, PCBs decrease from the upper to the lower reaches of the river. This reflects the association of these contaminants with high-technology industrial activities.

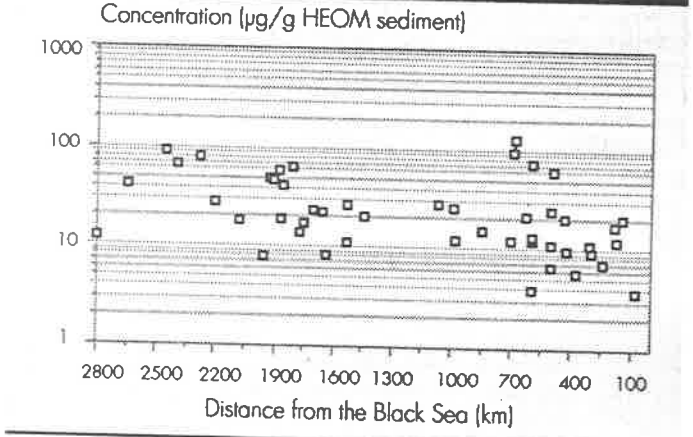


Figure 4.4 - Distribution of arochlor 1254 "equivalents", PCB, in samples from the river Danube.
4.4b - Distribution of arochlor 1254 "equivalents" in Danube bivalves

Concentrations of PCBs in biota vary comparatively little along the length of the river with the exception of a notable hot spot in the region of Vienna.

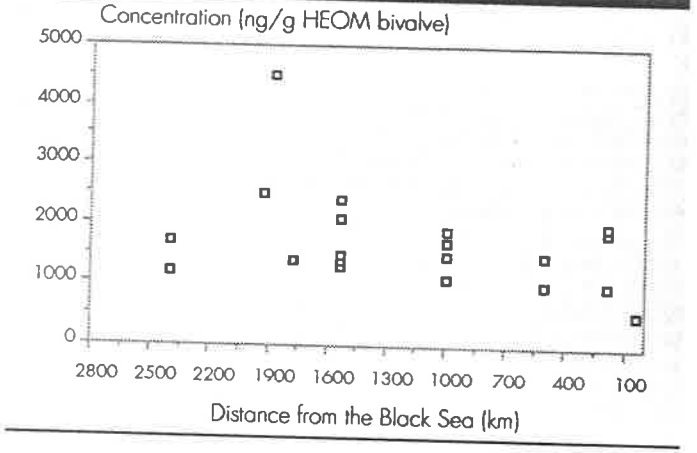


Figure 4.4 - Distribution of arochlor 1254 "equivalents", PCB, in samples from the river Danube.
4.4c - Correlation between arochlor 1254 "equivalents" concentration in sediments and bivalves

There is a complete lack of correlation between the biota and sediment concentrations, suggesting that, in the case of the PCBs, bivalves are rather poor sentinel organisms.

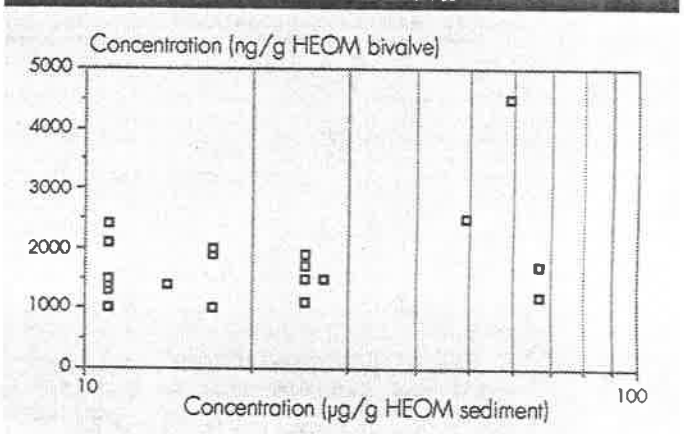


Figure 4.5 - The distribution of individual PCB congeners in bivalves sampled from the river Danube
4.5a - PCB 5 - PCB 28 - PCB 49

All the PCBs congeners show quite the same feature, with little variation along the length of the river and high levels associated with the city of Vienna.

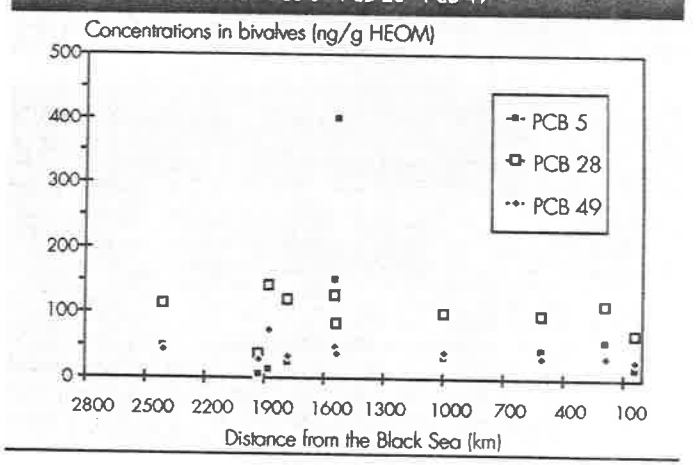


Figure 4.5 - The distribution of individual PCB congeners in bivalves sampled from the river Danube
4.5b - PCB 138 - PCB 153 - PCB 180

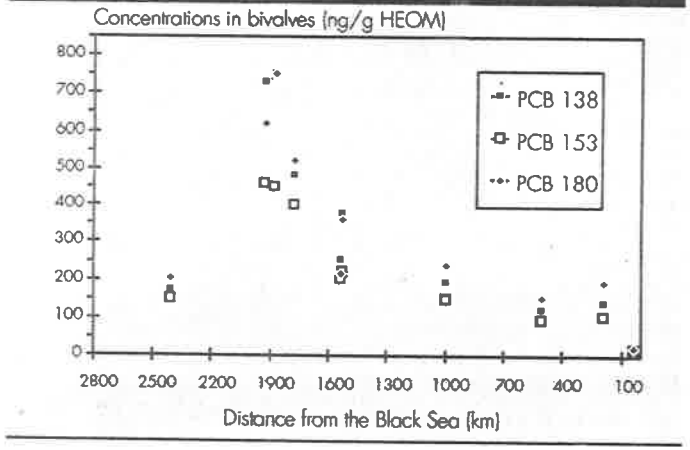


Figure 4.5 - The distribution of individual PCB congeners in bivalves sampled from the river Danube
4.5c - PCB 101 - PCB 52

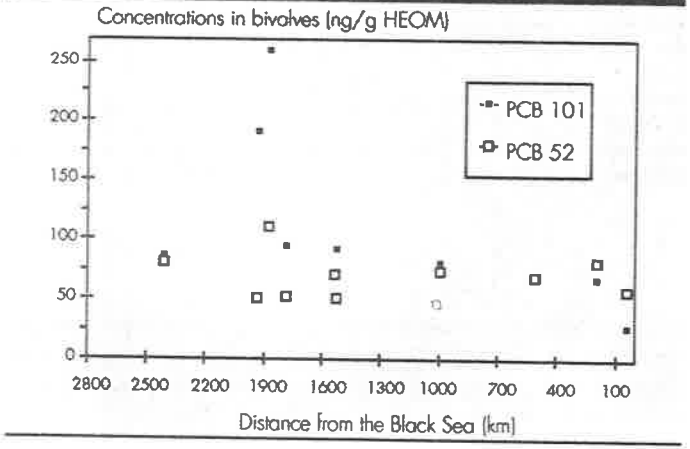
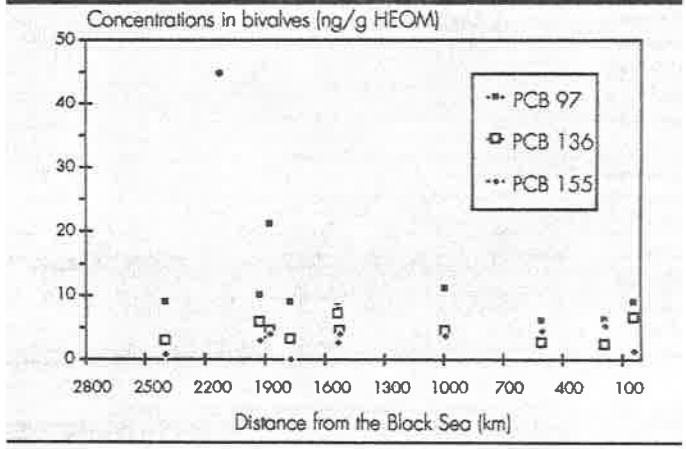


Figure 4.5 - The distribution of individual PCB congeners in bivalves sampled from the river Danube
4.5d - PCB 97 - PCB 136 - PCB 155



● PETROLEUM HYDROCARBONS ●

Figure 4.6 illustrates the sediment data for total aliphatic hydrocarbons (presented as a measure of total oil contamination) and benzo(a)pyrene (the PAH described previously). Sediments of the river are characterized by three reaches with elevated oil concentrations, the upper reach (in Germany), the middle "industrial" reach (from the Austria/Slovakia border to below Budapest) and the lower reach (from the industrial areas of Bulgaria and Romania). This pattern must be interpreted with some caution. The upper Danube includes a series of inter-connected artificial lakes which contribute relatively little water to the lower reaches of the river but are natural traps for oily waste. The absence of elevated concentrations in the section of the Danube from km 1100 to km 1450 only reflects the impossibility of sampling in this region due to the civil war in former Yugoslavia. In contrast to the petroleum hydrocarbon data, that for PAHs appear to reflect rather specific hot spots associated with major centers of human activity. There is no general trend down the river, suggesting that the assimilation capacity of the river has not been generally exceeded in areas outside the immediate influence of identified sources.

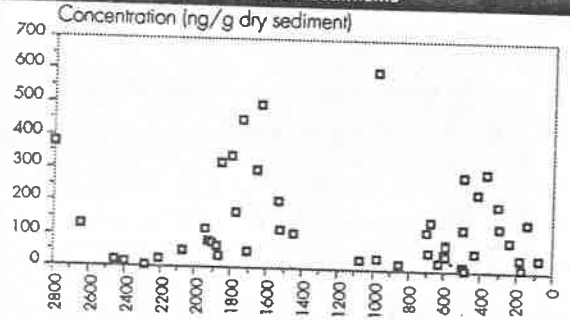
● TRACE HEAVY METALS ●

Trace metal data are illustrated by the distribution of chromium and cadmium normalized to aluminum *(Figure 4.7)*. The levels in the lower half of the river are generally about 50% higher than those in the upper reaches. There are however, notable hot spots.

Chromium is found in sediments downstream from Komarno in Slovakia at Gruia-Rudujervac (Serbia-Romania), at Ruse in Bulgaria. Cadmium is found at Cob-Szob (Slovakia-Hungary), in the Iron Gate reservoir and at Ruse.

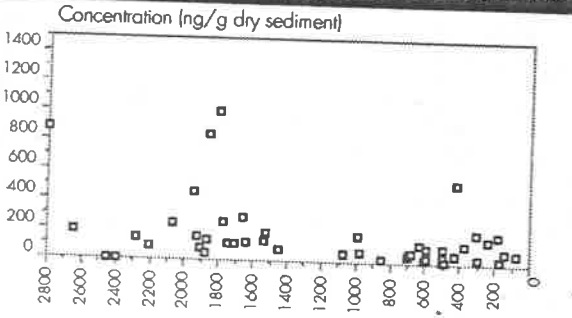
Sediments of the river are characterized by three reaches with elevated oil concentrations, the upper reach in Germany, the middle reach from the Austria/Slovakia border to below Budapest and the lower reach from the industrial areas of Bulgaria and Romania.

Figure 4.6 - Distribution of Petroleum Hydrocarbons and Benzo(a)Pyrene in Danube sediments
4.6a - Distribution of "total aliphatic hydrocarbons" in Danube sediments



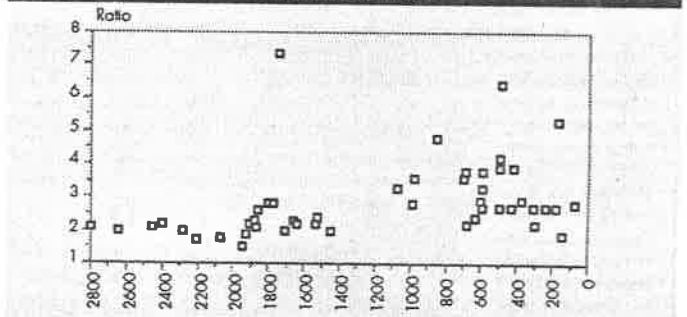
There is no general trend down the river, suggesting that the assimilation capacity of the river has not been generally exceeded in reaches outside the immediate influence of identified sources.

Figure 4.6 - Distribution of Petroleum Hydrocarbons and Benzo(a)Pyrene in Danube sediments
4.6b - Distribution of Benzo(a)Pyrene in Danube sediments



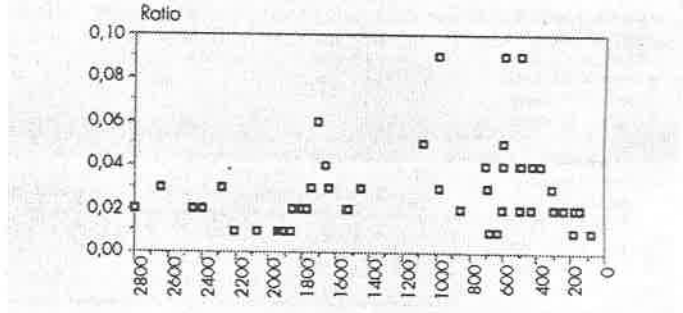
The main hot spot is downstream Komarno in Slovakia. Chromium pollution is often associated with the tanning industry and with the production of steel alloys.

Figure 4.7 - Distribution of normalized Chromium-52 and Cadmium-111 in Danube sediments
4.7a - Distribution of normalized Chromium-52 in Danube sediments



Levels in the lower half of the river are generally about 50% higher than those in the upper reaches. There are also notable hot spots (Iron Gate reservoir and Ruse in Bulgaria).

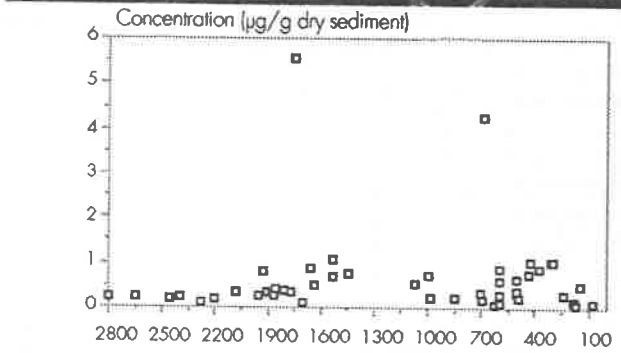
Figure 4.7 - Distribution of normalized Chromium-52 and Cadmium-111 in Danube sediments
4.7b - Distribution of normalized Cadmium-111 in Danube sediments



Levels of mercury in the lower reaches of the river are generally two or threefold higher than those of the region above km 2000 *(Figure 4.8)*. There are two extremely contaminated hot spots downstream from Komarno in Slovakia and at the mouth of the Jiul in Romania. The elevated concentrations in the lower reaches (concentrations above 0.8 mg/l), are well above those usually encountered in major European rivers. It would seem likely that they are associated with contamination arising from human activities in the lower part of the river basin.

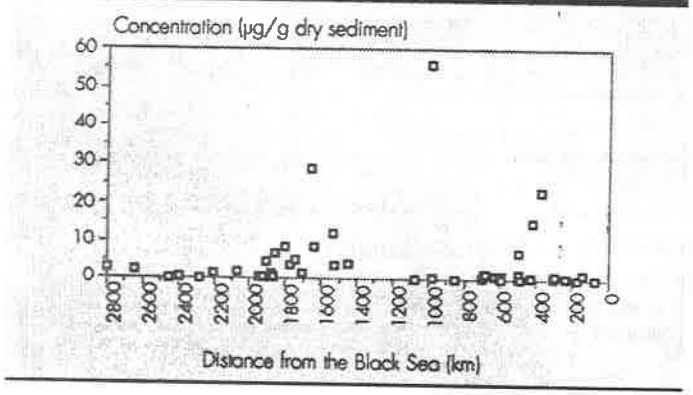
Levels in the lower reaches of the river are generally two or three-fold higher than those of the region above km 2000. There are two extremely contaminated hot spots, downstream Komarno and mouth of Jiul. The elevated concentrations in the lower reaches (concentrations above 0.8 mg/g), are well above those usually encountered in major European rivers.

Figure 4.8 - Distribution of total Hg in Danube sediments



There is no general geographical trend for coprostanol, a sewage indicator, but its presence appears to reflect sewage discharges from those settlements with inadequate treatment (e.g. Bratislava, Budapest, Bucharest). The extremely high levels within the Iron Gate reservoir may represent a worrying tendency for sewage to build up in sediments behind the dam.

Figure 4.9 - Distribution of Coprostanol in Danube sediments



• SEWAGE CONTAMINATION •

As would be expected, there is no general geographical trend for coprostanol but its presence appears to reflect sewage discharges from those settlements with inadequate treatment, e.g. Bratislava, Budapest, Bucharest *(Figure 4.9)*. Additionally, there were extremely high levels measured at km 1000, within the Iron Gate reservoir. This may be a chance observation or may represent a worrying tendency for sewage to build up in sediments behind the dam.

1.5
SIGNIFICANCE OF HOT SPOTS

One of the more useful aspects of the present data set is that it pinpoints areas in the river where there are particularly elevated concentrations of contaminants and where urgent management action is required. Such hot spots can be evaluated by careful inspection of the geographic distribution of contaminants or by more complex multi-parameter approaches, some of which will be mentioned below.

In some cases, a particular parameter may have a unique signal which clearly associates it with a given source. An example of this is the case of chlorpyrifos, an organophosphorous pesticide with an environmental half-life of some six months. In Danube sediments, there is a large single maximum in the concentration of this pesticide corresponding to the city of Budapest and the concentration level then subsides downstream *(Figure 4.10)*. In no case are the concentrations considered to be hazardous. Investigations are absolutely necessary. This is somewhat similar to the situation presented in *Figure 4.5* where elevated, but not necessarily hazardous, levels of PCBs were found to be associated with the city of Vienna. In the case of trace metals, there are also some single-parameter hot spots such as that of chromium in the vicinity of the Vah river in Slovakia. Chromium pollution is often associated with the tanning (leather) industry, or occasionally with the production of steel alloys.

Examples of a multi-parameter approach are shown in *Figures 4.11* and *4.12*. The idea of this approach is to examine the coincidence of two potential pollutants associated with a given human activity. In *Figure 4.11*, this approach is illustrated for the case of coprostanol and petroleum hydrocarbons in order to highlight those sites where oil is introduced in association with municipal sewage. This clearly occurs in the region of Bratislava, Budapest and in the region of Chiciu-Silistra (Romania/Bulgaria). The most spectacular co-occurrence is in the Iron Gate's reservoir, just upstream from the Djerdap power plant. *Figure 4.12* examines the coincidence between benzo(a)pyrene and lead, a combination of products characteristic of fossil fuel combustion (including the combustion of leaded fuel). Here the function displays peaks coinciding with the region of Bratislava (considerable heavy industry), the Iron Gate dam (as before) and the region downstream of Oltenita (Romania), where the Arges river introduces discharges from Bucharest.

There is a large single maximum in the concentration of chlorpyrifos, an organophosphorous pesticide corresponding to the city of Budapest and the concentration level then subsides downstream. In no case are the concentrations considered to be hazardous.

Figure 4.10 - Distribution of Chlorpyrifos in Danube sediments

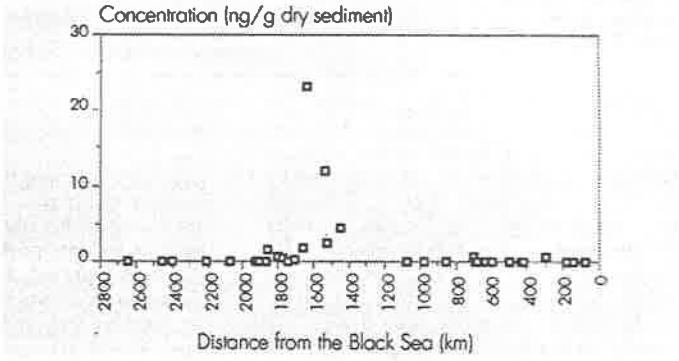


Figure 4.11 - Hot spot identification: Coprostanol and Petroleum

The multi-parameter approach examines the coincidence of two potential pollutants associated with a given human activity. Coincidence of coprostanol and petroleum hydrocarbons highlight those sites where oil is introduced in association with municipal sewage. The most spectacular co-occurrences are in the Iron Gate reservoir, at Budapest and at the Arges river (Bucharest).

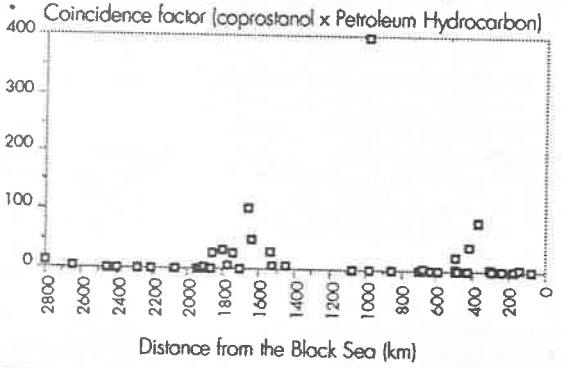
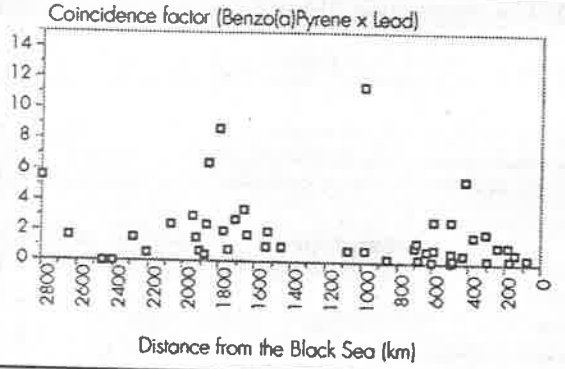


Figure 4.12 - Hot spot identification: Benzo(a)Pyrene and Lead

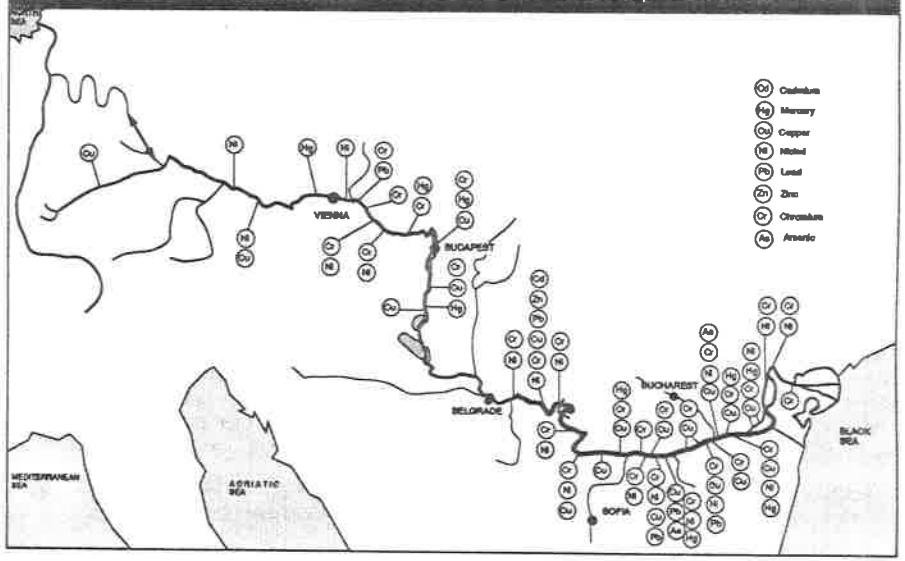
The coincidence between benzo(a) pyrene and lead is characteristic of fossil fuel combustion including the combustion of leaded fuel. Here the function displays peaks coincident with the region of Bratislava (considerable heavy industry), the Iron Gate dam and the region where the Arges river introduces discharges from Bucharest.



A procedure for identifying trace metal hot spots is to consider those samples with concentrations which, in the case of Rotterdam harbor, would be considered as too contaminated for disposal by dumping in the North Sea. *Figure 4.13* illustrates the results of this procedure. The map shows the elemental symbols for the hot-spot offenders in the appropriate position. It is clear that the lower reaches of the Danube are heavily affected by metals. From a management point of view, it is worth noting that dredged materials from many of these sites would be classified as "toxic waste" and would present enormous problems from the point of view of safe disposal.

Sediment monitoring is clearly a very useful tool for detecting hot spots. When a clear gradient is established to the source, effluent monitoring becomes the appropriate tool and control action should be evaluated. It is likely that the present distribution of stations will have missed many of the lesser hot spots in the Danube and an even more detailed survey should be contemplated in the future.

Figure 4.13 - Location of the trace metal hot spots.



Trace metal hot spots are the sites where samples reach concentrations which would be considered as too contaminated for disposal by dumping in the North Sea. The dredged materials from many of these sites would be classified as "toxic waste" and would present enormous problems from the point of view of safe disposal.

1.6

RESULTS OF THE PRELIMINARY SURVEY ON MACROZOOBENTHOS ALONG THE DANUBE

To assess pollution in any environmental situation, one requires information to determine whether measured levels of contaminants induce biological effects. In some cases, effects can be inferred simply by reference to comparative literature, but the evaluation of effects in "real" samples from the environment is the only fully satisfactory approach.

For the present survey, the approach is based on the study of the community structure of the macrozoobenthos. This work was carried out by Belà Csanyi from the Institute for Water Pollution Control of VITUKI, Budapest.

Macrozoobenthos consists of organisms belonging to a wide range of taxonomic groups. They are mostly sessile and share the common characteristic of a sediment or solid substrate habitat and, in their adult forms, do not usually move along large distances. The individual families of the benthos however, demonstrate widely different sensitivities to pollutants (snails, for example, are much more sensitive than oligochaete worms). The composition of the benthic community is therefore strongly influenced by the degree of pollution of the water column and sediments. Of course, physical factors are also important such as the river flow, temperature and the substrate. For this reason, sampling sites must be chosen carefully in order to study comparable habitats and avoid those stresses to the community which are not related to pollution.

In order to use benthic surveys for water quality assessment, a score system was developed in the

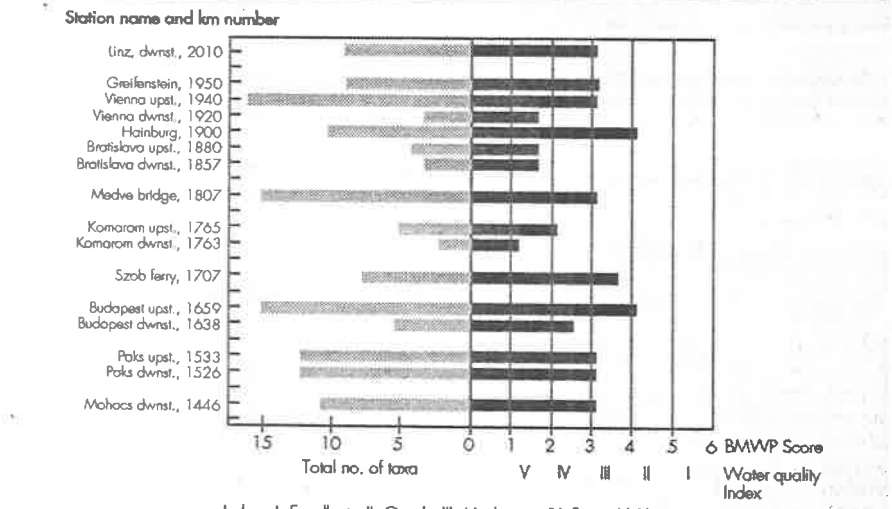
UK in 1978. In this system (known as the Biological Monitoring Working Party score system or BMWP) the families of the benthos are classified according to their relative sensitivities to pollutants and assigned a score from ten (most sensitive) to one (least sensitive). The scores are summed and the Average Score Per Taxa (ASPT) calculated. Over the past 15 years this system has been developed into a nationwide research and monitoring system for British rivers. It has now been applied in a slightly modified form to Hungarian rivers (River Tisza Survey, 1992).

For the present study, samples of macrozoobenthos were obtained from 50 sites close to those shown on the map sampling sites *(Figure 4.1)*. The samples were collected in shallow waters with a 1 mm mesh size benthic net and in deeper waters by an Eckman grab. Unfortunately, due to bad conditions during the sampling mission (winter flood), only samples from the Austrian, Slovakian and Hungarian sections proved to be sufficiently satisfactory in order to apply the modified BMWP score system.

Results obtained by applying the score system are summarized in *Figure 4.14*. This shows the total number of taxa found at each location, the modified BMWP score (the average rating derived from the total score and the ASPT) and the corresponding water quality index. Results are entirely consistent with the chemical measurements of contaminants. The water quality in the upper section of the river (above Vienna) is classified as "moderate: (III)". Just below Vienna there is a station classified as "very poor: (V)" but the situation improved 20 km downstream at Hainburg where "good: (II)" conditions were recorded. The stretch of the river through the industrial city of Bratislava was classified as "very poor: (V)" with only three taxa found downstream of the city. However, "moderate: (III)" conditions were found 50 km downstream at Medve. The two stations in Komarom,. upstream and downstream of the Vah river both revealed "poor: (IV)" water quality (there is major industry in the area, particularly on the Vah river). Just upstream of Budapest, the Danube river was classified as having "good: (II)" quality but "poor: (IV)" quality was revealed just downstream. The remaining Hungarian stations were classified as having "moderate: (III)" water quality. The Paks power plant had no influence on benthic diversity. The three springtime measurements at Braila, Ruse and Orsova on the Romania/Bulgaria section (not shown on the figure) all suggested "moderate: (III)", classifications.

In addition to the pilot scale application of the BMWP methodology, the present survey also revealed information on the biology of benthic macrofauna. The fauna includes opportunistic "imported" species such as the North American snail *Potamopyrgus antipodatum* which was known in Western Europe from 1893 and was found from Germany to Paks in Hungary, and the Chinese mussel *Sinanodonta woodiana* imported inadvertently in the 60s. For the latter species, the warm water channel of the Paks nuclear power station has been a favorable environment where some specimens were found to have grown to 28 cm length.

Figure 4.14 · Water quality rating based upon data on macrozoobenthos



Index - I: Excellent; II: Good; III: Moderate; IV: Poor; V: Very poor

The macrozoobenthos monitoring provided valuable evidence for chronic biological stress associated with contaminated sites. It was noteworthy that benthic biodiversity decreased downstream of recognised hot spots.

The macrozoobenthos monitoring programme provided valuable evidence for chronic biological stress associated with contaminated sites. Of course it is difficult at this stage to relate a particular pollutant to a decrease in biodiversity, however, it was noteworthy that benthic biodiversity decreased downstream of recognized hot spots such as major cities (Vienna, Bratislava, Budapest) or major industrial centers on the river or its tributaries (Bratislava, the Vah river, etc.). A more detailed study must consider a more statistically valid sampling scheme and seasonal measurements at selected sites. Such information, properly correlated with chemical measurements, could eventually lead to a Danube biological monitoring system as an extension of the Bucharest Declaration.

1.7
ELEMENTS FOR A COMPREHENSIVE ENVIRONMENTAL MANAGEMENT PLAN FOR THE DANUBE BASIN

The scientific campaign which has been conducted in order to measure the chemical pollutants contained in sediments and mussels sampled all along the Danube river as well as the phase of analysis allow the identification of the main elements of a long-term monitoring programme concerning Danube waters.

It is essential to acknowledge the unity of the Danube basin system including the delta and the Black Sea. The fragile delta ecosystem and the deteriorated Black Sea are the end recipients of river contamination.

The dams keep back millions of tons of sediments, which, without them, would add to the enrichment of the delta and to the accumulation in the Black Sea. Today, those sediments are considerably polluted. They constitute real chemical time bombs able to discharge massive pollution in case of chemical modification as a result of anoxic conditions developing, natural scouring or by mechanical dredging during maintenance operations.

● OBJECTIVES OF THE PROGRAMME ●

LONG-TERM GOALS

- Assessing how much in the load of contaminants and nutrients in the Danube waters must be reduced for the rehabilitation of the fluvial, delta and coastal ecosystems. This is the main focus of the eutrophication study and of that of the contamination of organisms.
- Defining the priority lines of actions to follow.
- Evaluating the time necessary for the return to a normal situation.
- Estimating the cost of the priority actions: municipal and industrial processing plants, forests and alluvial floodplains.

- Estimating the financial and ecological losses associated with the lack of action.
- Lines of research will be selected as follows:
  - The evolution of the pollutants contained in the sediments stored in the dams.
  - The kinetics of the solid/liquid exchanges between the pollutants and the sediments, suspended matter downstream form the hot spots.
  - The behavior of the main pollutants and nutrients in the Danube delta in relationship to the main physical and biochemical parameters of the environment.

SHORT-TERM PROGRAMME

The major focus is to set up a realistic monitoring programme in order to follow the evolution of the quality of waters.

The short-term programme can lead to:

- Identification of the hot spots and the non-point source pollution.
- Monitoring of drinking water taken from the river basin.
- Assessing the impact of pollutants on selected organisms, namely fishes, algae, mussels, etc.
- Setting up a system for environmental screening (detection of new pollutants from a limited number of samples).

The success of such a programme is possible if large-scale human and financial means are mobilized in favor of Eastern and Central European laboratories.

The laboratories involved in the programme will work in networks and will be closely associated with the national coordinators of the Environmental Programme for the Danube River Basin.

• MEASUREMENT STRATEGY •

The coherence of the programme is ensured if all the elements from the chain of evaluation of pollution are of appropriate quality. This will cover the following aspects of methodology: sampling, conditioning and treatment of the samples, analytical procedures, data processing and analyses of the results, their publication and diffusion, interests felt by the economic and political authorities.

Nutrients are measured in a dissolving phase. It is to be noted that the analysis of the dissolving phase has been abandoned by many administrations (the US Geological Survey, the Meuse/Rhine Agency, etc.). The procedures undertaken as part of the Bucharest Declaration may need review in the light of this situation.

A major component of the monitoring of the Danube waters and its tributaries should be based upon the chemical analysis of the deposited sediments, suspended matter and aquatic organisms. Quantitative inventories of flora and fauna - meso- and macrobenthos - will contribute to the estimation of the impact of the pollution on the ecosystem.

A. MEASURED PARAMETERS

- Nutrients, dissolved oxygen.
- Pathogenic elements.
- Typical contaminants representative of the industrial, human, national and agricultural activity: heavy metals, petroleum hydrocarbons, pesticides, PCB congeners, organophosphorous compounds, fecal sterols.

B. FREQUENCY OF MEASURES

Examination of the efficiency and feasibility of analyses leads to the following recommendations:

- Every five years: Sediments. Exhaustive inventory.
- Every year: Mosses, fishes.
- Every month: Suspended matter.
- Every week: Nutrients.

C. SAMPLING SITES

Careful placement of the sampling sites is necessary in order to obtain a clear picture of the real situation of Danube pollution.

Simple increase in the number of the sites is not a reliable guarantee. Priority will be given to:

- Urban and industrial hot spots.
- Dams' storage lakes.
- Places where drinking water is drawn, and where liquid wastes are disposed of.
- Delta.

The present study provides one of the most comprehensive data sets on the levels of contamination in sediments and bivalves from the river Danube. It shows the usefulness of sediment and biomonitoring for obtaining a preliminary view of contamination in the river and for providing information which facilitates management decisions on pollution control.

The initial results of this study have revealed the need and feasibility of cleaning up the Danube by paying attention to individual sources contributing to hot spots. In most cases the river is not chronically contaminated in its entirety. This may partly be due to the high flushing rate of the system which is, in turn, a consequence of the enormous discharge of the river and its large seasonal variability. The flow of the lower part of the river is currently unrestricted by dams. It is worrying to note that the most grossly polluted sample measured in this survey was taken from the Iron Gate's reservoir. This sample was a hot spot for almost every measured parameter. Whether his pollution arises from a local source or represents contaminant buildup behind the barrage, remains to be seen through the analysis of additional samples. The important point is that any barrage in the river downstream of identified sources of pollution, will create a potential buildup of contaminants and, in some cases, a future chemical time-bomb. The short-term economic benefit of operating the dam should be weighed carefully against the cost of removing and disposing of toxic dredged sediments when routine maintenance of the reservoir is required.

The data obtained by this study confirm the view that the Danube is not chronically polluted in its entirety. These reflect the discharge of waste and effluents from human activity and may be seriously damaging the riverine environment and the quality of its water as well as that of the associated water table. The results underline the urgent need for a comprehensive Environmental Management Plan for the whole Danube basin which includes the control of identified sources of pollution. The short term actions must be in accordance with the long term goals which are to achieve the sustainable management of the environment. Such a Plan should include detailed studies of the consequences of constructing new barrages on the river, particularly where these are downstream of major identified sources of pollution. Preliminary evidence from the present study shows that contaminants are already building up behind the Iron Gate dam.

The techniques employed in this study can make a useful contribution to future studies of the river. They are not to be considered as a substitute for systematic and regular monitoring of water quality, suspended particulate material and effluents, but they allow for a global vision of the river and the identification of major pollution sources. Followup activities should be planned to elucidate the influence of the Iron Gate dam, study the presence of individual hot spots and examine the impact of pollution on the depositional environment of the Danube delta.

2
RADIOACTIVITY IN AND AROUND THE LOWER RIVER DANUBE

To be comprehensive, pollution assessment of the Danube river must include study of chemical and other non-nuclear anthropogenic contamination and an evaluation of radioactivity in and around the river.

Equipe Cousteau committed to the IAEA-Marine Environmental Laboratory in Monaco the charge to evaluate radioactivity of the Danube region and in particular the assessment of radioactivity along the banks of lower stretch of the Danube from Budapest to the Black Sea and to nine selected areas of special interest in the immediate catchment area of that section of the river.

In order to collate existing data, to assist with the practical aspects of the mission and to involve institutions of riparian countries, IAEA-MEL appointed a team of experienced scientific consultants in Hungary, Bulgaria and Romania. IAEA-MEL controlled this scientific programme,

including supervision of the consultants and the aerial survey component. Dr. Jean-Marie Martin, head of the Marine Biogeochemistry Laboratory of the Ecole Normale Supérieure in Paris, also advised Equipe Cousteau in this area.

2.1
PRESENTATION

As the Danube catchment area contains a range of large nuclear and non-nuclear sites of special interest, the programme was directed toward an objective, comparative assessment of their radiological impacts.

Two specific and complementary reasons triggered realization of this radioactivity programme:

- There is growing scientific interest in, and awareness of the need for comparative assessment of radioactivity released to the environment by nuclear and non-nuclear industries. Activities such as fossil fuel burning, ore smelting, fertilizer and chemical manufacture, and oil drilling are increasingly understood to be associated with significant environmental releases of technologically enhanced levels of naturally occurring radionuclides.
- Modern radioactivity survey and monitoring increasingly require integration of techniques which combine rapid aerial or seabed gamma-spectrometry for semi-quantitative mapping of the geographical distribution of natural and man-made gamma-emitters with detailed radiochemical analyses of specifically collected ground-samples to quantify nuclide mix, contributions by a- or b-emitters and quantitative radionuclide inventories per unit surface area.

The programme objectives are:

- To collate existing information on the extent of any radioactive contamination of the Danube from Budapest to the Black Sea, including some selected industrial environments.
- To provide new radioactivity and radiometric data on the same area by a combination of ground sampling/radiochemistry (to indicate detailed a, b, g nuclide mixes, nuclide inventories, etc.) and of aerial survey (to indicate the geographical extent of any enhancements and to focus ground samplings).
- To combine the above data and hence produce an overview of the radiological condition of the monitored Danube region, including a comparative assessment both of natural versus anthropogenic radiation regimes and of any nuclear versus non-nuclear industrial perturbations of the radiation environment. An estimate of any radiological effects would also be included.
- To evaluate the field of possibilities of the aerial gamma mapping system in case of an important and sudden radioactive contamination.

2.2
ZONES AND SITES

The aerial survey was carried out close to both banks of the Danube for the full river length from Budapest to the Black Sea: i.e. 2,200 km. Mapping surveys were carried out around a selected range of nine industrial and nuclear sites with the objective of comparing radioactivity enhancement around a cross section of nuclear and non-nuclear activities. The exact limits of each study area were defined largely by Equipe Cousteau's team. The helicopter was generally covering a sector of 5 km x 5 km.

The nine selected sites studied were as follows:

Hungary	1	Csepel Island (Budapest): industrial zone
	2	Paks: nuclear site
Romania	3	Turnu Severin: fossil fuel power station and industrial area
	4	Giurgiu: industrial zone
	5	Cernavoda: nuclear site under construction
	6	Braila: industrial zone
	7	Galati: industrial zone
Bulgaria	8	Ruse: industrial zone, fossil fuel power station
	9	Kozloduy: nuclear site.

2.3
AERIAL SURVEY METHODS

Aerial radiometric survey provides an extremely rapid and economical means of locating high deposition areas in the event of an accident involving the release of significant quantities of gamma-ray-emitting radionuclides or in routine assessment of the geographical extent of any enhancement of the gamma-ray flux during routine operations of industrial processes. In essence, the gamma rays which accompany many nuclear transitions can penetrate up to several hundred meters in the air, producing radiation fields which can be mapped with sensitive spectrometry equipment operated from aircraft. The distribution of terrestrial, or superficial marine radionuclides, whether natural or anthropogenic, can be determined by constructing appropriate low-altitude flight paths.

These principles have been applied to mineral exploration and geological mapping for over forty years. Since 1970, the need to resolve the question of the contribution of U, Th and K gamma radiation to geological mapping and particularly for reliable location of uranium resources provided the impetus for further development of spectral analysis system coupled to high volume NaI detector arrays. The same equipment used for geological mapping has been used for environmental purposes. Canada, Sweden, France and the United Kingdom have developed this technique for emergency response and for detection of lost radiation sources.

The basis of the method lies in the character of gamma-ray emission and transport from terrestrially deposited radioactivity to an airborne gamma-ray spectrometer.

The aerial radiometric survey and subsequent mapping were carried out by the Helinuc team from the CEA based at the Centre d'Etudes de Valduc. The detection system was a 16 x 16 x 4 inch NaI detector (about 16 liters) deployed below the Ecureuil AS 350 B2 helicopter, feeding signals to appropriate data recording and processing electronics which also received positional and altitudinal information from ground beacons and a radar altimeter respectively. A TV camera and video recorder are also used to document locational information. The flight line spacing was normally around 100 meters. The spectrum integration time was 3 seconds.

After each section of the survey, the data were validated, corrected for altitude variation and the spectra stripped into nuclide-of-interest windows (total, ^{40}K, U and Th series, ^{137}Cs, ^{60}Co). The "window" data were then processed, with interpolation, into radioactivity maps. If available, the corresponding geographical maps were then superimposed on the final radiation maps.

In most cases, recordings were processed and pre-analyzed the same day. The first maps obtained permitted the team to adjust complementary investigations which were carried out the day after, either by aerial systems or by *in-situ* measures.

The aerial gamma mapping system used in this mission allows the detection of ^{137}Cs, spots having a minimum activity of 5 kBq/m^2 or pinpoints of 10 MBq minimum.

2.4
GROUND SAMPLING AND IN SITU GAMMA-SPECTROMETRY*

Field samples determined by the instantaneous results of the aerial survey were collected by the ground team during the mission and were returned to Monaco for analysis.

IAEA-MEL has analyzed a thematic suite of Danube river sediments collected by the joint Equipe Cousteau and VITUKI team, both upstream and downstream of the sites of special interest and at intermediate locations at accumulating sites along the river.

The ground team carried a high purity Ge detector deployed from a pneumatic pole/pivot system for *in situ* gamma spectrometry. The pneumatic pivot enabled the team to install the detector at different heights and, for each point, to modify the surface seen by the detector.

Analysis of the detected spectrum allows one to get the average value of contamination of the measured surface.

Detection limit is 100 Bq/m^2 for ^{137}Cs. *In situ* measures, samplings and gamma-spectrometry are essential to corroborate measures made from helicopter.

2.5
FIELD-BASED AND RADIOCHEMICAL MEASUREMENTS

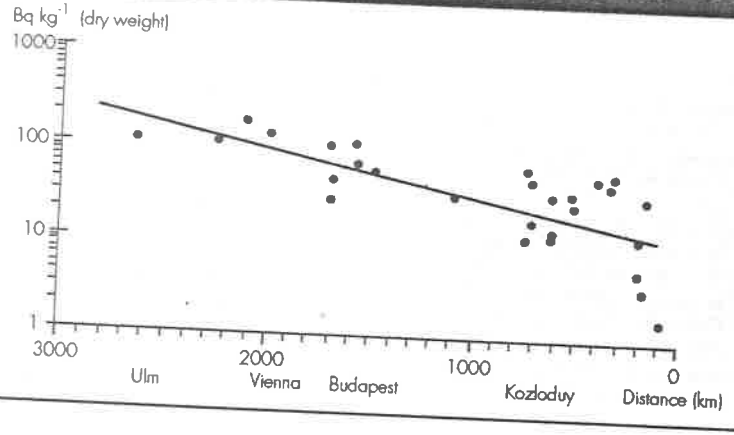
Radionuclide results obtained by radiochemical analysis of the sediment samples collected along the river from the sources to the Black Sea show the dominant artificial radionuclides are the two cesium isotopes ^{137}Cs and ^{134}Cs. The results, plotted on a logarithmic scale *(Figure 4.15)* demonstrate a very strong activity decrease with distance down river, for ^{137}Cs from 150 Bqkg^{-1} in Germany to 5 Bqkg^{-1} in the delta.

The radiocesium in the Danube is largely Chernobyl-derived and the upstream-downstream decreasing trend is caused primarily by the parallel decrease in Chernobyl radioactivity deposition in the Danube catchment area: for example, from about 14 kBq/m^2 in southern Germany to less than 4 kBq/m^2 in the Black Sea.

The analyses indicate that:

- Occasionally there are small activities of other man-made radionuclides, mainly of ^{241}Am and 238, 239, 240Pu. The existence in Danube river sediments of minute amounts of ^{241}Am and 239, 240Pu in addition to a radiocesium elevation in the vicinity of the Paks nuclear site in Hungary, respectively <0,16 Bqkg^{-1} and <1,5 Bqkg^{-1}, may indicate a localized and radiologically negligible effect. Similarly, near Kozloduy, radiocesium (<90 Bqkg^{-1}) and plutonium isotope (<0,1 Bqkg^{-1}) ratios atypical of weapons or Chernobyl fallout, plus traces of ^{60}Co and ^{241}Am, probably reflect a similarly measurable signal from low-level discharges from the nearby nuclear center. This effect has been confirmed later by the aerial survey results.
- The activities of the natural radionuclides greatly exceed those of the man-made nuclides. For example, at Kozloduy, the anthropogenic nuclides ^{60}Co + ^{134}Cs + ^{137}Cs + ^{239}Pu total around 50 Bq kg^{-1}, while the natural radionuclides measured, ^{40}K+U and Th series, total more than ten times that activity.
- The results for catchment soil samples show higher Pu activities to the north, with the highest value at Komarom having a ^{238}Pu/239+240Pu isotopic ratio (around 0.6) atypical of global weapons fallout (around 0.05).
- All these results are consistent with the view that concentrations of radioactivity in the river Danube are low relative to those in other rivers. For example, we can compare the IAEA-MEL data for ^{137}Cs in Danube sediments (< 200 Bqkg^{-1}) with the much higher values of ≤ 10^3 for the Rhone river in France and ≤ 10^4 Bqkg^{-1} for the Esk river in UK.
- The Danube waters contain artificial radioactivity at an extremely low concentration, dominated by the trace residues of Chernobyl fallout. This relative radiological "cleanliness" of the Danube may of course partly reflect the paucity of large industrial source-terms but must also be a function of the relatively large volume flux of the river, permitting rapid flushing and dilution of any pollutant input.

Figure 4.15 - CS-137 in Danube sediments



2.6
AERIAL SURVEY MEASUREMENTS

For each of the sites for which the Helinuc team has provided data, maps have been made of total counts, ^{40}K (a natural radioactive nuclide) and ^{137}Cs and ^{60}Co (anthropogenic radioactive nuclides), thus summarizing the radiation environments. A map is also produced of a ratio of ^{137}Cs counts to a reference baseline within each spectrum which corrects, in an empirical manner, for instrumental noise and spectral interference. The maps have been standardized to a reference altitude, typically of 40 m; geographical rectification has been achieved through a number of beacons, reference locations being indicated in the coordinate system on each map.

The survey data are interpolated in a number of directions to provide a complete grid of values over the survey area before mapping. In this form, the data may be explored and interesting features highlighted and further investigated. The contour levels for each map are automatically selected, typically in 8 categories which are appropriately color coded.

Table 4.5 provides a general summary of the radiometric data for the study sites. Hence the observed average external dose rates range from 4 to 179 nGy.h^{-1} varying by a factor of 40. However most of the low extreme values correspond to doses above, or contributed to by, the Danube river water itself and the purely terrestrial gamma fluxes thus show less variation, from 17 to 179 nGy.h^{-1} by a factor of ten. The variation must relate primarily to changes in U and Th series naturally occurring radioactivity, although, as can also be seen in *Table 4.5*, the ^{137}Cs activity also varies considerably. The only nuclide which remains relatively constant over land is seen to be ^{40}K.

On the basis of total gamma flux or gamma dose rate, the sites divide themselves into low and high gamma flux categories, comprising Paks, Giurgiu, Cernavoda and Braila as the low sites: < 60nGy.h^{-1}, i.e. < 70 mSv.y^{-1} and Csepel Island, Ruse, Galati and Turnu Severin as relatively high flux sites >70 mSv.y^{-1}. Note that, in the recently published CEC Radiation Atlas, the quoted gamma dose rates range from 30 to 80 nGy.h^{-1}, with a mean of about 50 nGy.h^{-1}. Assuming a mean outdoor occupancy of 20% and a 0.7 conversion coefficient from Gy to Sv, we thus have a European mean of 60 mSv.y^{-1} effective dose equivalent, varying by a factor of 4. These outdoor gamma dose rates are very small relative to the European average range for total radiation exposure from 2 to more than 7 mSv.y^{-1}.

The level of contamination by artificial radioelements ^{134}Cs and ^{137}Cs in the Eastern European basin of the Danube is comparable though slightly higher, than that measured in France. Irradiation values measured in the field show without any possible doubt that cesium contamination comes from the Chernobyl accident *(Figure. 4.16)*.

It is in Romania and in the Hungarian Danube plain that cesium activity is the lowest, the western side of the southern Carpathians presenting by far the highest activities.

Flight over industrial sites of Giurgiu and Turnu Severin, of the future nuclear power plant of Cernavoda in Romania and of Csepel Island

Table 4.5 - Summary of the radiometric data for the study sites (nGy. h^{-1})

COUNTRY	SITE	AVERAGE EXTERNAL DOSE	CESIUM	POTASSIUM	ALTITUDE (M)
HUNGARY	Csepel Island	76	2.49	1.4	40
	Paks	57	3	1.7	40
ROMANIA	Turnu Severin	111	4.98	2.15	80
	Giurgiu	66	2.06	1.46	40
	Cernavoda	58	2.06	1.46	40
	Braila	55	2.33	1.54	40
	Galati	72	2.23	1.63	70
BULGARIA	Ruse	93	2.58	1.55	40
	Kozloduy - East	54	2.15	1.38	40
	Kozloduy - South	69	2.88	1.46	70
	Kozloduy - North	179	13.41	2.15	40

The variation must relate to changes in U and Th. Outdoor gamma dose rates are small relative to the European average

near Budapest, Hungary, did not permit recording contamination other than that from ^{137}Cs and ^{134}Cs Chernobyl type.

PAKS NUCLEAR POWER PLANT

The ^{137}Cs distribution is spatially homogeneous and uniformly low with the exception of two regions on the eastern bank *(Figure 4.17)*. Given the presence of enhanced radiocesium plus traces of ^{241}Am and ^{239}Pu these features may have resulted from deposition on land, from flooding of the river, of locally released radionuclides.

INDUSTRIAL ZONE OF RUSE

Irradiation was measured for the industrial zone of Ruse *(Figure 4.18)*. Investigation of two small features close to the Danube river, revealed that they result from uranium series activity.

The area of enhanced ^{214}Bi is around 500 m diameter. This active area corresponds to a thermal power plant which uses fossil fuels. These commonly contain significant levels of radionuclides such as ^{238}U and ^{226}Ra, thereby producing radioactive products such as flyash.

In terms of the external gamma dose to inhabitants of the site, the dose rate is around 90 nGy.h^{-1}, which is well above the European average. Further study on the site is needed.

GALATI SOURCE IN ROMANIA

Flight over the iron and steel complex of Galati did not give information on any contamination. Coming from the flight over the delta, the helicopter flew over a shipyard where gammagraphy was under process (certainly for weldings'control).

Figure 4.19 gives an idea of the detected source intensity. After on-site inquiry, this very powerful source (10 curies) was revealed to be ^{192}Iridium. The signal intensity measured at an altitude of 100 m gives an idea of the poor precautions taken during utilization of this source.

CETATE HOT-SPOT IN ROMANIA

During the flight over the left bank of the Danube between Turnu Severin and Calafat in Romania, the detector recorded a ^{137}Cs activity on several spectrums *(Figure 4.20)*. This irregularity was not immediately signaled: only the systematic data processing allowed its detection. This activity may correspond either to a surface contamination in the 100 kBq/m^2 range, or to a point source which, in the case of a vertical flight could reach 1,200 MBq. No industrial activity appears on the video recording.

Romanian authorities have been informed by IAEA and Equipe Cousteau of that abnormality which could prove dangerous to the environment.

KOZLODUY NUCLEAR POWER PLANT

The map of total gamma flux shows two localized areas of very high activity, up to 180 nGy.h^{-1} *(Figure 4.21)*. The high count rates were observed during the flight. The presence of the Danube and of Kozloduy Island is clearly visible to the northwest. The numbers 1 to 4 on the map show the locations of sampling and *in situ* measurements by the ground team.

Contamination by ^{137}Cs and ^{60}Co occurs in the vicinity of sections of drainage channels which flow through the field system between the nuclear plant and the Danube *(Figure 4.22* and *4.23)*. The contamination is mainly localized above and along the edges of these drainage streams because the most active material is contaminated channel sediments, now overgrown with grass and weeds, is non-homogeneous and lumpy with an apparent depth of up to 60 cm and a mean depth of perhaps 15 cm. The contamination appears to originate at a small sewage works whose effluents were originally discharged to the field drainage system. The sewage works is now closed down. There are two areas of major contamination lying along parallel drainage channels, one of them being nearer to the nuclear site and unfortunately at the extreme edge of the permitted survey area. Channel 1, containing sites 1 and 2, links with channel 2, sites 3 and 4, via an artificial concrete aqueduct which appeared to be completely dry. As seen in the figures, the areas of contamination are limited in size, reflecting the very high adsorptive capacity of the sediments for both Cs and Co. Both drainage channels are extremely slow flowing, even stagnant, but they ultimately drain into the Danube. That the main river banks are radiologically rather clean and that the drainage channel contamination is so clearly highly localized suggest that scavenging and retention of radionuclides have been extremely efficient and that there has not been a major activity influx to the open Danube environment.

The main contaminated areas are around 10 m in width and extend for up to 3 km along channel 1 and for around 600 m along channel 2. The channel 2 material also contains $^{239+240}$Pu at trace concentrations atypical for the region (13.4 Bqkg^{-1}). Small amounts of ^{54}Mn, ^{65}Zn and ^{241}Am are also recorded. Again, the different nuclides and activities observed at the two channel sites suggest that different contamination events have affected each.

In taking account of all parameters, it is possible to estimate contamination for the entire zone: 1,4 Ci for ^{137}Cs and 0,64 Ci for ^{60}Co. The evidence is that the Bulgarian authorities have known about this contamination for a considerable number of years. Nuclear power plant authorities have monitored it. The public and IAEA were never informed before 1990 of this non-negligible contamination.

The Kozloduy north site has been contaminated by liquid waste leakage into the sewage and drainage systems. Much of the contamination has been dredged from the drainage streams and is now overgrown with grass. There is no evident radiological consequence of any significance. However, to prevent any access by animals or personnel, consideration could be given to erecting internal fences and warnings around the whole contaminated zone. Nevertheless, the contamination is already well localized within the restricted area. The main concern arising from the study is that radioactive waste leakage is apparently continuing at a low rate but occasionally such as to give rise to excessive activities in sewage shaft waters. The problem of liquid waste

leakage from auxiliary building No. 1 requires further urgent investigation to eliminate the leakage.

The aerial survey of both banks of the Danube has clearly demonstrated the potential for conducting an assessment of levels of radioactivity, both natural and anthropogenic, over a 2,200 km stretch. The results from the survey have demonstrated the presence of ^{137}Cs along virtually the whole stretch but at low uniform levels. At a small number of distinct locations increased ^{137}Cs activities, ranging from 5 kBq/m2 to 50 kBq/m^2, are observed — a factor of 1-10 variation. Indications are that the most likely source of ^{137}Cs is the Chernobyl accident, as also indicated by the laboratory analyses. The natural radionuclides may also be identified, particularly ^{214}Bi, at a number of locations, probably reflecting the underlying geology and sedimentary mineralogy along the shoreline. Left and right banks show some small differences in distribution of both natural and anthropogenic radionuclides.

Delimitation of zones contaminated by former discharge, but which seems to continue, at the nuclear power plant of Kozloduy allows appropriate measures to be taken to prevent any transfer through the food chain.

The results obtained concerning ^{214}Bi at Ruse, a point source of ^{192}Ir gammography in Galati and a contaminated zone in the surrounds of Cetate demonstrate that airborne gamma cartography is a fast, sensitive, powerful, and well adapted means to control radioactivity in the environment.

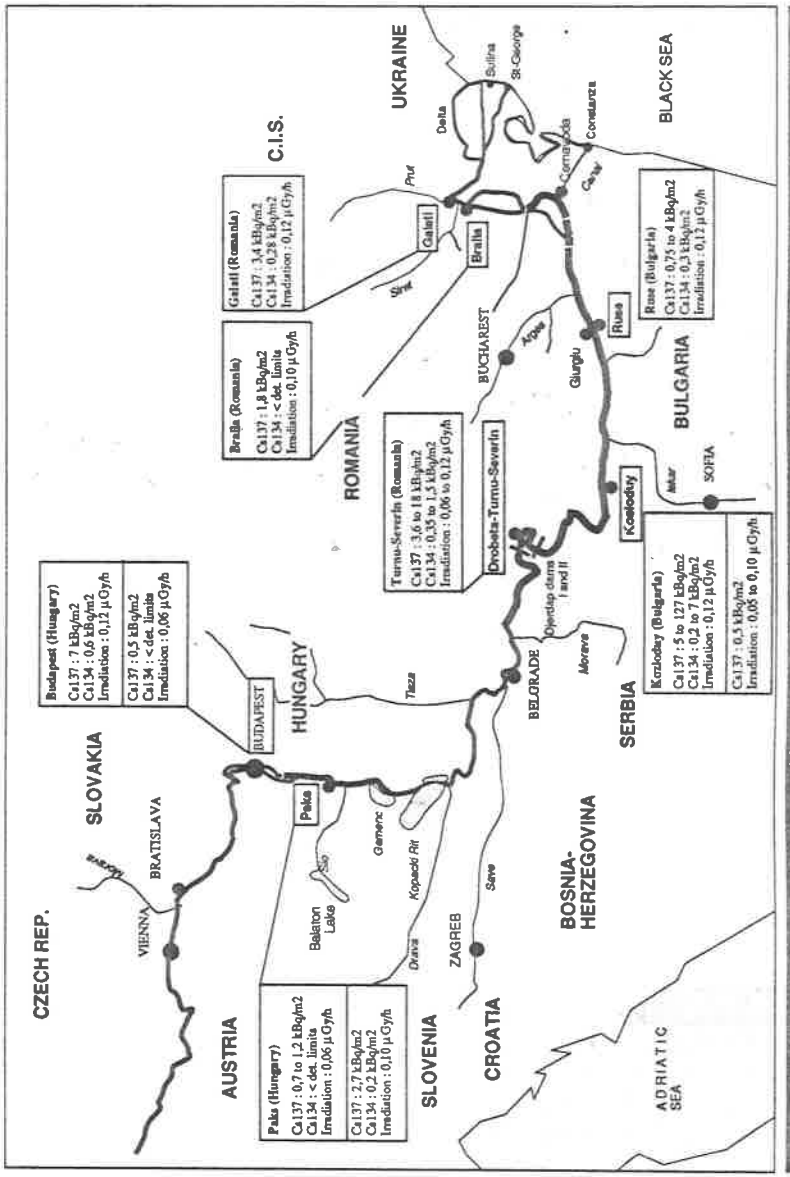
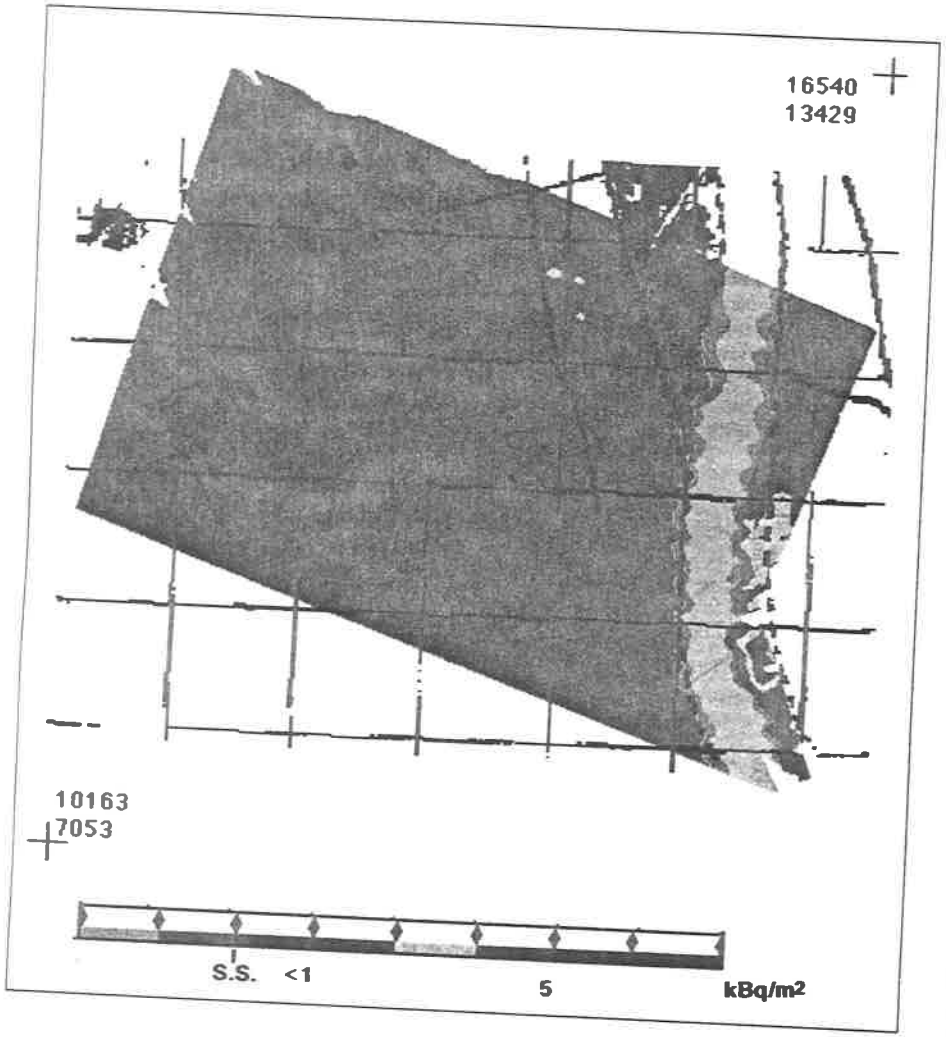


Figure 4.16 - Field measurement of irradiation values along the Danube.

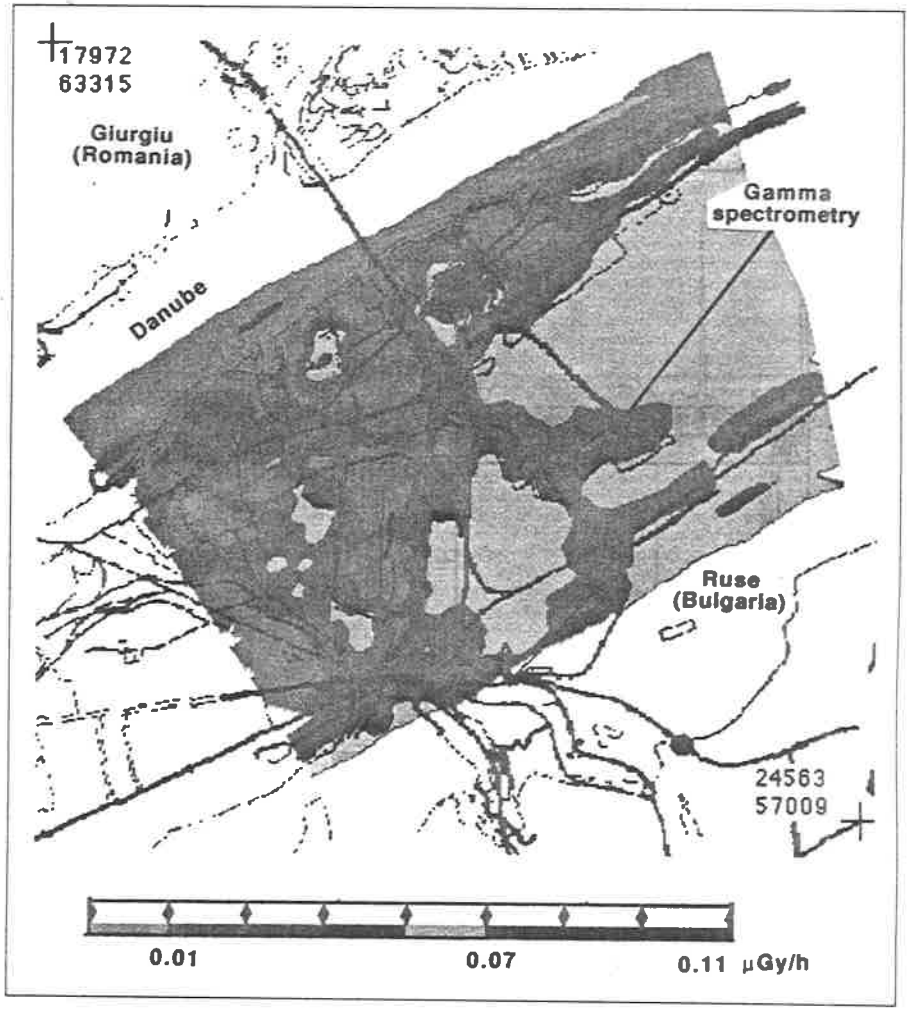
Cesium contamination comes from Chernobyl accident April 26, 1986.

Figure 4.17 - Cesium-137 distribution south of Paks nuclear plant (Hungary).



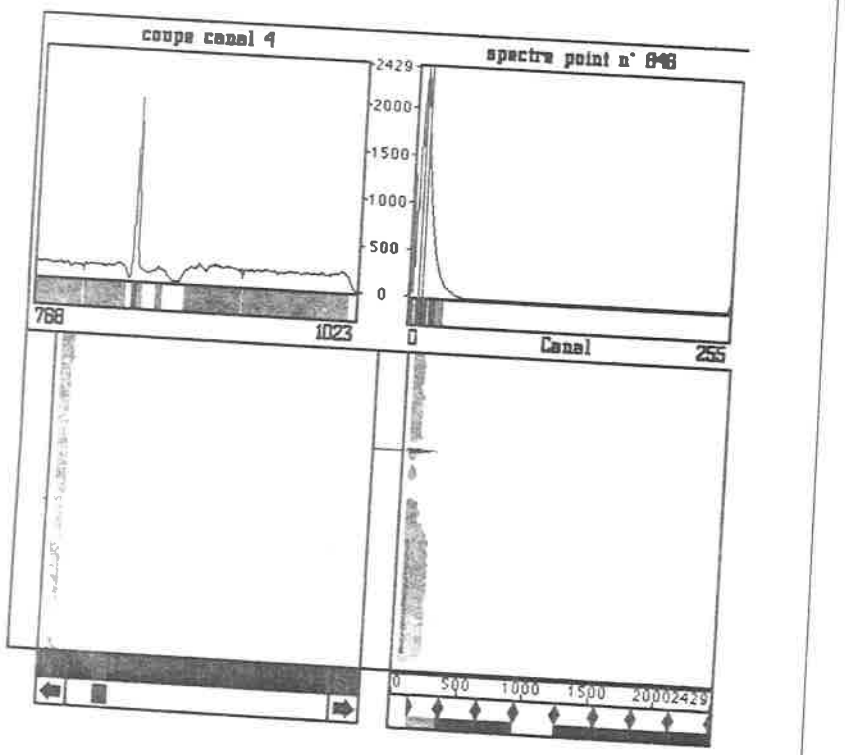
Two regions on the Eastern bank of the Danube present ^{137}Cs low contamination. Traces of ^{241}Am and ^{239}Pu have been found in the sediments.

Figure 4.18 - Irradiation measured in Ruse (Bulgaria).



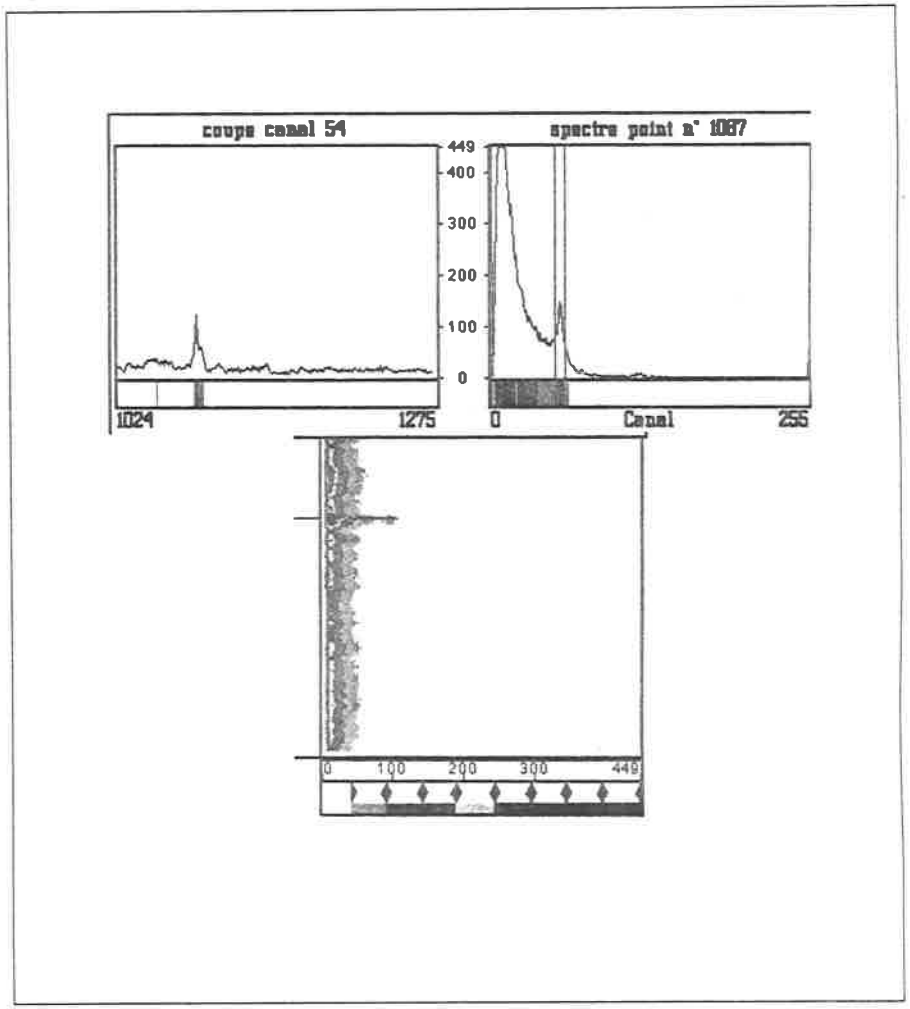
Two zones are contaminated by bismuth-214, uranium-238 and radium-226. These active areas correspond to the thermal power plants which use fossil fuels.

Figure 4.19 - Transect data showing the point source at the naval dockyard in Galati (Romania).



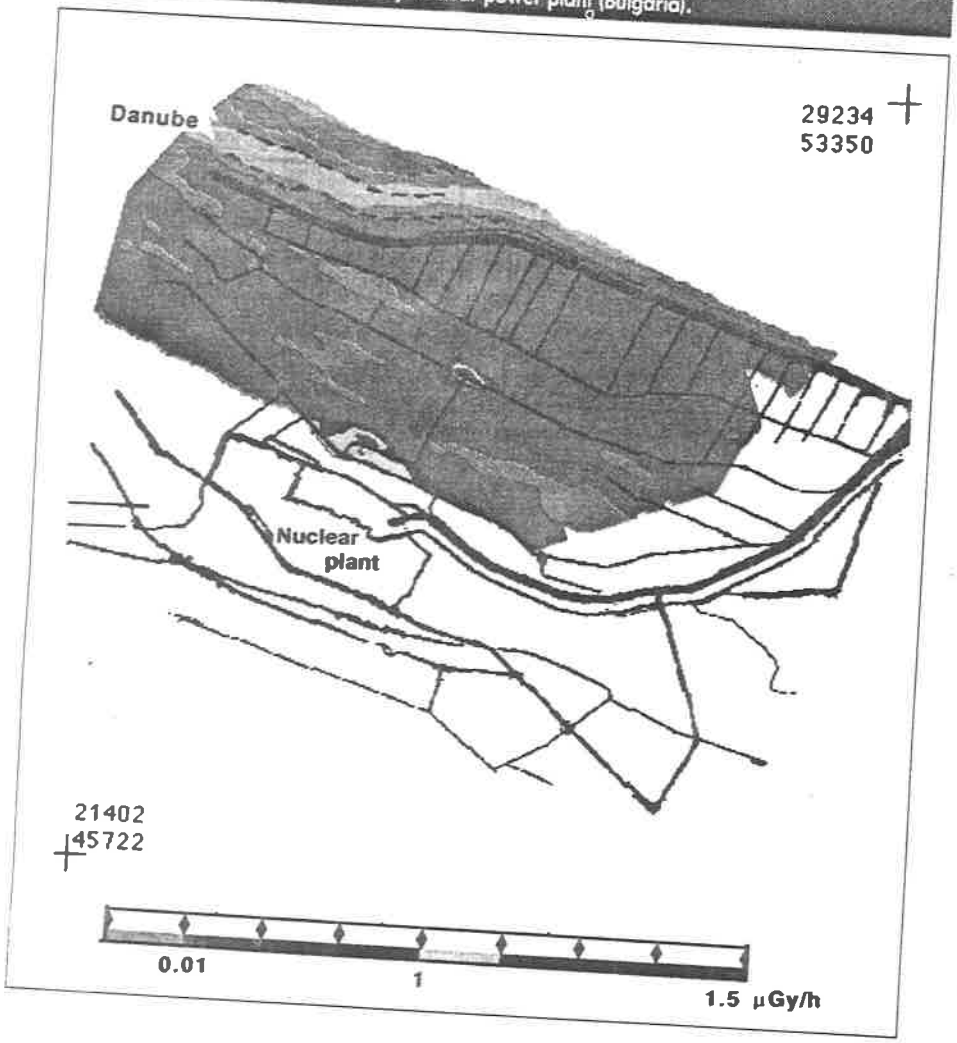
The powerful source, 10 curies, revealed to be iridium-192. The high signal intensity measured at an altitude of 100 m gives an idea of the poor precautions taken during utilisation of this source.

Figure 4.20 - Transect data showing cesium-137 activity on several spectrums near Cetate in Romania.



Field investigations are necessary to identify this abnormality located far from any industrial activity.

Figure 4.21 - Total gamma flux measured around Kozloduy nuclear power plant (Bulgaria).



Two localized areas are contaminated. Irradiation is very high: up to 180 nGy.h^{-1}

Figure 4.22 - Cesium-137 distribution around Kozloduy nuclear power plant (Bulgaria)

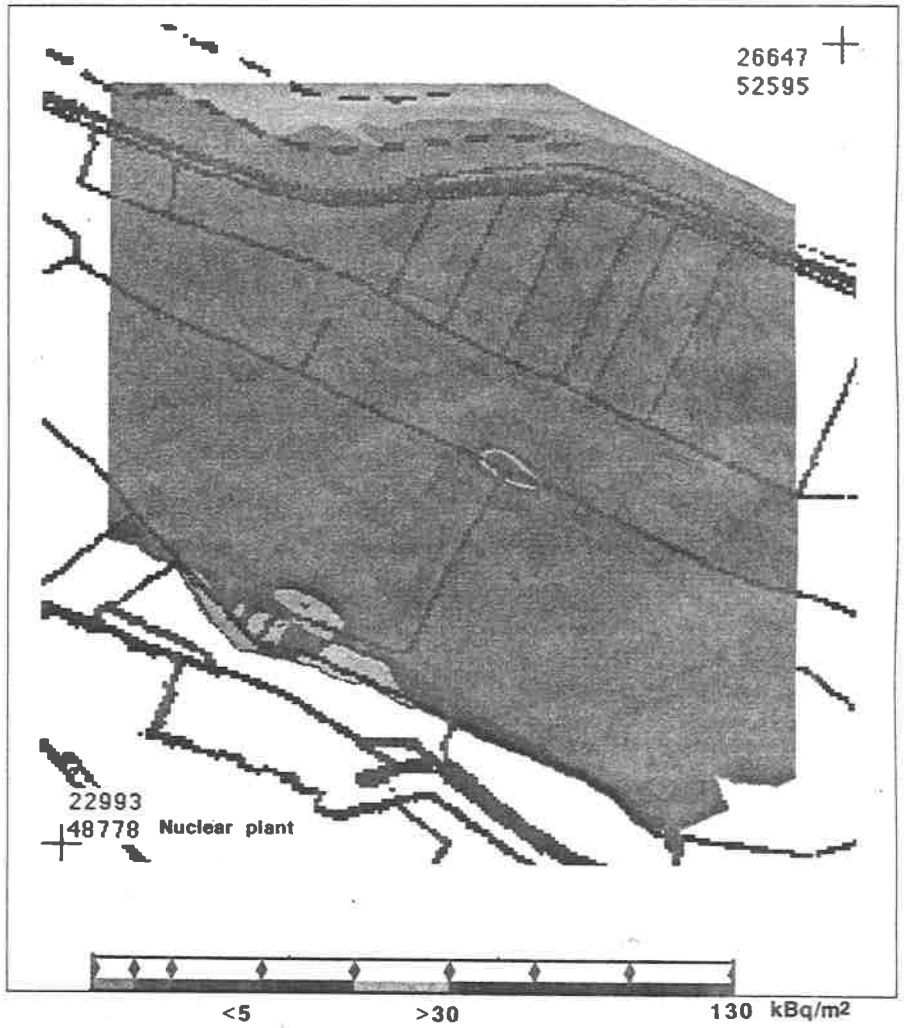
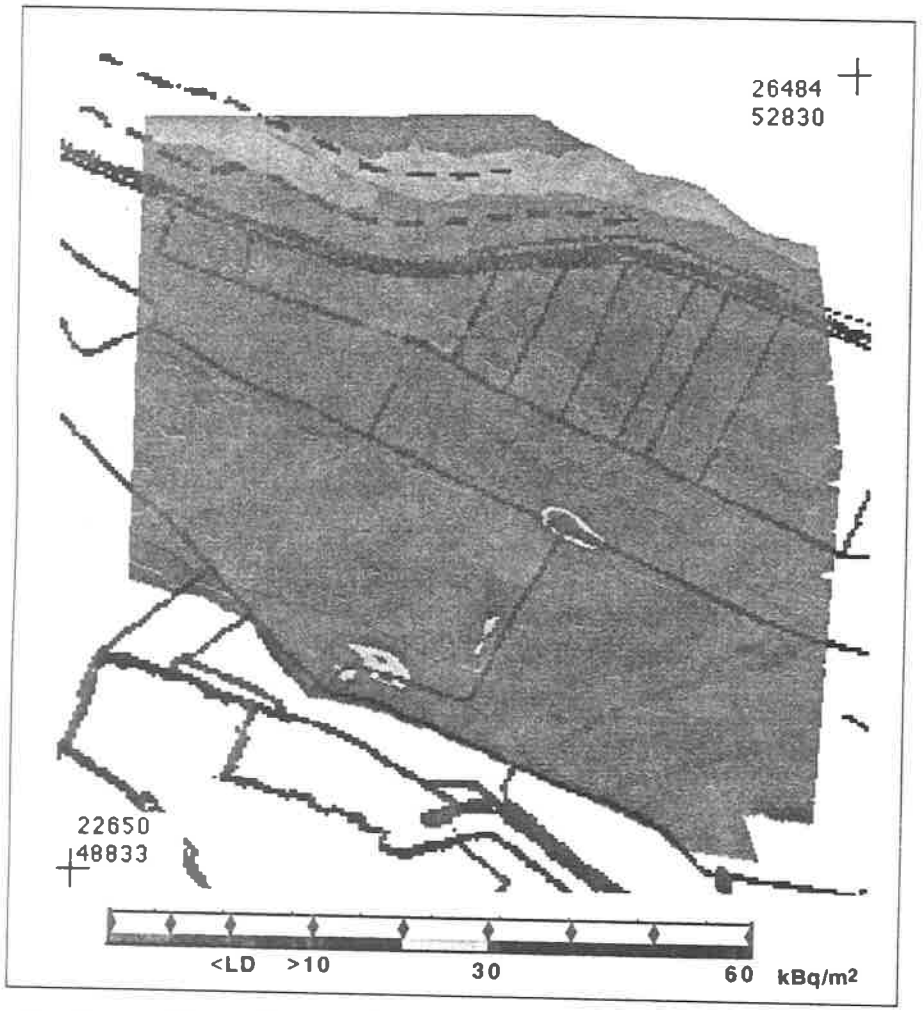


Figure 4.23 - Cobalt-60 distribution around Kozloduy nuclear power plant (Bulgaria).



Contamination by ^{137}Cs and ^{60}Co is mainly localized along the edges of drainage and sewage channels. Trace concentration of $^{239+240}Pu$, ^{54}Mn, ^{65}Zn and ^{241}Am are recorded in the channels sediments.

TOOLS FOR SUSTAINABLE ENVIRONMENTAL MANAGEMENT

3
OVERALL EVALUATION OF POLLUTION AND HIGH-RISK ZONES

The aim of this study is to achieve an overall evaluation synthesizing the state of pollution for the whole of the catchment area and to define high-risk zones requiring priority action. The system developed to carry out this evaluation has been designed in a way allowing its evolution. It makes up what could become in a long-term view a decision-making support tool for environment and water management.

This work should be able to guide programmes of environmental action currently being developed in the Danube basin.

It was carried out by a multidisciplinary team including hydrologists, environmental scientists, geographers and data-processing experts (CRITT-Verseau, GIP Reclus; ALITEC). We greatly appreciated the help of Pr. Marjanovic and his team of the University of Novi Sad. Unfortunately, the war prevented a closer cooperation.

3.1
METHOD

The aims of this study and the conditions imposed upon its execution, i.e. an immense geographical surface area corresponding to countries access to which is difficult, and a short time-span for completion, led us to develop an original method aimed at evaluating pollution in the Danube catchment area.

An "upstream" approach enables the levels of pollutants to be quantified on the basis of socio-economic data concerning the activities generating them: industry, domestic pollution, agriculture. A group of coefficients enables these discharge hypotheses to be translated into pollution types and quantities.

For this work four determinants are considered:

- Organic matter (OM) = (COD + 2 BOD_5)/3
  COD = Chemical Oxygen Demand
  BOD_5 = Biological Oxygen Demand over 5 days
- Suspended Solids (SS)
- Nitrogenous matter (NM)
- Phosphorous matter (PM)

Other pollutants, such as inhibiting substances for example, may also be quantified in a subsequent phase by implementing suitable coefficients.

Pollution was evaluated in 66 geographical sub-areas covering the whole of the Danube catchment area and constituting the spatial unit for the purpose of our analysis *(Figure 4.24)*. These are class 3 sub-basins except for certain larger sub-basins (such as for example the Tisza sub-basin) which have been sub-divided.

This approach enables problems and deadends associated with access difficulties and with the lack of reliability of statistical data concerning water quality, with comparison difficulties created by non-homogeneity of methods implemented by various countries and with difficulties experienced in linking measured pollution with its source to be avoided.

It also enables models to be built concerning the evolution of human activities (modification of agricultural practices, installation of purification stations for towns, modification in structure of the industrial production apparatus or processes used, etc.) and their consequences for pollution to be easily evaluated.

This study is limited to water pollution, but it is possible to evaluate air pollution or soil pollution using the same data pool by implementing different coefficients.

Conversely, the results obtained do not describe the actual status of water quality, but express the pollution intensity generated by human activities and the risks of environmental deterioration.

The main interest of these results is that they make possible hierarchization of impacts of diverse human activities and that they help in defining priorities. The deviation between the measured reality and our evaluation may be reduced by refining the coefficients implemented, by incorporating calculation moduli enabling pollution transfer, fixation and self-purification mechanisms to be taken into account by "grafting" the evaluated data onto known measured data.

Implementation of this method requires the superimposition of different types of information concerning the same area of space. We have therefore used a Geographic Information System enabling computer processing of these information types to be carried out and cartographic representations of them to be produced. The system is endowed with sufficient interactivity and cooperative capacity: Macintosh hardware; MapGrafix (GIS) software connected to the 4D database software.

In the results presented below, classification of sub-basins based on the degree of pollution pressure exerted by each of the activities (agriculture, industry, domestic pollution) or all activities combined was reached by means of ranking: the classification of a sub-basin is the product of its classification for each pollutant quantity generated by one of the activities or all activities combined.

The quality of results is closely linked with that of the data which have enabled them to be obtained. It was impossible to construct a data pool which was homogeneous in time; the oldest data date from 1985 and the most recent from 1991. Given the speed of the changes which have occurred in these countries (production has plummeted by around 30% in the last three years), it is clear that these data do not in all cases still reflect the present situation. It is moreover very difficult to evaluate the quality and reliability of data acquired from countries where statistics sometimes had to bend with the political wind...

The level of uncertainty concerning the presented results is not the same for all the activities. Domestic pollution has certainly not undergone major changes. The trend leans rather toward a regular increase in town populations. Where agriculture is concerned, it is difficult to estimate what the consequences of land privatization (which often results in land units being split up) may be for agricultural practices. Nevertheless, there is usually quite significant inertia in the evolution of these practices and we therefore think that the situation described is probably only slightly different from that which currently prevails. It is particularly in the industrial sector that uncertainties are the greatest. Profound and fast-moving transformations are currently underway in this sector of activity and will continue.

Consequently, we are anxious to point out that the results described here must be used with care. The values described or represented in cartographic form must be considered as orders of magnitude. They are excess values, since self-purification phenomena have not been taken into account. Nevertheless, inasmuch as the basic components of the results are based on relative and not absolute values (classification of the most threatened sub-basins, respective importance of the various activities within a sub-basin), we think that they remain representative.

3.2
SENSITIVE ZONES

Certain zones considered as "sensitive" were mapped:

- The karst zones in which direct infiltrations are likely to contaminate the karstic aquifer. Their total area is 2,552,615 hectares, i.e. 3% of the Danube basin surface area.
- The wet zones in which the ecological equilibrium is fragile and where the largest groundwater tables are for the most part located: 13,949,651 ha, i.e. a total of 17.5% of the basin area.
- The natural zones protected for their interest from the landscape, fauna or flora point of view: 1,311,874 ha, i.e. 1.7% of the basin area. The delta areas recently designated as a Biosphere Reserve have not been taken into account in this calculation.

They are for the most part located in the plains, involving four main regions: the northwest centered around Bratislava the plain of the Tisza, the former Yugoslavia and, in particular, the Vojvodine, and the delta and the region upstream of it (Braila).

The sensitive zones total more than 22% of the whole Danube basin area.

3.3
DISTRIBUTION AND IMPACT OF HUMAN ACTIVITIES

• POPULATION AND DOMESTIC POLLUTION •

Most of the capitals and large towns are on the river. The population density (diffuse population) is quite high, particularly on the upstream sections of the tributaries in the northern part of the basin.

Given the very low number of purification plants in these regions except in Austria, calculation of pollution generated by the population does not take them into account.

Very logically, it can be seen that among the sub-basins worst affected by domestic pollution are those in which large towns are located. A town such as Budapest discharges 315,600 m^3 of waste daily, i.e. 189 tons of suspended matter, 120 tons of oxidizable matter, 32 tons of nitrogen, 8 tons of phosphorus.

Domestic pollution is the major source of phosphorous matter for the whole basin, 60% to 80% for the Budapest, Vienna and Belgrade sub-basins, and is a significant source of suspended solids and nitrogenous matter in the sub-basins in which it is high, amounting to between 40% and 50% of the nitrogen total for Budapest or Vienna *(See Table 4.6)*.

The Nis, Arad and Bacau sub-basins are also included among the most threatened. Here, the pressure is not exerted by a large town but by several medium-sized towns and by diffuse population which represents around 1/3 of inputs.

Table 4.6
The sub-basins most affected by domestic pollution

BUDAPEST
BUCHAREST
VIENNA
BELGRADE
NIS
ZAGREB
ARAD
SOFIA
BACAU

• IMPACTS OF INDUSTRY •

No data concerning industry in former Yugoslavia has been obtainable and it has not been taken into consideration in this chapter.

Industrial activities are concentrated in the large towns and centers of varying size located on the river or its main tributaries. Budapest and Bucharest are the two largest centers. Romania is by far the most industrialized country of the basin. Bulgaria also has a certain number of large centers scattered throughout its territory.

Among the sub-basins most affected by industry, only that of Budapest is not Romanian or Bulgarian *(See Table 4.7)*.

Table 4.7
The sub-basins most affected by industrial pollution and the main types of activity responsible

BUCHAREST	Chemicals, machine making
BACAU	Chemicals, ferrous metallurgy
IASI	Chemicals
CLUJ	Nonferrous metallurgy, chemicals
TOLBUHIN	Machine making, textiles
ARAD	Chemicals, ferrous metallurgy
VRACA	Machine making, building
BUDAPEST	Machine making, textiles
PLOESTI	Chemicals, energy

Industrial activity throughout the basin is the major source of organic and suspended matter, 97% of OM, 87% of SS for Bucharest. It also plays a large part in the output of nitrogenous and phosphorous matter in the areas where it is intensely carried out, 40% of the nitrogen, 68% of phosphorus for Bacau.

• IMPACTS OF AGRICULTURE •

The zones in which agriculture is dominant occupy the great plains with an intensity which decreases from west to east. The most intensive agricultural use is in Slovakia, Hungary and Vojvodine, while it is over all less intensive in Romania. The Bulgarian Danube plain and the delta region nevertheless remain intensively used. In many cases, these zones overlap with the wet zones classed as sensitive *(See Table 4.8)*.

Agriculture is above all a source of nitrogen and, to a lesser extent, of phosphorus. The quantities of nitrogen output by agriculture are greater than the output by industry, even in the sub-basins where a mixture of activities dominates (Cluj: 60% agricultural nitrogen, 24% industrial; Arad: 64% for agriculture, 22% for industry).

3.4
THE SUB-BASINS MOST UNDER THREAT

• TOTAL POLLUTANT CHARGES •

The sub-basins selected are those which display the largest burden of pollution, for most of the 4 determinants considered *(See Table 4.9)*.

Bucharest is at the top of the list. It cumulates household and industrial pollution, the latter being mainly from the chemicals industry. The nitrogen and phosphorus burdens evaluated are by far greater than those of the other sub-basins.

Two sub-basins, Bacau and Arad, undergo significant pressure from all three of the human activity types.

Finally, sub-basins such as Oradea and Budapest are mainly subjected only to one type of pollution (agricultural and household respectively), though in a very intense manner.

The impacts of pollutants and their remedies differ depending on their origin. Industrial or household waste is localized, generally located in the river network, and leads to the risk of eutrophication. Agricultural pollution also contributes to eutrophication by leaching but, as it is by definition diffuse, may reach groundwater tables and represent a potential risk for human consumption. It has a slower kinetics, is less visible and thus is difficult to identify and monitor.

Remedies in the first of these instances (industrial and urban waste water) will use de-polluting tech-

Table 4.8
The sub-basins most affected by agricultural pollution

ORADEA
SZEGED
ARAD
IASI
BACAU
TOLBUHIN
SEKESFEHERVAR
CLUJ

Table 4.9
The sub-basins most under threat and the respective importance of the three types of human activity as a source of nitrogenous and phophorous matter

	NITROGENOUS MATTER				PHOSPHOROUS MATTER			
	TOTAL kg/day	% IND.	% AGR.	% POP	TOTAL kg/day	% IND.	% AGR.	% POP
BUCHAREST	300,520	63%	23%	14%	50,686	76%	4%	20%
BACAU	192,719	40%	48%	12%	23,022	68%	12%	20%
IASI	177,832	34%	53%	13%	19,701	62%	15%	23%
CLUJ	134,808	24%	60%	17%	13,682	48%	18%	34%
ARAD	200,100	22%	64%	14%	19,268	46%	21%	32%
BUDAPEST	95,489	33%	24%	43%	17,987	36%	4%	59%
TOLBUHIN	99,850	4%	87%	8%	*	*	*	*
ORADEA	212,189	9%	81%	10%	13,595	29%	41%	30%

The above data have to be considered only as an order of magnitude which enables comparison between sub-basins.

Identifying which human activity generates the most pollutants guides the choice of remedies which have to be implemented in priority.

nology or restructuring of the industrial production apparatus while, in the second, agricultural practices will have to be changed.

• POTENTIAL CONCENTRATION INDEX •

If one wishes to specify the impact on the environment of output burdens of pollution, dilution phenomena will have to be taken into account. The total burden of each pollutant for a sub-basin expressed as a mean output at its outflow gives a theoretical approach to expressing its concentration. It must be noted that the flow of the Danube is not taken into account when the river crosses a sub-basin. Calculations must be made carefully because these potential concentrations do not take the infiltrated proportion of diffuse pollution, the proportion of fixed pollution and the proportion degraded by self-purification mechanisms into account. This is why one must speak of a *potential concentration index* without allocating a unit. The values obtained should be compared with the values measured in water analyses.

These calculations and the corresponding cartographic representations nevertheless have the advantage of providing for another interpretation and improved possibility of comparisons taking dilution phenomena into account. Classification of the sub-basins most under threat as calculated from these concentrations is quite different from the preceding one *(See Table 4.10)*.

This classification highlights the low outflow sub-basins, particularly Brno in Slovakia, the basins of the central plains (Budapest, Novi Sad and Pancevo) and the Eastern basins surrounding the delta (Braila, Tolbuhin, Tulcea). The pollution sources in the Bucharest sub-basin are such that

Table 4.10
The sub-basins with the highest potential concentration indices (for all parameters)

BRAILA
BRNO
BUCHAREST
NOVI SAD
PANCEVO
TOLBUHIN
TULCEA

the dilution effect (70 m^3/s) is not sufficient for this sub-basin to fail to appear in the class above!

One must underline the fact that the delta, both the pearl and the dustbin of the Danube, is surrounded by sub-basins in which the potential pollution concentration indices, particularly for nitrogen and phosphorus, are the highest of the whole basin.

3.5
HIGH-RISK ZONES

The high-risk zones introduced here were obtained by redivision of the sensitive zones and spatial distribution of the concentration indices in each sub-basin. The risks mapped are mainly eutrophication and pollution by nitrogenous or phosphorous matter because only these two elements have been taken into account. The risks of attack against water resources (groundwater tables or karstic aquifers) are also represented to the extent that the main aquifers are located in the wet zones classed as sensitive zones.

Lack of information concerning certain types of activity (fishing, leisure, irrigation) has made it impossible to incorporate these parameters into the sensitive zones at this point. This economic dimension ought to be incorporated at a later stage.

Examination of the map shows that the most endangered sectors are the low plains of the Tisza and Vojvodine, and the downstream section of the Danube. Some karstic aquifers are in areas with high nitrogen pollution. They are nevertheless located upstream from the sub-basins and ought to be relatively sheltered from too much effect. About 25% of the wet zones and about 10% of the natural reserves are located in areas with heavy potential nitrogen discharge.

A reading of *Figure 4.35* also shows the improvements which ought to be made to our approach. The map is the picture of the static situation and does not take transfer phenomena from an upstream area to a downstream one into account. Thus the area downstream from Budapest does not seem affected! The classification difference between the two banks of the Tisza in its downstream section also presents a problem which might be solved by taking a fluvial "corridor" into account in the GIS.

The execution of this work came up against extreme difficulty in gathering usable (homogeneous and reliable) data throughout the basin. Any development of GIS systems, at any scale, ought to involve solving this particular problem.

This problem has been largely remarked upon by all the participants to the workshop organized by Equipe Cousteau and the Technical University of Budapest concerning the role of the GIS in environmental and water management.

The aims of this work have been to a great extent achieved. We now have a synthetic picture of the whole Danube basin where pressures exerted by human activities and burdens of pollutant generated by them are concerned.

Conclusions may be drawn from this concerning overall pollution of the Danube catchment area:

- *Romania contains most of the sub-basins most affected by pollution. The delta is seriously under threat, though it is one of the most sensitive and richest zones on the Danube and in Eastern Europe generally and principally by all the sub-basins immediately upstream. Vigorous actions must be carried out there as a matter of priority.*
- *Certain basins centered around Bratislava display high burdens and concentrations, particularly of nitrogen and phosphorus. The filling of the Gabcikovo dam reservoir located downstream increases the risk of eutrophication and its potential consequences.*
- *The central plains of the basin in which most of the wet zones are located are also subject to significant pollution pressures.*

One can also point out priorities in terms of sectors of activity:

- *Domestic pollution is preponderant in the sub-basins of the large towns (Vienna and Budapest in particular). Installation of purification plants and repairing of sewage collector networks when necessary would considerably improve the situation in these sub-basins and in those in which medium-sized towns are numerous. Remedies for domestic pollution are the most obvious ones, the simplest ones and the quickest ones to implement.*
- *Industrial pollution presents the greatest problems in Romania and, to a lesser extent, in Bulgaria. It is added to the domestic pollution problem in the Budapest region. Intense and indispensable restructuring of the production apparatus in these countries should cause this situation to evolve quickly and, no doubt, improve it to some extent. The uncertainty surrounding these factors nevertheless ought not to justify a wait-and-see policy which would aggravate a situation which is already critical.*
- *The problems presented by agriculture are practically never brought up. They are nevertheless important in the central plains of Hungary and in certain Romanian and Bulgarian sub-basins. Among the sub-basins most globally under threat, three are so mainly due to pollution originating from agricultural sources. The impact of agriculture gives even more cause for concern in that it is sensitive in the long term. The experience of Western countries has also shown that remedies are difficult to implement.*

The system developed by Equipe Cousteau and its partners has shown the advantages of a procedure which favors consideration of the origins of and socioeconomic factors causing pollution rather than analytical criteria of water quality. It makes it possible to identify the direct causes and to define priorities for action in the relevant sectors of activity.

This system can be improved, particularly in the following directions:

- *Increase of the geographic precision by division into a larger number of sub-basins and, eventually, by connection to national and/or local systems.*
- *Updating of certain data and incorporation of new information, particularly concerning other pollutants such as heavy metals or organic pollutants, concerning water out-takes, concerning economic activities supported by rivers and their basins and concerning description of natural environments, etc.*
- *Updating and improvement of the calculation coefficients relevant to burdens of pollution.*
- *Incorporation of moduli enabling upstream/downstream interactions and pollutant transfers to be taken into account.*
- *Increase in the complexity of high-risk zone definition criteria to incorporate the economic dimension and competition between different uses of the river.*
- *Development of models concerning the evolution of socioeconomic contexts and their impact on the environment.*

This Geographic Information System could be the basis for a truly all-embracing approach to the environmental problems of the Danube basin and constitute an important decision-making tool in the context of development and the environment.

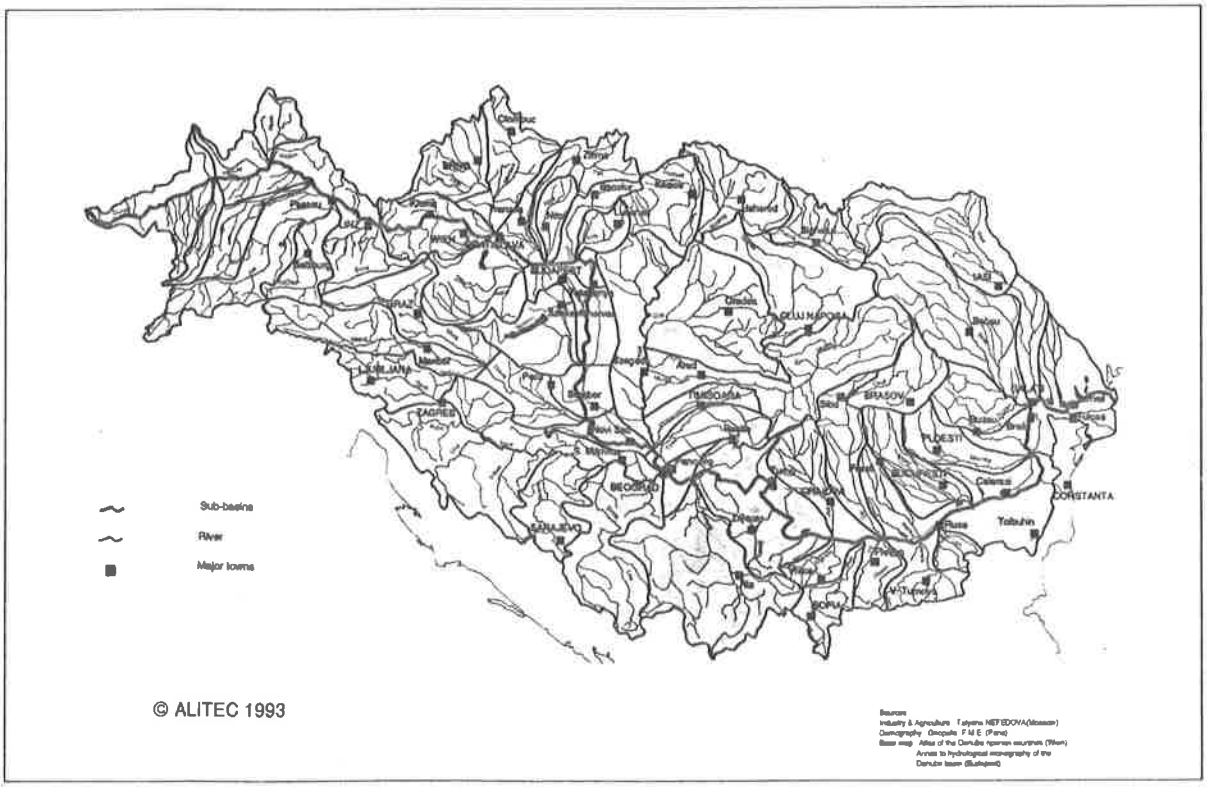


Fig 4.24 - Map of the Danube basin showing borders, river network, sub-basins and major towns.

The 817,000 km^2 of the Danube basin area have been divided in 66 sub-basins (generally class 3 sub-basins).

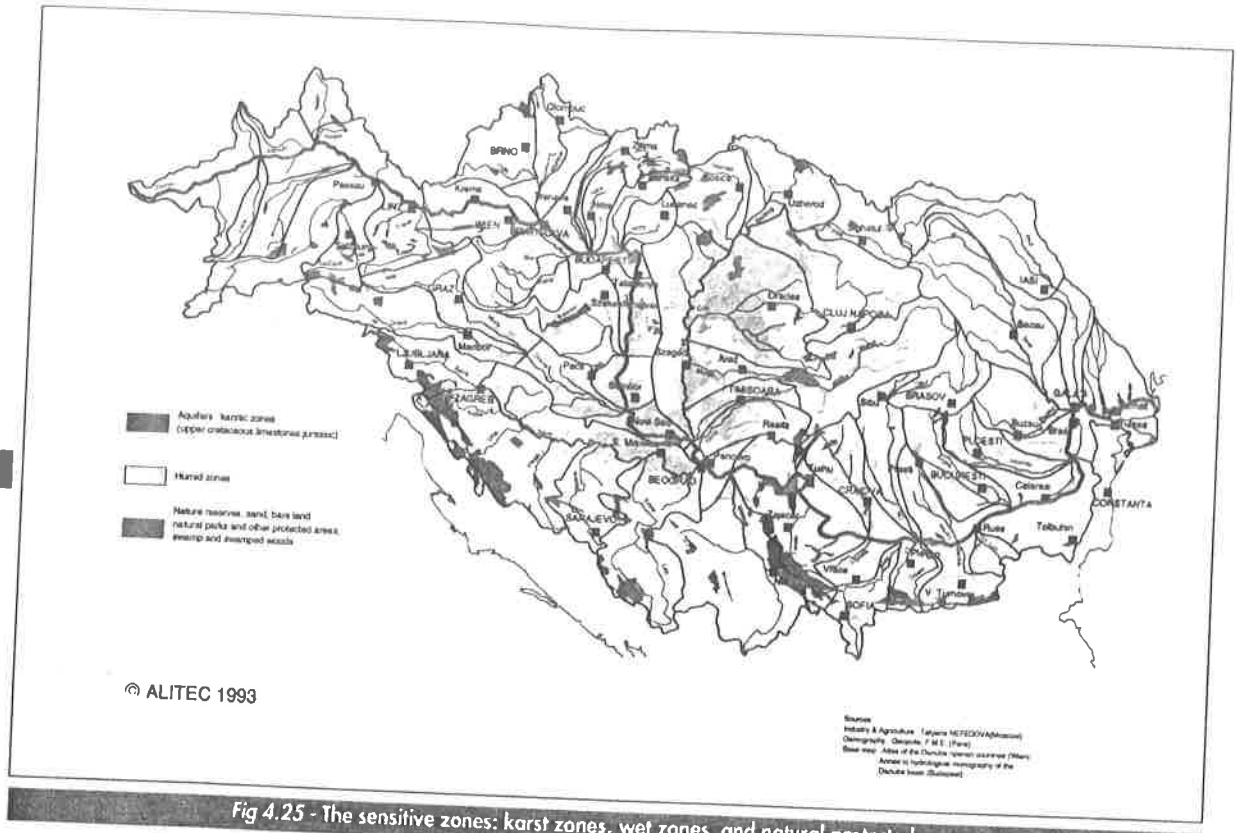


Fig 4.25 - The sensitive zones: karst zones, wet zones, and natural protected zones.

Karst zones in which direct infiltrations are likely to contaminate the karstic aquifers cover 3% of the Danube basin area. Wet zones in which the ecological equilibrium is fragile cover 17.5%, natural zones protected because of their interest from the landscape or wildlife point of view cover 1.7% of the basin surface area. The sensitive zones amount to more than 22% of the whole Danube basin area.

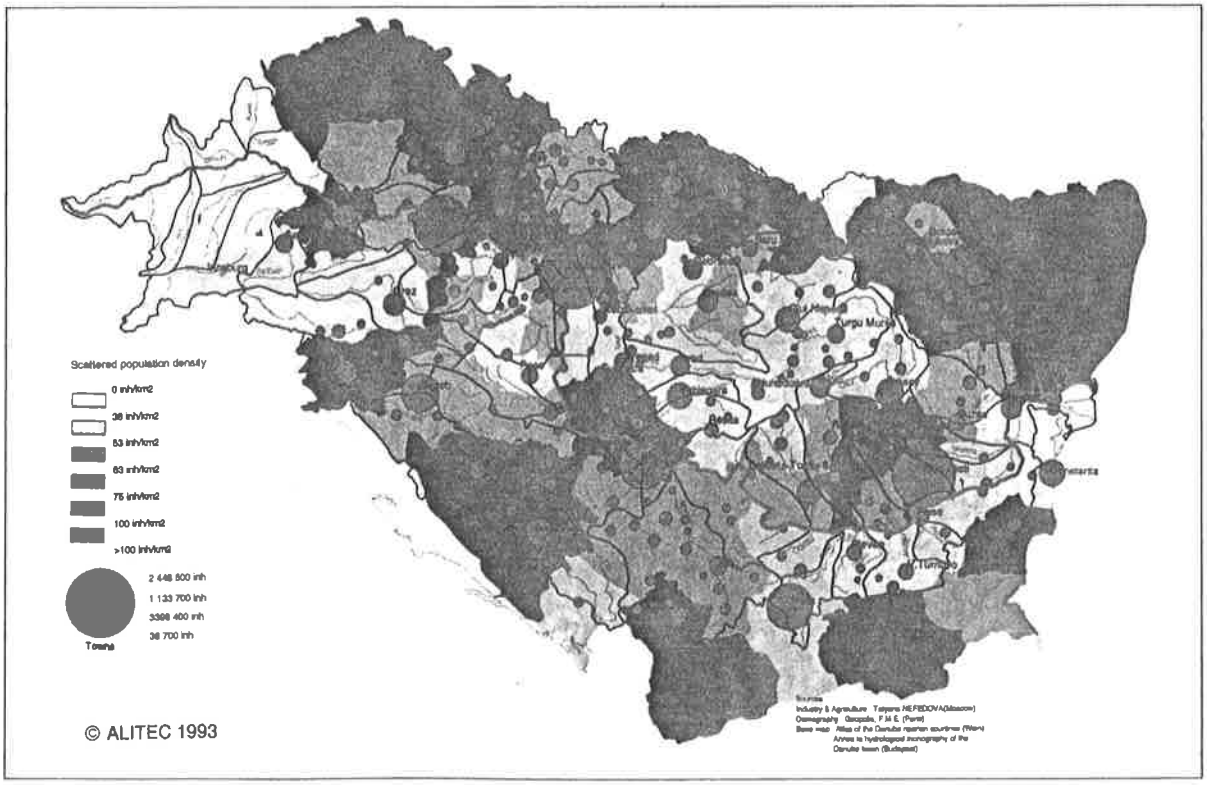


Fig 4.26 - Population of the main towns of the Danube basin, and density of diffuse population in the 66 sub-basins.

Most of large cities and capitals are on the river or connected by a river to the Danube. Population density is quite high, particularly on the upstream sections of the tributaries in the northern part of the basin.

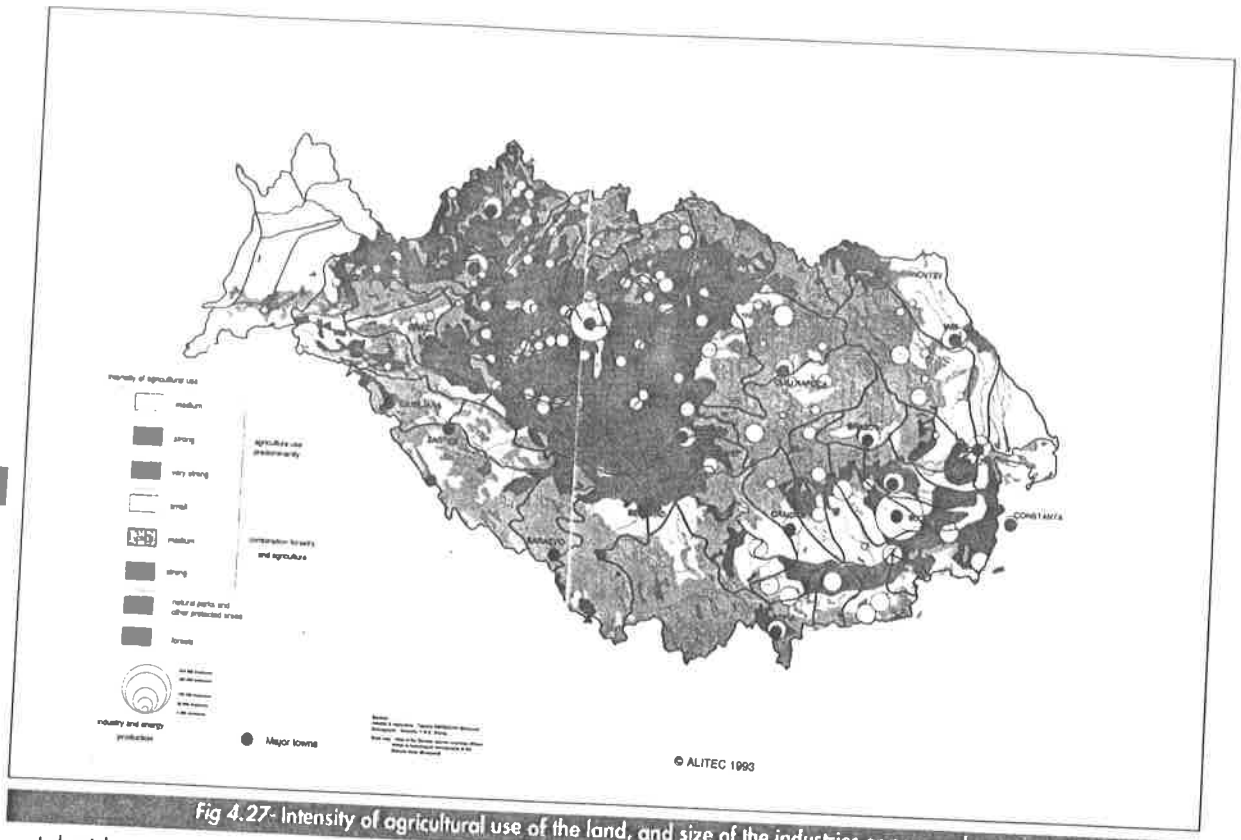


Fig 4.27- Intensity of agricultural use of the land, and size of the industries or power plants.

Industrial activities are concentrated in the large cities and centers of varying size located on the river or its main tributaries. Agriculture is dominant in the great plains with an intensity which decreases from West to East. In many cases, these zones overlap with the wet zones designated as sensitive.

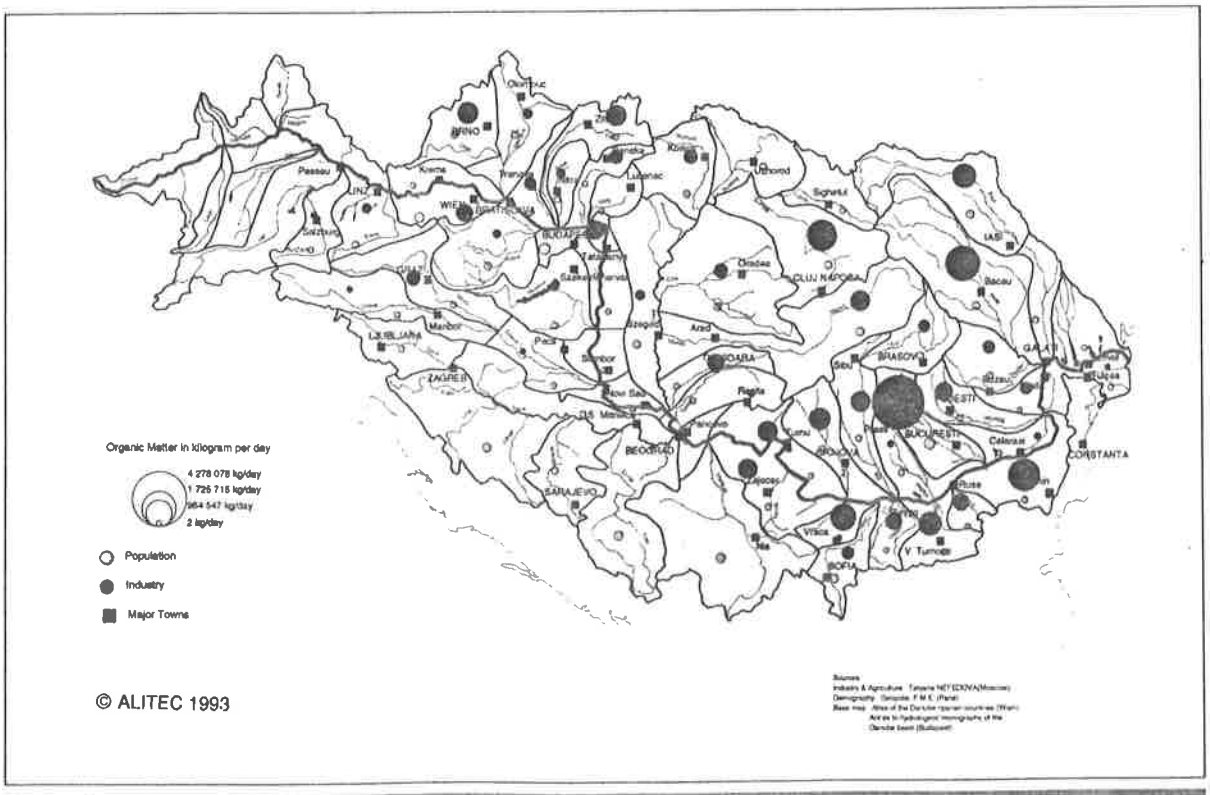


Fig 4.28 - Production of organic matter (kg/day) by source for each sub-basin.

Industrial activity throughout the basin is the major source of organic matter. In Bucharest, industry produces 97% of the total organic matter.

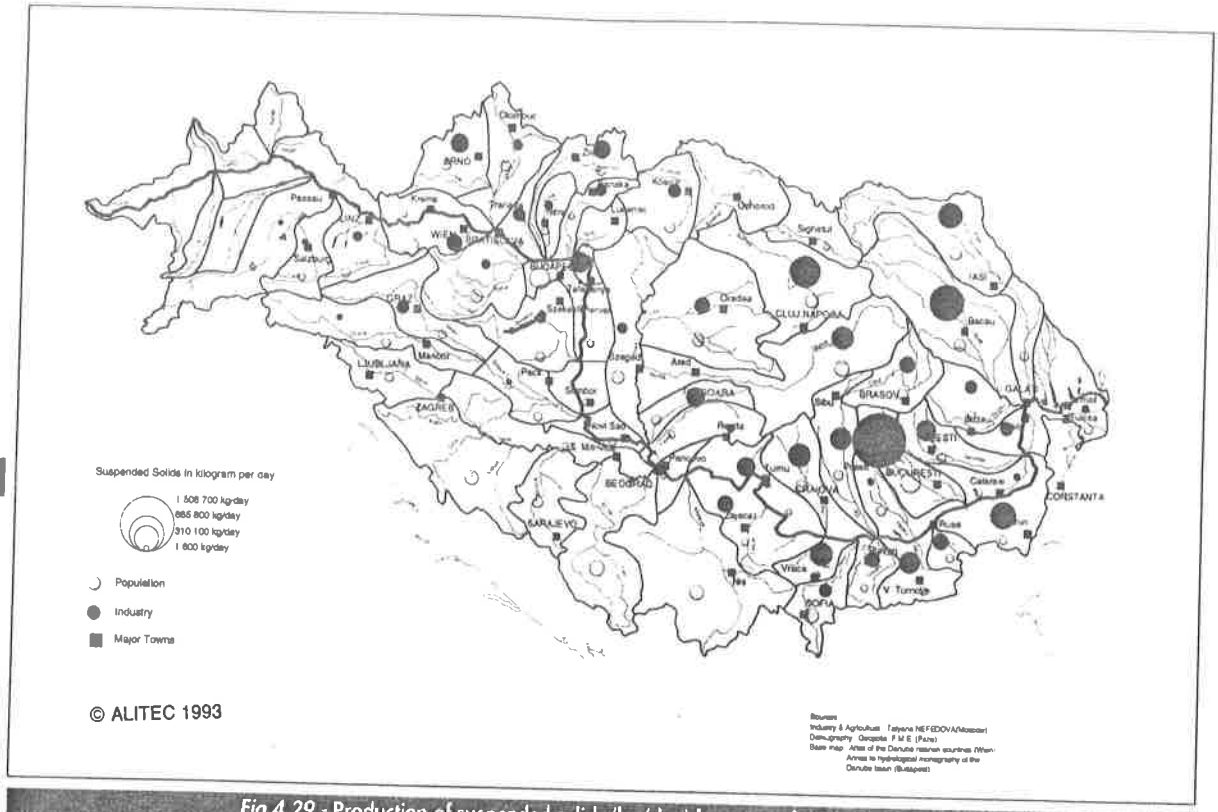


Fig 4.29 - Production of suspended solids (kg/day) by source for each sub-basin.

Industry is the main source of suspended solids (87% for Bucharest), followed by the domestic pollution in the vicinity of large cities (a city such as Budapest discharges 190 tons of suspended solids daily).

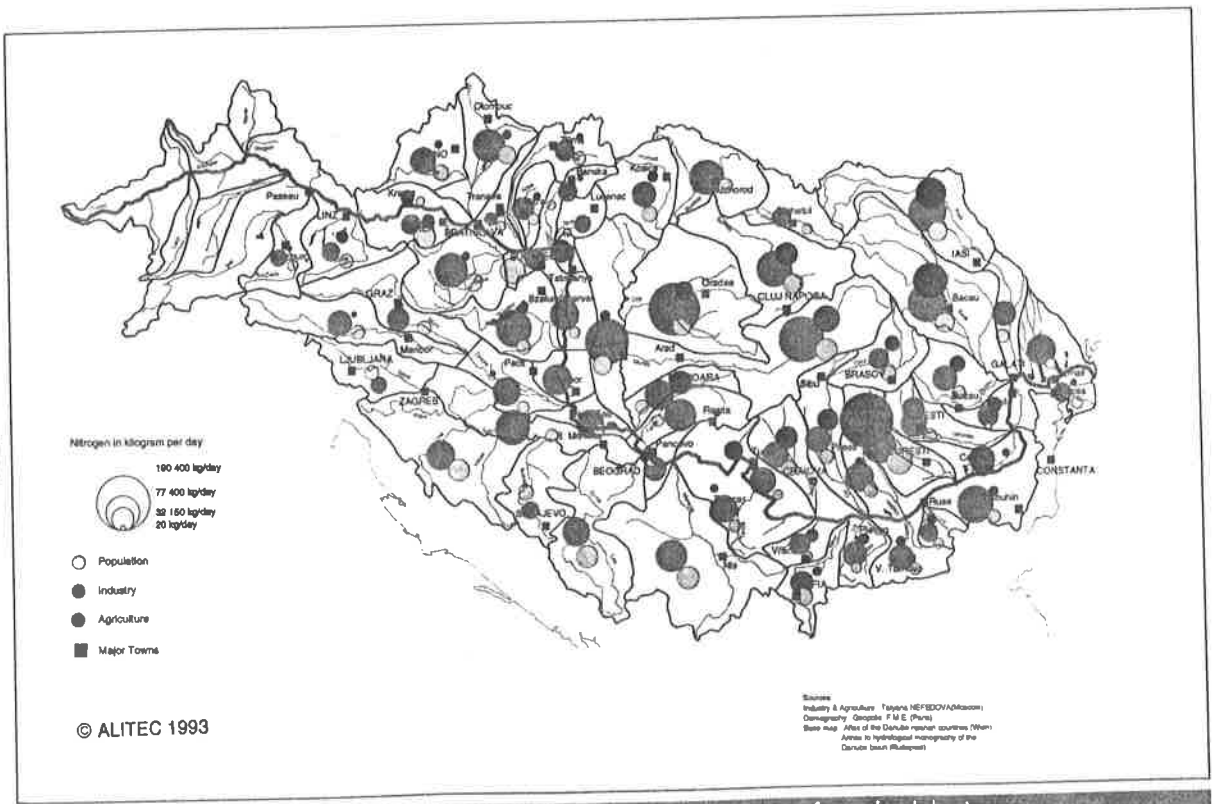


Fig 4.30 - Production of nitrogenous matter (kg/day) by source for each sub-basin.

Agriculture is the main source of nitrogenous matter. It is particularly obvious in the central plains of the basin where other sources (industry and population) are very low.

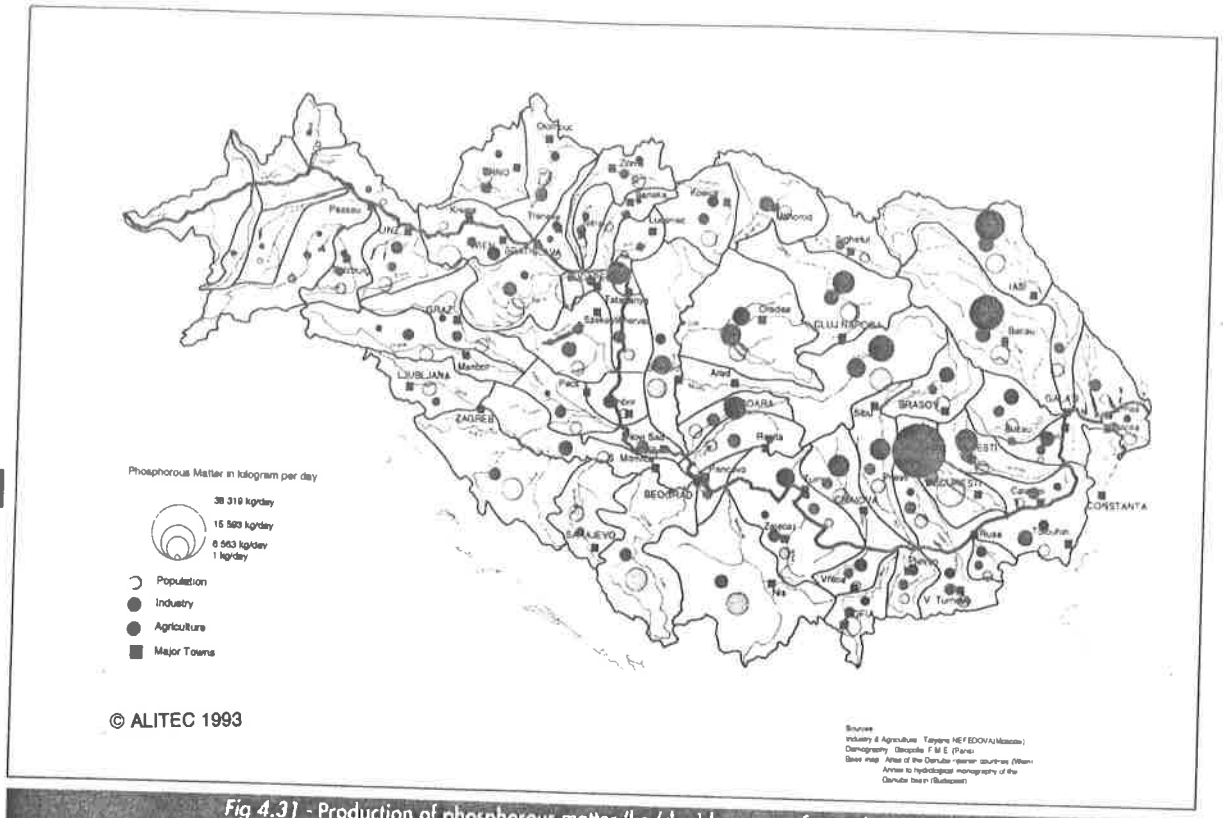


Fig 4.31 - Production of phosphorous matter (kg/day) by source for each sub-basin.

Domestic pollution is the major source of phosphorous matter for the whole basin (60% to 80% for the Budapest, Vienna and Belgrade sub-basins). Industry and agriculture are also important sources in the sub-basins where their intensity is high.

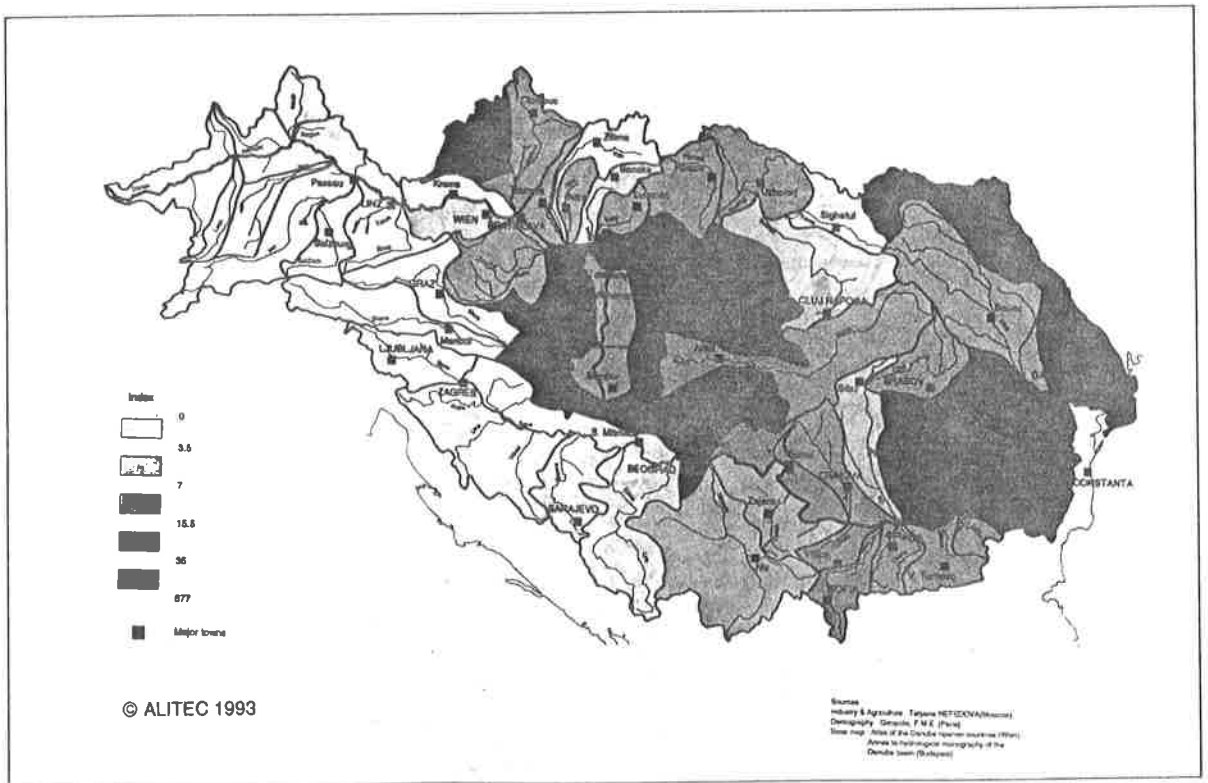


Fig 4.32 - Nitrogenous matter concentration index for each sub-basin.

The classification with concentration index highlights the low outflow sub-basins, particularly Brno in Slovakia, the basins of the central plains (Budapest, Novi Sad and Pancevo). The delta is surrounded by sub-basins in which the potential pollution concentration indices are the highest of the whole basin.

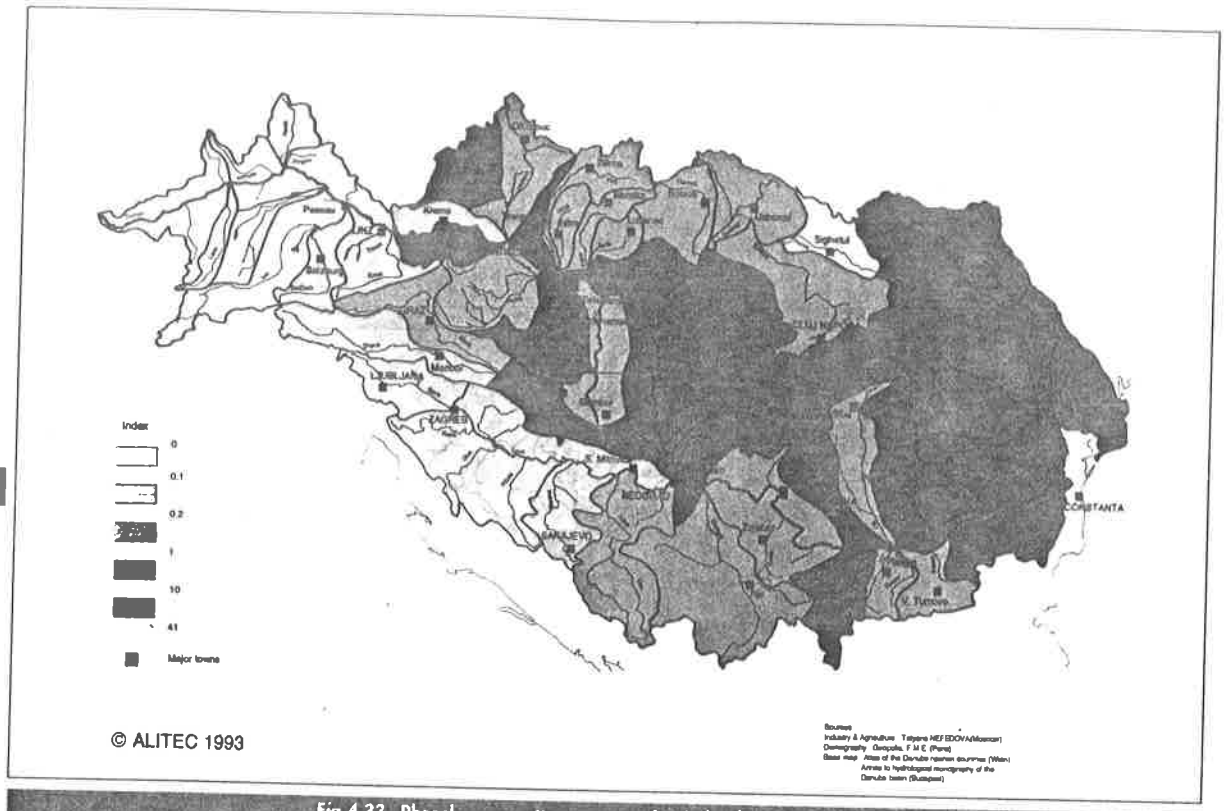


Fig 4.33 - Phosphorous matter concentration index for each sub-basin.

Pollution sources in the Bucharest sub-basin are such that the dilution effect (70 m^3/s) is not sufficient for this sub-basin to fail to appear in the above class.

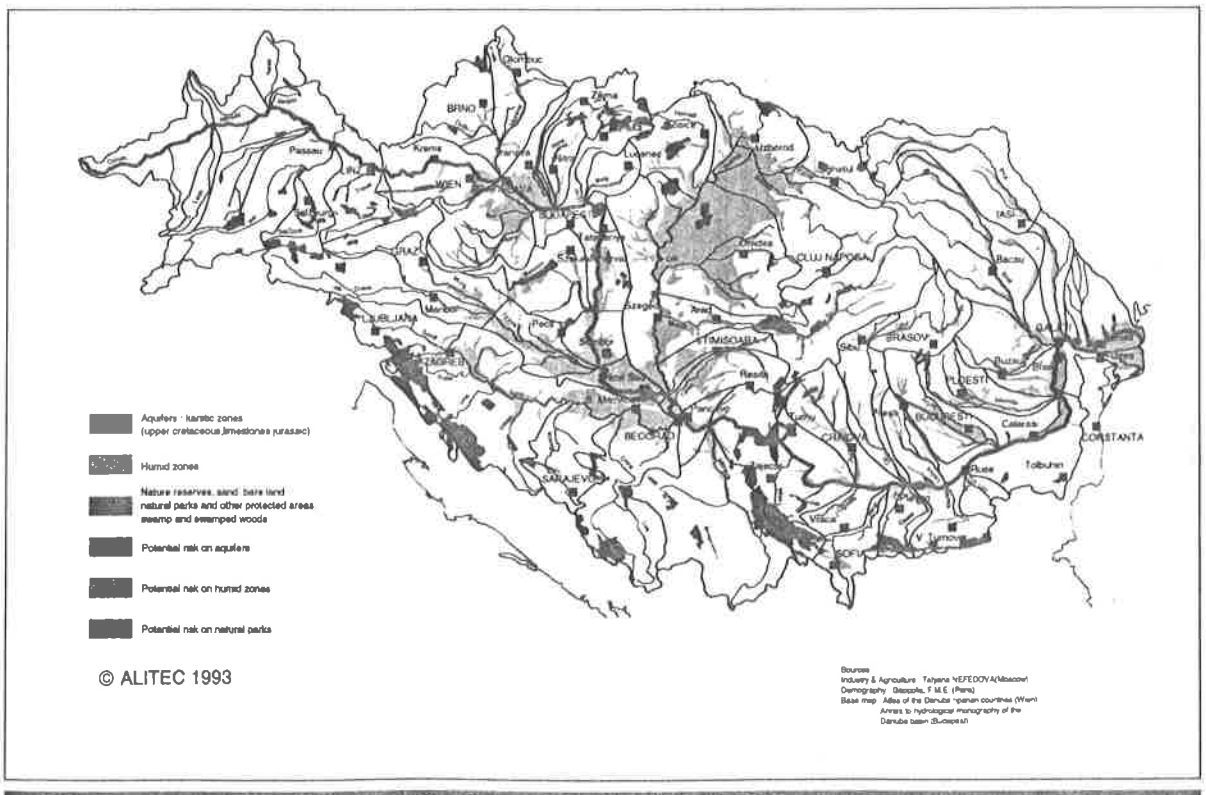


Fig 4.34 - Location of the high risk zones.

About 25% of wet zones and about 10% of natural reserves are located in areas with heavy potential nitrogen and phosphorus discharges.

4

DEVELOPMENT OF A DECISION SUPPORT SYSTEM IN THE DOMAIN OF ENVIRONMENT AND WATER MANAGEMENT

The state of the environment is moving very rapidly and must be kept up to date regularly. The recent experience in western countries has proved that an appropriate environmental management requires a global approach to the problems, which supposes a treatment and a confrontation of multisectorial and extensive information (economy, ecology, technique, social).

The successful management and rational, sustainable and environmentally sound use of natural resources require an adequate assessment of the available resources prior to planning and management of its use.

Only reliable and systematically collected data and information on the status and trends of the environment can the basis be of sustainable and rational planning and management. This is a basic prerequisite for all aspects of environment and water resources development, management and planning.

The tool developed by Equipe Cousteau and its partners using a Geographical Information System (GIS) is liable to fulfill these objectives but to do so it must be developed and spread throughout the Danube countries.

To achieve this goal, we organized a workshop on "Geographical Information System (GIS) in Environmental and Water Management" involving eastern and western experts. It provided feed back on the system developed by Equipe Cousteau, information on the state-of-the-art of GIS and the programmes which are currently carried out and general recommendations for the development of GIS in the Danubian countries.

This material enables us to propose a project of an Environmental Decision Support System for the Danube River Basin (EDDS - Danube).

4.1

WORKSHOP ON GIS IN ENVIRONMENTAL AND WATER MANAGEMENT

Equipe Cousteau, with the support of the Delft Center of Technical University, the UNESCO Department of Water Sciences and the Technical University of Budapest have organized a workshop held from the 28th to the 30th of September 1992 in Budapest about the following theme: "GIS in Environmental and Water Management workshop."

Due attention must be paid to the work done by Pr. Ijjas and his team, and by Dr. Miloradov and Pr. Marjanovic in organizing and preparing this workshop and following up this study.

It brought together 43 participants and more than 30 observers coming from most Danubian countries (with the exception of Germany and Romania) as well as the Netherlands and the European Bank for Reconstruction and Development.

The objectives of the Workshop were the following:

- To evaluate, discuss and analyze the method and application of the GIS as a useful tool for sustainable and environmentally sound river basin management and administration.
- To promote and to ensure the linkage and the compatibility between the different systems implemented on the Danube river basin at the national and international scale.
- To use the Rhine basin experiences in the field of environmental and water management and GIS in order to optimize the current GIS programmes in the Danube river basin and to promote cooperation and exchange experiences between the Rhine and Danube basins.

• MAIN RESULTS •

Two scales for implementing GIS have been identified:

- At the basin-wide scale using the approach and technology developed by Equipe Cousteau.

It has been demonstrated that the activities-analysis approach has numerous advantages for whole transboundary basin GIS application. Until a detailed environmental monitoring system is designed and implemented at basin-wide scale, or until data exchange methodology and protocols are agreed upon, the activities approach is the most practical and feasible way to implement a GIS on the whole-basin scale. The analytical tools developed by the Cousteau team can improve environment and water management in practice and also improve and develop further cooperation among the Danubian countries.

- At the national and local level using a two way approach:
  - Basin activity analysis and loading through export coefficients.
  - Environmental monitoring approach which should be based on distributed data collection, storage and retrieval and integrated modular GIS development and implementation. Design and implementation experiences from the University of Novi Sad, Mihajlo Pupin Institute and River Danube Water Authority are very useful guidelines as to the approach and concept of the GIS system for detailed national and local scales as are the experiences of other countries present at the meeting.
- Works like the Rhine-Danube Project should be harmonized or new ones should be initiated immediately on the integration of the basin-wide approach and measurement approach at national and local scales (data exchange methodology, data collection procedures, etc.).

In order to be able to fulfill the above objectives, the following work should be initiated:

- Harmonized data collection and exchange methodology.
- GIS training programmes in the Danubian countries. This work should include the development of GIS curriculae as well as the organization of seminars, workshops and short courses to train the people working with GIS in Danubian countries.
- In order to aid the transfer of technology and the accumulated knowledge of Equipe Cousteau, existing hardware and software in each country should be supplemented in an adequate manner. Training should also be conducted with respect to software and hardware use necessary to implement the Cousteau team's tools.
- In response to the requirements of the international funding agencies and their need for tools to aid decision-making and project evaluation, work should be initiated on the development of the decision support system for project evaluation, utilizing the tools developed so far and the results of the future work resulting from this workshop. Similar work should be initiated at the national level also.
- International student and staff exchange programmes should be developed utilizing the experience of the Rhine-Danube Project to improve the flow of information among Danubian countries and the transfer of technology from the developed to the less developed countries in the field of GIS.
- As we have seen at this workshop, there is at least one team in each Danubian country working on GIS (institutes, ministries, private enterprises, etc.). This fact makes it possible and relatively easy to establish a basin-wide network of experts who will continue to work together to promote the development and widespread use of GIS development.

4.2
ENVIRONMENTAL DECISION SUPPORT SYSTEM FOR THE DANUBE RIVER BASIN

Equipe Cousteau and its partners: Pr. Istvan Ijjas (Technical University of Budapest), Pr. Milorad Miloradov, Dr. Prvoslav Marjanovic (University of Novi Sad), Michel Soulié (CRITT-Verseau), Jean-Paul Cheylan (GIP-Reclus), and the company ALITEC in Montpellier, propose to develop an advanced approach to decision-making in the field of environmental management. It is called the Environmental Decision Support System for the Danube river basin (EDSS-Danube). This project was conceived in principle during the first Geographical Information System in Environment and Water Workshop held in Budapest at the end of September 1992.

The state of the environment in Central and Eastern Europe has been attracting increasing attention from the world community in recent months due to the significance of environmental problems which are coming to light since the collapse of centrally planned economies in these countries. Initial evaluation of the environmental problems in the Danube river basin has identified two groups of potential or existing problems and issues. The first is related to the existing state of the environment. The second to the problems and issues related to the way environment was studied and managed in the past and the changes and restructuring necessary to ensure future well being of the people.

The environmental situation in Central and Eastern Europe highlights the following problems:

- Environmental quality of the Danube river basin is under great pressure from a diverse range of human activities.
- Urban populations are generating pollution because of largely inadequate waste water treatment and solid waste disposal facilities.
- Inadequate attention to environmental impacts from industry, energy production and agriculture has resulted in significant water, air and soil pollution at local, regional and transboundary levels.
- The situation on the tributaries of the Danube river is much more severe since concentrations of pollutants often exceed acceptable standards.
- Local actions to control and manage waste discharges, though important, have not been sufficient to ensure environmental sustainability in most areas of the basin.
- Non point sources of pollution of the Danube river may represent a serious problem.
- Remains from past pollution may represent a problem at certain localities and will deserve attention.
- Proposals for large-scale investment schemes on the Danube river have revealed serious conflicts over alternative land uses, particularly the preservation of ecologically important wetlands.
- Danube river environmental evaluation has yielded important insights into the nature of the regional problem.
- The critical interdependence of upstream and downstream neighbors is seen at all levels of the Danube basin.

Today:

- Financial resources for investment in new infrastructures and for rehabilitation, restructuring and modernization are limited.
- International agencies and riparian countries face important choices in deciding how to allocate limited funds to ensure the highest regional environmental benefit.
- International and bilateral cooperation on environmental problems and their solutions has not yet reached a sufficient level to solve environmental problems inherited from the past.

It is obvious that the existing situation in Central and Eastern Europe calls for prompt action at an international level if the existing trends are to be reversed and if the environment is to be protected and preserved. Never before has a region in Europe been faced with such a vast environmental degradation problem and never before has there been a situation in which local communities had so few resources to devote to the environment over such a short period of time. This unique situation calls for new and innovative approaches to environmental protection, rehabilitation, planning and management. Experiences from the developed countries, even though very useful, cannot be transferred without criticism and adaptation. Partial approaches will yield only partial solutions which will not be sufficient to change the existing situation in a major way.

It is necessary to approach the problem holistically and to develop integrated strategies based on a new and emerging environmentally sound philosophy.

• PROJECT PRESENTATION •

This holistic approach presumes an integration of economy, ecology and technology with the socio-political system. Integral democratic decision-making processes are aided by the complex decision support tools whose use is made possible by the technological advancements of the recent past.

The decision-making process and successful management and rational, sustainable and environmentally sound use of natural resources require an adequate assessment of the available quantity and quality of resources prior to planning and management of its use.

Resource assessment is of critical importance for the wise and sustainable management of resources.

The backbone of an advanced decision support system is information and the system used to manage it. Since environmental problems manifest themselves in space and time, the data from which information is extracted also have a temporal and spatial character and the data management and analysis system must reflect this, besides including all the data necessary to describe the relevant aspects of the environment triangles. Furthermore, an advanced decision support system must allow for a holistic evaluation of the environment as well as for partial analysis of the environment with respect to space and time of the data which are available. An advanced decision support system must also be flexible and allow the analyses of different scenarios for the future; in other words, it must be modular, with forecasting and alternative evaluation tools built into it.

The core component of such an advanced Environmental Decision Support System is the GIS system for data analysis and information extraction coupled to modules for forecasting and analyses of alternative solutions.

The Equipe Cousteau Danube Programme provides a global evaluation of the environment in the Danube basin and, using specifically developed methodology and GIS, identifies risk zones.

The evaluation is based on an upstream approach to sources of pollution through an estimation of human-activities pollutant releases. On these bases, some priority interventions and a general short-term basin-wide action plan for the Danube basin can be developed. The proposed project builds on this on national and subregional (tributary sub-basin) levels. However, before this can be done, concerns and problems resulting from scale reduction from global (basin wide) to national and local levels must be solved.

In accordance with the Environmental Programme for the Danube River Basin this requires:

- Institutional building and restructuring to improve environmental planning and management. This should include inventories, development of analytical tools for planning and management, strengthening of networks, institutions, human resources, non-governmental organizations and applied research.
- Development of a strategic action plan and investment programme which should include national reviews of the environment of each country in the basin, and preparation of environmental improvement projects and studies (national and regional level).

In order to do this and ensure that national strategic action plan for each Central and Eastern European Danube Basin country are comparable, and in order to be able to transfer the Equipe Cousteau approach for the whole basin to a national level, it is also necessary to develop:

- Methodology of environment assessment at the national scale.
- Methodology for the evaluation of pollution at the national scale.
- Methodology for the identification and evaluation of sensitive zones at the national level.

Related to this is the resolution of questions regarding:

- Technical and practical choices of the Equipe Cousteau GIS implementation at the national scale.
- The GIS data model for national scale analysis.
- Other issues related to the Decision Support System.

The potential to combine all of the elements of the state-of-the-art Decision Support System (DSS) and GIS technology, and build a distributed network of national nodes provides potential users of the project with results that did not exist in the Danube basin before.

This network will link national EDSS nodes *(Figure 4.35)* all working together as national support units to National Focal Points established within the Environment Programme for the Danube River Basin so as to achieve integration of national and international efforts. The National Project Coordinators have already been identified in most of the countries on the occasion of the Budapest workshop.

Today, the technology exists for the implementation of DSS-GIS technology across the network of experts. It is very important to make the project a prototype using the technology which has been chosen, as well as to test the database design and database management schema to be used. Through a pilot project, critical issues related to database design and technology implementation can be evaluated and reviewed, and improvements and adjustments can be made for final implementation.

However, the following bottlenecks are expected in the development of an environmental Decision Support System for the Danube basin:

- Incomplete organizational structure of public administration.
- Lack of adequate data for some major sectors.
- The variety of hardware and software platforms.
- Limited funding.
- Lack of a sufficient number of experts to ensure adequate system implementation at national and local levels.

These bottlenecks must be overcome through activities within the Environmental Programme for the Danube River Basin.

The organizational structure and management that support the EDSS-Danube are also crucial to making distributed GIS implementation work.

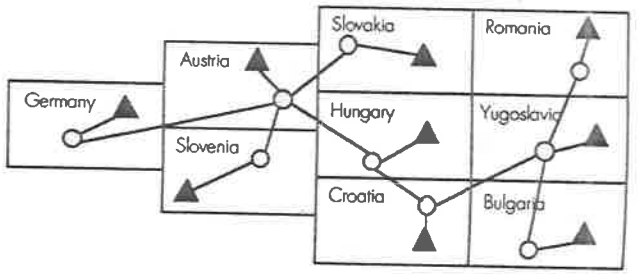
• PROJECT OBJECTIVES •

The objectives of the project are to develop the EDSS-Danube system and use it in the development of the Strategic Action Plan for the Danube River Basin in such a way as to provide an integrated framework to address distinctly national and regional issues as well as local problems.

The bases for this integrated framework have already been developed within the Equipe Cousteau Danube Programme and this should be

Figure 4.35 **· Network of national Environmental Decision Support System nodes.**

The objective is to create a network of national Environmental Decision Support System nodes all working together as national support units to national focal points established within the Environment Programme for the Danube River Basin coordinated by the Commission of the European Communities.



tested and verified at a national, regional and local levels through a Tisza River pilot study.

The results of the pilot study will be applied and verified by a series of sub-basin studies in each Danubian country.

The overall goals of the project are:

- Developing a methodology for EDSS-Danube system and implementation using an holistic approach to the environment for global, national and local levels. This requires:
- Developing resource assessment methodology for global, national and local scales.
- Splitting EDSS into functional modules for sequential methodological development.
- Precisely defining user needs at different levels of the decision-making tree.
- Precisely defining data needs for the EDSS Environmental Programme for Danube River Basin.
- Applying the EDSS methodology on a pilot scale for the Tisza river basin to test and verify it. Implementing the EDSS on a national scale.
- Making the EDSS technology available to everybody who wants and should use it. This includes training of the potential users of EDSS in each basin country.
- Transferring the results of the Equipe Cousteau Programme to each country in the Danube basin and implementing the environmental evaluation methodology at the national and local level. This requires:
- Forming a national EDSS node in each country as a support unit to National Focal Points and outfitting it (hardware, software, methodology) to handle the Equipe Cousteau methodology.
- Developing national/local level procedures for the adaptation, calibration and verification of the Equipe Cousteau methodology. This will be done through a pilot study for the Tisza river basin and will be based on a comparative analysis of the human activities analysis approach and environmental monitoring approach.
- Verifying the results of the pilot study on the Tisza river basin in each participating Eastern or Central European Danubian country using a selected characteristic river basin.
- Bringing to the public's attention the scope of the environment problem in each participating country.
- Demonstrating the effects of new technology upon environmental decision-making and management.

The above objectives may be modified to suit the particular situation in each participating country due to the fact that the level of EDSS and GIS use in different Danube basin countries may differ. The local situation must be considered and every effort made to accommodate it.

• EXPECTED RESULTS •

Expected results from the project are:

- Improved environmental analyses, protection, rehabilitation, planning and management.
- Integrated global, national and local decision-making.
- Improved decision making.
- Harmonized data collection and exchange.
- Integrated systems analysis.
- A network of EDSS-GIS nodes connecting Danubian countries.
- Improved national environmental institutions and administration.
- Easier bilateral cooperation.
- Easier Danube Convention monitoring.

The proposed project fully complements the activities within the Environmental Programme for the Danube River Basin and should be an integral part of it. The project represents the integration of the work on a number of other environmental projects in the Danube basin carried out with the participation of the complementary expert teams (Tempus, Rhine-Danube Project EDSS, US AID, etc.).

This project could also play one of the most important roles in the future development of the Danube basin. Natural resources and environmental problems will be evaluated on both global and local scales using compatible methodologies. Environmental evaluation will be implemented in all the Danubian countries using the same general methodologies. Environmental data collection, storage and retrieval will be harmonized. Transboundary environmental problems will be evaluated. Methodology for project eval-uation on global and local scales will be devel-oped and implemented in each country. Decision-making processes and technology will be improved. Western technology will be transferred to the Danubian countries.

The budget for this project is estimated at 2.5 million ECU for a three-year period.

With respect to other planned activities or those already in progress, the proposed project represents an important step towards integral environmental management and development. This is fully in accordance with the conclusions of the Rio Summit and the needs of the Danube Basin Ecological Convention currently under consideration by the Danubian countries.

RECOMMENDATIONS

The requirement for control and monitoring of the Danube's environmental condition can under no circumstances justify a lack of immediate action to limit environmental contamination.

• Urgent and immediate measures

- The Danube is mainly polluted by heavy metals and human waste. This leads to ask as a matter of priority that the countries' capital cities, the largest towns and the industries causing the most pollution should equip themselves with purification plants as a matter of priority. Refitting sewage and drinking water collector networks is also a priority. These measures should be accompanied by an improvement in industrial processes in order to limit the amount of polluted waste entering the Danube's water.

- Measures must be implemented as quickly as possible to reduce or eradicate the causes of pollution identified by means of hot spots and high-risk zones such as the Romanian sub-basins, the delta and the wet zones of the basin's central plains.

- The water tables of the Danube basin are particularly under threat from industrial and domestic pollution. Preventive measures must be undertaken as a matter of priority. In particular, the filling of the Slovakian dam at Gabcikovo must be shelved and the construction of new dams can no longer be envisaged.

- Diffuse pollution from agricultural sources can no longer be ignored in the Danube basin. Most of the threatened sub-basins are under threat from diffuse pollution. The long-term consequences of diffuse pollution are serious enough to warrant precautionary measures being implemented immediately.

• Environmental resources assessment

- Measures for monitoring environmental pollution and, in particular, water from the Danube must be integrated into a comprehensive environmental programme incorporating a main-river-and-tributary water-quality monitoring programme among others.

RECOMMENDATIONS

The Bucharest Declaration may serve as a basis for the control and monitoring programme if its prerogatives are extended and its resources greatly complemented.

- Physical/chemical analysis of the samples taken at over 50 points along the Danube give a representation of pollution in the river and enable a certain number of hot spots and the main contaminants to be identified. In order to complement these data, the number of sampling points must be increased to around a hundred on the Danube itself and extended to the main tributaries. A detailed map of sedimentary contamination in the Danube basin must be drawn and be periodically updated.

- In each of the countries, laboratories or institutes will be identified and chosen to participate in the Danube water control and monitoring network. Technical and financial resources will be allocated to them in order to fulfill this task. Measurement procedures will be standardized without being carried out by a single body. Intercalibration between laboratories will be scheduled, as will staff training.

- Analyses will have to be carried out:
  - every five years for sediments and deposited substances,
  - every year for benthos, fish and mussels,
  - every month for suspended substances,
  - every week for nutrients.

- A multi-parameter approach must be developed in order to identify particularly polluted zones.

- International exchanges between laboratories and institutes from the west and east should be encouraged and developed.

• Environmental management

- The unique situation existing in Central and Eastern Europe calls for new and innovative approaches to environmental protection, rehabilitation, planning and management. It is necessary to approach the critical environmental situation holistically and to develop integrated strategies based on a new and emerging environmentally sound philosophy.

- To provide better environmental management, Equipe Cousteau and its partners are proposing the realization of an Environmental Decision Support System for the Danube River Basin combining all the elements of the state-of-the-art of Decision Support System and Geographical Information System and build a distributed Network of National Nodes. Environment assessment is of critical importance for the sustainable management of natural resources.

• Radioactive survey

- Measurement of radioactive contamination on the banks of the Danube and at a certain number of industrial sites using aerial gamma-spectrometry has proved the efficiency of the method.

  Additional investigations are required in order to evaluate whether the method should be used to identify contaminated zones which are still kept secret or are unknown.

- In Eastern Europe, just as in Western Europe, all precautions have not been taken in storage of nuclear waste of industrial or medical origin. Uncontrolled dumping sites do exist. The aerial survey has enabled one to be identified near Cetate in Romania.
  Systematic searches for uncontrolled dumping sites are an obligation for environmental protection and of course for protection of the population.
- International cooperation must be encouraged and sustained in the field of monitoring and controlling radioactive contamination in the environment.

Finally, in a general way, data concerning environment and water quality situations must be available to each state and this is the responsibility of state leaders.

PART 5

GABCIKOVO: A CASE STUDY

GABCIKOVO: A CASE STUDY

The concept and execution of Equipe Cousteau Danube Programme are based on a complete overall approach to the environmental problems which takes the long-term into account. The Gabcikovo dam supplies us with ideal proof to demonstrate by example that this approach is a suitable one to use.

In recent decades, the consequences of our shortcomings in development planning have manifested themselves in the form of a proliferation of environmental problems at the local, regional, and global levels. Remedial efforts have engendered two principles which are now well recognized:

- Most of the problems result from narrow sector-based processes of logic. The solutions developed by specialists acting on the basis of their own field of skill alone result in deadends. Development projects or solutions to existing problems must be researched from the point of view of all their various aspects.
- Short-term reasoning results in consequences for which heavy premiums must be paid in the long term. It is no longer possible to exploit our resources as if they were infinite. The concept of long-term management, or sustainable future, imposes itself as a necessity.

Equipe Cousteau, using these two fundamental principles as a basis, has developed the concept of Ecotech. This involves compromising within the same rational process among technical, economic and ecological rationales in order for decisions made by the sociopolitical mechanism to proceed *(See Figure 5.1)*.

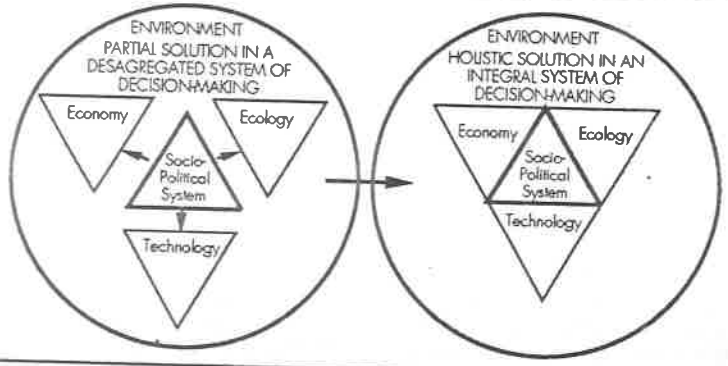
The importance of a complete overall approach and taking the long term into account is rendered absolutely crucial in river exploitation, as rivers are highly complex ecosystems and constitute resources common to a great number of human activities. This applies all the more so since river developments are irreversible.

The Gabcikovo dam is the legacy of the past in which narrow rationales and short-term reasoning were exacerbated by a factor inherent to the communist system: a totalitarian approach to government, where opposing viewpoints were unacceptable, and a will to raise humanity's status by controlling the environment. These brought about the hegemony of technology.

The Gabcikovo dam is the perfect result of this "technician's" rationale, which gave carte blanche to the know-how of hydraulic engineers and which still persists. Such a rationale is not limited to the design of civil engineering works but is extended to the ecological and economic fields:

- The solutions envisaged for environmental problems are "added on." Rather than removing the causes of problems, new technical devices are designed which are intended to correct the consequences of preceding technical devices. The results sometimes attain the absurd. For example, the installation of a network of pumps was envisioned in order to compensate for the water-table level variations downstream from the dam. These pumps would have con-

Figure 5.1 - Ecotechny, a new concept for long term environmental management and sustainable future.



sumed a large part of the electricity produced by the dam!

- The evaluation of the dam's economic viability as presented in the reports which were accessible was carried out using a simplistic rationale involving no strategic reflection or long-term forecast concerning future energy requirements or navigational development potential.

The work carried out in the context of the Danube programme enables us to present a complete overall evaluation of the dam's advantages on an economic level and of its environmental consequences.

1 DESCRIPTION OF GABCIKOVO

The Gabcikovo dam is located on the Hungarian-Slovak section of the Danube, a few kilometers downstream of Bratislava.

In the initial design, the system included a set of dikes containing the reservoir, a dam at Dunakiliti (in Hungary) blocking the Danube and diverting water toward the supply canal, a hydroelectric station at Gabcikovo, an outlet canal returning water to the Danube at km 1811 *(See Figure 5.2)*.

After the works on the Hungarian side had been stopped, the Slovaks had implemented the alternative C, which comprises a new dam at Cunovo (in Slovakia) and new dikes modifying the right bank of the reservoir, limiting its perimeter to Slovak territory.

2 CONSEQUENCES FOR THE ENVIRONMENT

We will limit ourselves here to the two major problems: the effect on the alluvial ecosystems lining the Danube in this zone and the risk of pollution of the water resources. For further details, please refer to the report "The Gabcikovo Dam: a Textbook Case."

2.1 EFFECT ON THE ALLUVIAL ECOSYSTEMS

Filling of the dam at the end of October 1992 raised the risks or threats which were hanging over the alluvial ecosystems to the level of a concrete reality. In a few days, the consequences of flow reduction in the river bed to around 300 m^3/s were measurable; while it was possible to cross the Danube without wetting one's feet, the water-table level plummeted by several metres. The wells dried up and secondary channels and ponds drained, leading to the death of thousands of animals, in the medium term, threatening the whole of the plant communities.

These facts demonstrate the incompatibility between operation of the dam according to the planned method, which scheduled flows in the Danube comparable to those actually observed: 200 to 300 m^3/s, and survival of the ecosystems which line the river. They also demonstrate the failure of the environmental studies carried out by the dam builders.

Studies which we carried out on these alluvial ecosystems "Alluvial ecosystems: a unique heritage" enable their value to be specified.

• VALUE AS HERITAGE •

These alluvial plains and forests are the richest regions in Europe, not only in terms of the diversity of species, but in terms of biomass and productivity as well. This richness is directly linked to river dynamics - proportional to the surface area flooded - and the extent and steadiness of the flooding. Because they combine the resources and diversity of terrestrial and aquatic ecosystems, while remaining a highly dynamic and unique environmental interface, alluvial ecosystems are the richest and most productive ecosystems of the temperate regions.

Alluvial zones are used by animal and plant species as migrating and travel corridors. These corridors played a crucial role for terrestrial plants during glaciations. That is why current alluvial forests are so abundant in remnants from the tertiary era.

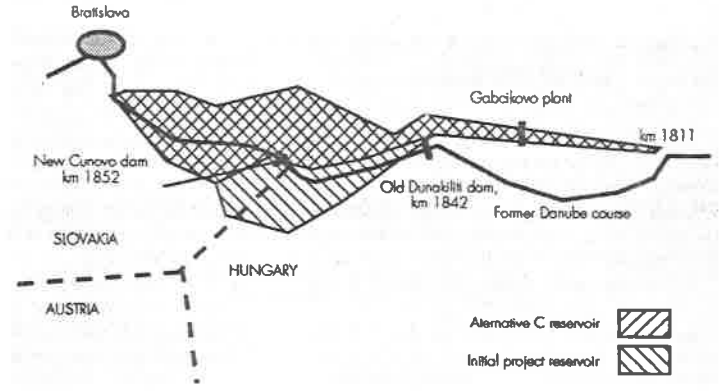
Taking this heritage value into account was recommended by the Rio Conference through the Biodiversity Treaty.

• FUNCTIONAL VALUE •

Alluvial plains have direct economic value linked to this exceptional diversity and productivity. However, it is difficult to evaluate because alluvial zones no longer exist along the courses of Western European rivers, and in Eastern Europe it is still impossible today to obtain reliable economic data on river resource exploitation in recent years.

Figure 5.2 - Schema of the Gabcikovo dam and of the alternative C.

After work was stopped on the initial design of the dam on the Hungarian side, the Slovaks unilaterally simplemented the so-called "alternative C" on their own territory. It was put in operation at the end of October 1992.



Fishing communities, which have completely disappeared from the rest of Europe, subsist only in the alluvial zones. Logging is particularly promising in these alluvial zones with high productivity.

Alluvial plains, but more importantly alluvial forests, provide the best system for purifying water and recycling organic matter. The assimilation of nutrients (phosphates, nitrates) by terrestrial and aquatic plant life in the alluvial plain offers a means to purify river water and groundwater.

Alluvial plains offer the best protection against flooding, because they slow the flow and give the water room to spread out. In addition to the roughness of the plant life on the riverbanks and the plain, which slows water speed, seepage decreases the level of flooding. On the other hand, canalization increases the power and propagation speed of flooding.

The importance of the functions of the alluvial plain is not marginal. Certain territorial collectives in the French region of Alsace have understood this importance perfectly: with a view to long-term management of the quality of their drinking water (taken from an alluvial water table), they fund maintenance of natural meadows in the wet zones in order to favor self-purification of the water passing down towards the water table during high water.

2.2
CONSEQUENCES FOR THE QUALITY OF WATER RESOURCES

Following filling of the dam, a reversal in the position of Slovak experts concerning the risk of subterranean water pollution was observed: whereas it had always been denied, it suddenly became a very serious threat to the Samorin taps which supply the town of Bratislava, upon which it was proposed to reduce the water flowing through the bypass channel!

Our studies fully agree with the recent convictions of these experts.

The risk of contamination is linked to two phenomena:

- The accumulation of polluted sediment on the bottom of the reservoir may enable the passage by pressure of pollutants through to the subjacent water table. This storage may create the conditions for a chemical time bomb: beyond a certain concentration threshold or if reducing conditions develop on the bottom, massive re-release of pollutants may take place with serious consequences for the environment.
- Eutrophication, created by the conjunction of strong nutrient concentration (leaching of agricultural soils, urban or industrial waste), of water clarification by settlement and water temperature increase through reduction of current velocity in the reservoir and creation of still, shallow zones. The explosive development of algae leads to anoxic conditions and to the development of reducing conditions on the bottom.

Two of the studies which we have carried out enable these risks to be determined. The first "Overall evaluation of pollution and high risk zones" highlights significant sources of pollution upstream of the dam: the cities of Vienna and Bratislava, which are very poorly equipped with purification plants, the Brno region connected to the Danube by the Morava. These are sources mainly of organic substances and nitrogen and of phosphorus to a lesser degree. The presence of these sources worsens the risk of eutrophication.

The second "Concentration of chemical pollutants in sediments and mussels along the Danube" carried out by the Marine Environmental Laboratory of the International Atomic Energy Agency confirms the existence of these sources and defines them. High concentrations were measured in the sediments of the Bratislava region for the following pollutants:

- PCBs associated with the city of Vienna.
- Hydrocarbons.
- Coprostanol (an indicator of sewage pollution) associated with the city of Bratislava.
- Benzopyrene and lead, a combination of products characteristic of fossil fuel combustion (including the combustion of leaded fuel).

Another result of this study is the highlighting of the very high level of pollution in sediments taken from the Djerdap dam reservoir (Iron Gate); this sample was a hot spot for almost every measured parameter.

One of the conclusions of this report is "The important point is that any dam in the river downstream of identified sources of pollution, will create a potential buildup of contaminants and, in some cases, a future chemical time bomb."

Moreover, installation of purification plants in the surrounding urban areas of the reservoir, promised by the dam builders, has always been postponed. It has now been postponed until the first profits from the power station. In the meantime sewage from the cities and villages will be ejected untreated into the storage lake ...

All of the above factors would tend to result in contamination of the region's drinking water reservoir. Loss or deterioration of these resources would have serious consequences at an economic and social level. A large number of the inhabitants are not connected to a drinking water distribution network and depend on the quality of subterranean water in their daily lives.

3
THE DAM'S ECONOMIC VIABILITY

Will the economic advantages of the dam be sufficient to compensate for its drawbacks?

3.1
ELECTRICITY PRODUCTION

In the documents supplied by the Hydroconsult firm analyzing the economic value of the dam, the production of electricity is considered as a net profit (equivalent to the energy produced multiplied by the import cost of the same amount of energy). However, this is only true if it meets a quantitative need both now and in the future and if the production is coherent with the most applicable energy strategy.

The study "Energy in the Danubian Countries. Current situation and outlook." shows that this is not the case.

The Czech Republic and the Slovak Republic consume large amounts of energy and electricity with a very high electric intensity (two to three times higher than in western countries).

Efforts made in energy efficiency could allow these countries to have energy supplies comparable to those of Western Europe today by the year 2020. Electricity consumption would be then about 6.5 TWh lower than its current levels for the Slovak Republic alone.

In this future context, which is indispensable to ensure the transition of the Slovak economy to a modern economy open to the rest of the world, the Gabcikovo dam does not respond to any future requirement.

Moreover, electricity production from the dam is very slight by comparison with Slovak consumption and with the savings potentially able to be made by improvement of energy efficiency. Production, which was to rise from 1.2 TWh to 2 TWh depending on the configurations applied, will have to be reduced further because filling of the dam has proved that it corresponds to a flow distribution which cannot be withstood by the alluvial forests. This being the case, electricity production will be absolutely marginal.

Nor can Gabcikovo be considered as one component of a strategic reorientation of electricity production, since the Slovak Republic is continuing its investments in the nuclear industry and in hydroelectric equipment on its other rivers.

These investments combined, which contribute to over-equipment in Slovakia, are taken away from other sectors which are far more crucial to the economy. Allocated to industrial modernization, they would have been able to energize this sector of activity and at the same time generate energy savings.

Investment could also have been made in renewable energy sources which represent a far greater potential than that of Gabcikovo's production (it totals 7% of current consumption in ex-Czechoslovakia as a whole). Exploitation of these resources would also have the advantage of solving certain environmental problems such as

exploitation of rural or urban waste and of inducing the integration of new technology which constitutes a development opportunity for the private sector.

3.2
IMPROVEMENT OF NAVIGATIONAL CONDITIONS

The major difficulties for navigation on the Danube are located along the Hungarian-Slovakian section, since the depth of 2.5 dm recommended by the Danube Commission is not reached there for 30% of the year. These difficulties are particularly expensive as they occur during periods in which the Danube's other sections are generally navigable.

Following the same simplistic line of reasoning as for energy, it was thought that the advantages of the dam would correspond to a traffic increase equal to the increase in the number of navigable days (around 30%) and to the fuel savings associated with the reduction of current along the developed section. It was also thought that opening of the Rhine-Main-Danube canal would lead to a significant increase in deep draught traffic.

But evaluating the advantages of a project like Gabcikovo requires an overall assessment which includes the following phases:

- Clearly setting out the existing traffic hindrances caused by bad navigational conditions and defining the developments and investments required to remedy the problems.
- Establishing a forecast of the potential future traffic using the Danube, taking the developing economies of the local populations and the opening of the Rhine-Main-Danube canal into account. This will make it possible to define the quantity of traffic that will use the river as a result of development.
- Evaluating the profits to be gained from the increased traffic and the improvements that would be made to the fleet following development, and identify the beneficiaries.
- Comparing these profits with the costs of development in order to calculate the profitability and the economic and social efficiency.

This assessment was carried out by Patrice Salini and presented in this report (Part 2).

In fact, this evaluation exceeds that of Gabcikovo proper because the thresholds which limit navigation do not only concern the developed dam sector. The latter alone does not solve the problems, and this fact suffices to show Gabcikovo's non- advantageous nature where navigation is concerned.

In a broader hypothesis in which the entire Vienna-Budapest Danube bottleneck would be developed by four dams in addition to Gabcikovo, analysis shows that such investments would not have any direct profitability. The increase in traffic following development would be very limited, around 1.8 million tons per annum. The major beneficiary of these developments would be the Austrian steel industry, which competes with Slovak steel and would imperil its continued existence.

It seems far more profitable to invest near the Danube in order to improve the organization of transport and the operability of harbor infrastructures.

The Gabcikovo dam provides excellent proof of the advantages of a complete overall approach, since its multi-sector characteristics (it integrates the fields of energy, transport, water resources, nature conservation) match perfectly the complexity of environmental problems.

This approach paints a very negative picture and it is clear that if it had been used from the project's outset, Gabcikovo would never have seen the light of day.

This absurd decision to build a dam reveals itself as the stumbling block of a system in which decision-makers incorporate only a very narrow range of criteria. No alternative solution which would have enabled the same energy or navigation services to be provided, implementing alternative resources less detrimental to the environment and more profitable for the economy, was seriously studied.

Granted, Gabcikovo is an heirloom from the past, but it is to be regretted that the current Slovak government has at the same time inherited the mode of thought from which Gabcikovo was born. By being willing to put this dam into service at all costs, the Slovak authorities are starting on the path to a sequence of technical and environmental problems and financial difficulties.

Only two months after the dam had been filled, catastrophic reports were coming in: the alluvial forest had dried out to a great degree, with as yet unforeseen consequences; the dam's electricity production potential had been reduced significantly; two boats had wrecked in the storage lake; structural erosion problems had been observed; several gates of Cunovo dam had been washed away by high water; one of the locks of the Gabcikovo plant has never worked; the ferry linking inhabitants of one bank of the canal to the rest of the country is chronically malfunctioning; navigation had repeatedly been blocked.

This situation requires energetic measures if it is hoped to avoid serious, and in some cases irreversible, consequences for the environment and the quality of life of the region's inhabitants.

In the longer term, removal of the two main sources of disturbance, i.e. the storage lake and reduction in flow in the Danube's bed, fundamentally calls into question the design of the dam and its advantages. Basic reflection on the matter is imperative in order to find a viable solution.

RECOMMENDATIONS

Solving the Gabcikovo problem and saving the endangered zone would be a landmark decision and an example for the future.

• To refill the Danube as priority

Most of the water in the Danube (95%) must be returned to the river bed as soon as possible and at the latest before spring growth season.

• To apply the principle of precaution for the intermediate period

The principle of precaution must be applied in decisions concerning the dam's future, especially concerning how the water is managed, decisions due to be made for the near future. The Danube must not become a laboratory where experiments are carried out.

• To engage in a global integrated reflection guided by democratic principles

Basic reflection on the matter must be engaged in incorporating the technical, ecological, economic and social data and drawing on international experts, the public and non-governmental organizations for environmental protection. It must lead to an exhaustive and detailed cost/benefit analysis of all alternative solutions. It must be carried out in a spirit of transparency and its conclusions must guide decisions concerning Gabcikovo's future.

• Courageous and reasonable solutions must be supported by western countries

Our own analysis leads us to the conclusion that abandoning the dam and reinstating the site is the most courageous and also the most reasonable solution with a view to achieving a sustainable future. This solution must have the advantage of solid financial backing from western countries and the large international financial institutions. Such aid is indispensable for implementing alternative solutions in the field of energy and navigation and for a site reinstatement project if these are to have credibility with the public and with political leaders.

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