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WATER RELATED RISK MANAGEMENT

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INTRODUCTION

Water is the topic of the day on the international scene, because of a critical situation in numerous countries and regions. Fresh water is perhaps the single most important resource on Earth. World is faced with growing vulnerability of society to natural and anthropogenic water disasters. The growing frequency and magnitude of extreme environmental events world-wide has intensified research interest in natural disasters as well as regional vulnerability and response capabilities.

At present international scientific community is faced with an environment ecologically, climatically, geologically, and due to these socially and politically, so fragile and vulnerable to risks of floods, droughts, landslides and water and soil pollution. Now it is hence the decisive moment to start a process of co-ordinated international multi- and inter-disciplinary research and other activities covering knowledge and information exchange.

Risk is defined as the chance or possibility of loss or bad consequences. It refers to the possibility, with a certain degree of probability, of damage to health, environment and goods, in combination with the nature and magnitude of the damage. Risk denotes a possibility that an undesirable state of reality may occur as a result of natural events or human activities. This means that humans make causal connections between actions or events and their effects, and that undesirable effect can be avoided or mitigated if the causal events or actions are avoided or modified.

Natural disasters equally affect countries large and small, rich and poor, unrespectable of their political stance, and they present the formidable barriers to national, regional and global development. There is a growing consensus that natural disasters must be viewed as a world-wide problem, one that requires concerted global action. Without this social mandate, our scientific and technical progress cannot impart its full benefit to those at risk.

Water related natural hazards (earthquakes, droughts, floods, landslides, volcanic eruptions, hurricanes, wildfires, water and soil pollution etc.) are risks to inhabited regions due to extreme aberrations in nature (Burton et al. 1978). As such, natural and anthropogenic hazards know no political boundaries. Common among all hazards is the inadequacy of methods to express risk to the public. Risk gauges are lacking that could adequately quantify the probability of occurrence, the consequences to life and property as well as the temporal and spatial scales of such events. There are many commonalities in origins among hazards. For example, earthquakes and landslides, floods and landslides, droughts and wildfires, floods or droughts and soil and water pollution occur together. Unfortunately little joint research goes on.

Many of natural and anthropogenic hazards are closely related to water. Figure 1 shows all water hazards and their dependencies. Water as the water related disasters do not respect national, regional or any other borders. Co-operation over all aspects of water could be seen as a possible salvation from severe crisis or potential conflicts.

The main water hazards are droughts and floods. From the hydrological point of view they could be consider as independent. All others water hazards are more or less interrelated and dependent of one or both of them. Because of this as well as due to the necessarily limited length of this paper, only their related risk management will be discussed.

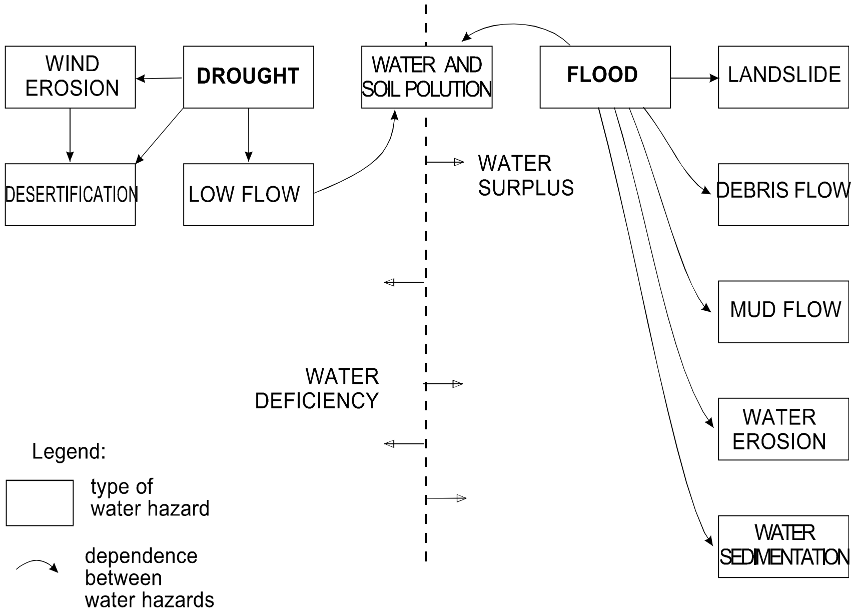

Figure 1 Water hazards and their dependences

INTEGRATED WATER RESOURCES MANAGEMENT (IWRM) AND SUSTAINABLE DEVELOPMENT

For a long time, mankind has seen the world as an inexhaustible resource to be used for its own profit. Humans especially learned to bring water where and when they needed it. Today, under the combined pressures of increased demand, water-related disasters and the deterioration of water quality, traditional management approaches have failed. It is responsibility of the international scientific community to develop new approaches that will allow for satisfaction of human needs while maintaining the quality of environment.

Water management principles are: 1) Manage water for all human beings and their descendants, while preserving the environment through a sustainable development policy; 2) Closely associate the end-users with the development choices; 3) Consider water as an economic and social good and allow for an access for all. In accordance with these principles the new emerging paradigms are: 1) Dealing with water management in a more integrated way; 2) Looking for sustainable use of water, satisfying the needs of both man and nature; 3) Learning to live with water disasters and reducing their losses; 4) Moving away the centralised management system in order to adopt increased public participation processes.

Water related hazards control policies couldn't be separated from more general, integrated, water management and planning. The main objective of scientific community is to discuss and propose possible solutions for more effective measures for water hazards mitigation using IWRM based on principles of sustainable development. Nowadays problems in water management cannot be solved by technical and legal measures alone**.** IWRM should become the leading principle. Public understanding of risk assessment and management is vital to the success of IWRM.

IWRM consists of next three general systems (UNESCO/WMO 1991): natural water system, human activity system and water resources management system. The natural water system consists of the hydrologic cycle with its components. This system is composed of water and water-related natural resource endowment available for human and environment uses and services. The human activity system is composed of numerous different human activities that affect or are affected by the natural water resources system. The water resource management system consists of the activities and relationships in the public and private sectors concerned with harmonising the supply and demands sides so as to achieve the objectives of the society. An essential support to the water resources management system is the institutional framework for management, consisting of organisations, rules and codes governing the use and control of water resources.

Sustainable development of water resources requires respecting of hydrological cycle by using renewable water resources which will not be reduced by a prolonged exploitation. Sustainability should not be limited to physical and ecological dimensions but must encompass the socio-economic elements in the process of achieving society's overall objectives without sacrificing those of future generations (Dixon and Fallon 1989). Sustainable water resource management can therefore be regarded as the transformation of factor inputs, land, labour, capital and entrepreneurship, into co-ordination activities aimed at achieving society's objectives without putting at risk the legitimate aspirations of future generations.

World Water Council gives next actions required to achieve objectives of IWRM: 1) Involve all stakeholders in integrated management; 2) Move to full-cost pricing of water services for all human uses; 3) Increase public funding for research and innovation in the public interest; 4) Recognise the need for co-operation on integral water resource management in international river basin; 5) Significantly increase investments in water.

COPING WITH DROUGHTS

The terms "aridity", "drought", "dryland", "desert", "water scarcity" cover a wide range of natural and social phenomena. Aridity is a state caused mechanisms leading to a water deficit in air and soil by the feeble nature of the precipitation and by the intensity of evaporation, which represent the most important factors but by no means the only ones (Mainguet 1999). Dryland is an environment, which is permanently, seasonally or temporarily subjected to a significant deficit in moisture. One third of the land mass of the Earth or about 45 million km^2 is dry. It is inhabited by 15% to 20% of the world's population. Desert is a truly arid and hyper-arid area which is virtually permanently dry and receives less than 100 mm of rain per year. The usual consequence of a drought is water scarcity. It is among the main problems to be faced by many societies on the Earth in the near future. Water scarcity is commonly defined as a situation where water availability in a country or in a region is below 1000 m^3 per person per year (Pereira et al. 2002).

WMO defines drought as a period of two consecutive years in which precipitation is less than 60% of normal in an area covering at least 50% of a geographical region. Drought is also often defined in many other ways, with the definitions being specific for each science and/or region in relation to its impact and management. Nevertheless, all of the definitions include the attribute of precipitation or moisture deficiency. By itself, lack of precipitation does not necessarily make a drought. The moisture and precipitation deficiency equates with drought when such deficiency impedes the well being of human activities and/or natural ecosystems upon which such activities depend for sustenance. Examples of drought effects on society and environment range from short-term disruption of food, water supply, and water-dependent commerce to long term degradation such as desertification and soil erosion (Easterling 1989).

Drought is harsh climatic event and natural disaster. Their impact on the environment, their socio-economic and political effects lead to disturbance of the equilibrium, to crises of the production systems, to a drop in foodstuff production and to social upheavals (Mainguet 1999). Droughts are among the most expensive disasters. Drought means lack of water, water that normally would be available in a region and to which nature and mankind have adapted over centuries (Tallaksen and Van Lanen 2004). Droughts build up gradually and passively as the cumulative effect of below-average precipitation in a given area during a certain period. Drought has temporal and spatial dimensions, but boundaries may be fuzzy. The beginning and end of droughts are not easy to determine. It should be accepted that drought is a normal feature whose recurrence is inevitable.

Drought is set apart from other natural hazards by a number of characteristics. Unlike other natural hazards, it is caused by a "non-event", the accumulative lack of moisture. It is difficult to pinpoint the onset and ending of a drought. Drought can persist for months or even years. Drought often covers large areas. Due to the above mentioned characteristics drought often impact broad aspects of environment, economy and society. Interdisciplinary research is therefore needed to conceptualise drought as a natural hazard (Easterling 1989).

Term drought in literature often has two meanings. First is climatologic one: period during which precipitation is considerably below the mean. Second is hydrologic one: period during which the runoff is considerably below the mean. There are many different types and definitions of drought as for example: 1) Meteorological drought; 2) Hydrological drought (Bonacci 1993); 3)

Soil moisture drought and/or edaphic drought; 4) Groundwater drought; 5) Agricultural drought etc. It should be stressed that droughts and wildfires are highly dependent.

Costs of drought are inequitable. Within a drought-affected region, some stakeholders (especially farmers) are hurt more than others. Whole industries within a drought-affected region are impacted differently by the same drought. There are some individuals and groups who are not affected severely enough to qualify for initial relief but who suffer significant loss. They are referred to as "hidden victim" of drought.

Drought response is an interdisciplinary task. Next four interdisciplinary aspects of drought are important to effective management of drought risks (Wilhite and Easterling 1987): 1) Drought prediction; 2) Drought detection and monitoring; 3) Assessment of drought impacts and adjustments; 4) Policy response.

Drought prediction is the anticipation of future (usually monthly or seasonal) average moisture conditions such that the likelihood of the predicted conditions actually occurring is greater than the statistical chance. To be useful in decision making, drought predictions must not only be skilful but they must also be timely. Having drought prediction at the right moment means having adequate lead-time. Lead-time is defined as the period from the release of prediction to the onset of the period being predicted. Problem is that methods of drought prediction are not highly reliable. Improvements in prediction skills, timeliness and adaptation to needs of decision makers could make drought prediction more useful in the future.

Drought detection and monitoring is observation of the development, onset, maturation and dissipation of drought conditions such that information generated from such observation can be used as a drought mitigation tool. Drought detection and monitoring activities emphasise rapid accumulation of information about moisture conditions and rapid dissemination of such information to drought response bodies. Drought detection and monitoring activities fall within the categories of: 1) Networks of low technology and high technology surface-based instruments; 2) Satellite imagery; 3) Onsite inspections.

Drought impact is the effect of meteorological drought (precipitation deficiency) on physical systems (runoff, groundwater level, water level in lakes and reservoirs, soil moisture, soil erosion, desertification etc.), biological systems (ecosystem productivity), and social and economic system (food production, farms, water supply systems, economy etc.). It is to be viewed in the broad context of drought and non-drought periods. The aim of drought impact assessments is to provide scientific understanding of the extent to which drought interrupts the functioning of environment, society and economy. Three broad categories of drought impact assessment methods exist: 1) Descriptive empirical observations; 2) Simulation; 3) Comparative experiences.

Drought as a natural hazard cannot be prevented. However, the various impacts on the economy, environment and social fields can be mitigated by preventive measures. For their efficacy it is necessary to have a good knowledge of the causes of extreme events. There are two main directions in dealing with drought and water scarcity as its consequence when water becomes scarce: 1) Finding new sources of water; 2) Finding ways of minimising demand.

Droughts can and should serve as a catalyst for positive change. It means a move toward new and more sustainable approaches to managing water. During long term drought water managers and stakeholders are forced to change their behaviour and manage water more carefully. If these changes would be institutionalised society would have a system that is less vulnerable to drought and generally more productive. Experience of people living in arid regions could be of great benefit.

Maybe it is the right time to start thinking about establishment new concept called "living with drought".

COPING WITH FLOODS

Throughout the history, floods have been part of human destiny (Smith and Ward 1998). Among the natural catastrophes today, flood events are world-wide of outstanding importance, representing 32% of the damaging events, 31% of the economic damage and 55% of the causalities in 1986-1995 period (Toesmann and Koch 2000). The number of disasters attributed to flooding is on the rise, while the number of people killed due to flooding remains steady (Pilon 2004). Experts estimate that the number of people living in flood-prone areas will roughly double due to: 1) More extreme weather system that accompany global climate change; 2) Rising sea levels; 3) Continuing deforestation, especially in mountain regions.

The terms "flood", "flooding" and "flood hazard" cover a wide range of natural phenomena (Ward 1978, Smith and Ward 1998). Next are the most frequently: 1) River flood; 2) Flash flood (urban and karst); 3) Hazard of flooding low-laying deltas, estuaries and low-laying coastal land from the sea by storm surges and tsunamis. Causes of floods are: 1) Rain; 2) Snow and ice melt; 3) Combined rain and ice melt; 4) Ice jams; 5) Landslides; 6) Failure of dams and control works; 7) Estuarine interactions between streamflow and tidal conditions; 8) Coastal storm surges; 9) Earthquakes. Flooding is triggered by such conditions as severe thunderstorms, tornadoes, tropical cyclones and hurricanes, the El Nino effect, monsoons, dam breaks, ice jams or melting snow. These conditions annually cause thousands of deaths through drowning in vehicles and homes, accidents while walking or driving around water, electrocution, roof collapses, lightning strikes and heart attacks as well as through the spread of water-related disease.

Without non-structural measures like on-site storage of rainwater, traditional structural measures like river channel improvement works cannot save the catchment from habitual flooding. Non-structural measures are an attractive alternative and addition to structural measures that may reduce the loss of lives and property caused by water-related problems. Recent water resources management is emphasising a more integrated approach including measures such as insurance, forecasting, warning and land use planning. The advent of non-structural measures can be viewed within the wider context of the need for the development of more hazard effective and sustainable relationships with the environment in an era of IWRM (Simonovic 2002).

Floods are one of the most dramatic interactions between human beings and environment. They emphasise the sheer force of natural events and man's inadequate efforts to control them. There is clear evidence that the flood situation is getting worse in terms of damage caused by flooding all over the world. Despite huge expenditures on flood control, flood losses continue to rise in both highly developed as in developing countries. Today it is certain that floods resulting in significant inundation cause larger disasters than in earlier times. Floods are undoubtedly becoming one of the greatest planetary concerns. Protective measures often are counterproductive. They may result in higher damages than would otherwise have occurred.

At the same time flooding brings many benefits particularly for ecological variability and soil fertility. Flooding promotes exchange of materials and organisms between habitats and plays a key role in determining the level of biological productivity and diversity. The beneficial aspects of flooding are less obvious to many people, and particularly to those whose dwellings are at risk of flood inundation. Due to those facts in floodplain management it is important to understand all different aspects of flood flow behaviour. Floodplain restoration is one of the crucial goals of the new integrated flood management approach. The most important prerequisite in improving the management is understanding the floodplain ecology. Recent extreme flooding events have attracted much publicity. They should be use as an incentive towards the fast and efficient changes in flood management system.

International Flood Initiative (IFI) is UNESCO-International Hydrological Programme (UNESCO-IHP) and World Meteorological Organisation (WMO) joint action dedicated to the UN International Decade for Action called "Water for Life" (2005-2015), earlier known as Joint UNESCO-WMO Flood Initiative (JUWFI). The concept of IFI builds on the successful record of co-operation between UNESCO and WMO and other organisations to conceptualise, design and implement flood mitigation and protection actions and activities within their individual areas of expertise. IFI is a process that promotes a holistic risk-based approach to flood management. IFI aims at reducing the human and socio-economic losses from flooding and at the same time increasing the social, economic, and ecological benefits from floods and use of floodplains. It integrates land and water resources development, includes the institutional components of flood management, and recognises the critical importance of stakeholder participation and cultural diversity.

Kundzewicz (1998) states that a flood-protection system guaranteeing complete safety is an illusion. Due to this reason it is necessary to live with awareness of the possibility of floods. Now the emphasis is on living with floods rather them fighting them, despite the fact that, in future, the frequency and magnitude of floods can be expected to increase all over the world (Smith and Ward 1998). Living with floods recognises that while it is not possible to completely eliminate floods, their negative impacts can be reduced through an understanding of flood risks and by working towards modifying this risk-generation process in a holistic manner.

Flood risks are processes that result from a combination of flood hazards and societal vulnerabilities, hazard modification and amplification, vulnerability enhancement due to various social processes and factors. Such an approach should recognise the community resource base and benefit from traditional knowledge and include training and incentives to reveal and utilise the benefits from floods.

In most part of the world floodplains and low-laying coasts have attracted economic development and settlements. In arid areas, floodplains are oasis of agricultural development. In mountain and rigged areas they represented the only extensive tracts of flat land easy for cultivation and communication. Floodplains are of major socio-economic and ecological importance (Marriott and Alexander 1999). The predominant human desire to reduce or prevent flooding may not be the best management strategy in the long term and especially in several areas. Human beings domiciled in floodplains should be prepared to live with floods.

It is obvious that only long systems of embankments cannot represent a final and safe solution to the problem of protection of floods. Reinforcements and rising of levees have only made flood hazards less frequent but not have prevented them. A scheme of deliberated and induced inundation of washland storages or selected areas, for which flooding damages were smaller than for downstream areas, could be a successful solution. The proposed solution presents legal and social difficulties, but it opened the discussion about possible decisions based on warning systems in order to mitigate flood damages.

Throughout the history, and particularly during the past two centuries, humans have not coped well with floods. Reason for this lies in extremely complex structure of floods and non-well known their positive and negative consequences on physical processes and environment. During nineteenth century the problem of floods was approached through river regulations and engineering structures. After 1960s a broader approach involving a combination of structural and non-structural measures was involved. During the last two decades, concern about the economic and technical performance of some flood control measures, together with a heightened awareness of environmental issues and the relationships between flooding and human vulnerability, has led to the new policy era. Non-structural flood control measures attracted public and professional attention after conclusive reports were made by local and national governments that more money was being spent on remedying consequences of flooding rather on preventing it.

World Wildlife Fund (WWF), the conservation organisation, in 2002 year had called on the EU and national governments to do more to prevent future flooding and not to use many today available different funds to repeat the mistakes that have led to Europe's recurring and intensifying floods. It pointed out that policies for flood mitigation exist in EU Water Framework Directive (WFD). This requires the joint management of all land and waters in a catchment, leading to improved land-use and reduced flooding by preventing rapid runoff and utilising retention capacities of upland wetland and lowland floodplain areas. Traditional forms of flood protection do not work. As the dykes have got higher and higher, so have the floods. In light of the tragic, costly and catastrophic flooding events across the Europe in a few recent years, the time has come for governments to begin working with nature rather than against it. Governments, as part of their legal obligations under the WFD, must begin to use wetlands and floodplains as part of an ecological approach to flood control. It is well known that wetlands and floodplains play positive role in alleviating the worst damages of flooding. Straightening of rivers from uplands to lowlands and excessive loss of natural inundation areas across many river basins, together with settlements right on the riverbanks have caused the unprecedented flooding damages. For sustainable future it is important to restore wetlands.

Dams and reservoirs are the main flood control structures. In recent years their construction is controversial issue. The current debate on dams and reservoirs has become dogmatic, emotional and counterproductive (Biswas 2004). The result is that construction of artificial reservoirs decreased drastically all over the world. It is not a promising solution. The main question is not whether dams and reservoirs have an important role to play in the future, but what would be the best possible design and where exactly should they be constructed. Water stored in artificial reservoirs can serve not only for flood control, but also is vital for many other goals as a source of drinking water, food and hydro-energetic production, support to the ecosystem etc. Reservoirs are multipurpose objects. Today very often they serve mainly for only one purpose, which is the main reason for disagreement among different stakeholders. The best decision on reservoirs operation should be based on an environmentally sensitive evaluation of the river and its catchment system, and the relative values of its use, both economic and ecological. It should be stressed that there is no one single solution valid for extremely heterogeneous natural and social conditions which exists in various regions. Reservoir performances in economic, social and especially environmental terms should be maximised and their adverse impacts should be minimised.

Flood management under physical and/or climatic changes has been a subject of much discussion in civil and hydraulic engineering design. These systems often have a service life of decades or longer. The practicing engineer cannot afford to wait for more definite answers about potentially important land use and climate change impacts before taking some measures. Due to this reason it is necessary to treat uncertainty in flood protection design due to climate change and man's activities. It means that a procedure for incorporating the impact of the uncertainty into risk evaluation of extreme flood losses should be involved.

Flood management is not an easy task, because rivers serve a large number of functions and flood warning must be given as soon as possible. The flood early warning system comprises three different tasks: 1) Data-acquisition; 2) On-line estimation; 3) Forecasting. In a last few decades, the operational use of flood early warning systems has spread over the world. Special problem is that the extensive theoretical descriptions of the flood forecasting systems available in the scientific literature are not backed up by the user's report on the efficiency of the systems both in terms of their practical use and in terms of the obtained results vis a vis the postulated objectives. This may indicate either that the forecasting systems are not really used or that their use does not provide successful results.

CONCLUSIONS

Although the study of water related disasters is in steady progress, there still remains a lot to be done. For Rosenthal and t'Hart (1998) one of the blind spots in disaster research continues to be cross-national knowledge of disasters and disasters management. During the last decades a number of encouraging efforts have been made to promote a more international perspective in disaster management. But as disaster and crises will increasingly feature transnational and even global characteristics, in this sense disaster and crises research are lagging behind. Investigations of disasters and crises cannot be limited to local and domestic events. They should cross the borders and engage in cross-national studies, which fit in the transnational dimensions of contemporary and future disasters and crises.

Our knowledge of the role of geosciences (especially hydrology) in the pattern development in water related risk management is poor. Transfer of information across spatial and/or temporal scales is one of the most fundamental issues in the water hazard and risk management investigation. Each region and catchment has particular natural characteristics, but the hydrological laws of water circulation are the starting point of any further understanding of the ecological relationships that govern productivity and biodiversity within it. Understanding these relationships is vital to successful and cost-effective nature conservation and restoration, and water hazard and risk management (RNAAS and DFCHS 2005).

General opinion is that whole society (governments, scientists, education system etc.) does not cope well with drought. Governments have tended to respond to drought from a posture of crisis management instead of risk assessment. Once a drought is over, relief efforts are dismantled and planning is forgotten. It should be improved ways of: 1) Predicting drought; 2) Detecting and monitoring drought and drought-related conditions; 3) Assessing drought impacts; 4) Effectively responding to drought. Social science and climate science are both critical to developing an effective drought plan. The current resources available for drought planning, data collection and analysis are very limited. There is very little documentation of past impacts of drought across multiple sectors and regions. New and more sophisticated and accurate approaches to monitoring drought conditions, implementing adaptation measures, and responding to drought should be developed.

Extreme floods in the recent time (Mississippi-Missouri, Vltave, Danube, Tisza, Rhine, Limpopo, Yellow River, Oder, Po, Inn etc.) have shown numerous weaknesses of existing forecasting and early warning systems in different countries. They have shown that improvements in their management are always possible and necessary. Improving the flood handling qualities of reservoirs, power stations and other hydraulic structures can be done. Some of river authorities started to design new large systems or upgrade the existing ones. New forecasting techniques have emerged, which may result in essential improvements to the forecasts. One of the first objectives is to report on the use of the existing operational flood forecasting systems in terms of their practical use and in terms of their performances meeting users' requirements. After that it is very important to describe the basic research on new technologies and emergent techniques including link to meteorological models, use of alternative measures and non-physically based approaches together with the place and role of these techniques within the flood forecasting and warning systems.

The objective of World Commission on Dams (WCD) is to review effectiveness of large dams and develop internationally acceptable principles, strategic priorities, criteria and guidelines for their application. Storage of water in large dams is of crucial importance, first of all for drought mitigation and flood protection. In the same time it is very expensive and ecologically dangerous solution. The problem is that the losses of water due to evaporation (and infiltration), especially in warm and arid regions are enormous. Answer on extremely complex and controversial question how best is possible to develop and operate dams and reservoirs most efficiently and precisely, where they are needed, should be one of the main concerns.

Of special importance is the establishment of firm network of contacts with leading independent scientists, who promote new ideas and concepts independently of mainstream directions.

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