Zeitschrift: ASMZ : Sicherheit Schweiz : Allgemeine schweizerische Militärzeitschrift

Herausgeber: Schweizerische Offiziersgesellschaft

Band: 169 (2003)

Heft: 11

Artikel: Cooperation or confrontation? : sustainable water use, property rights and transboundary conflicts

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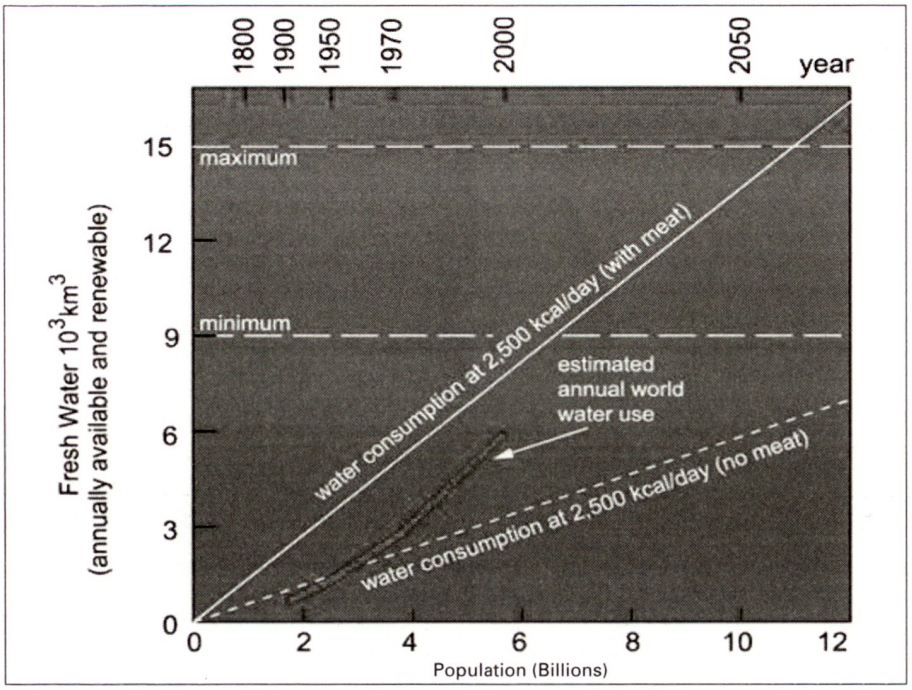
DOI: https://doi.org/10.5169/seals-68778

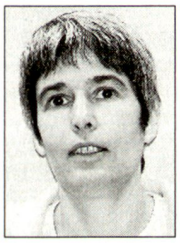


Zukünftige weltweite Verfügbarkeit von Wasser.
Source: Zehnder, Wasserressourcen und Bevölkerungsentwicklung, Nova Acta Leopoldina, 2002, NF 85, 323:399-418. Data: FAOSTAT (FAO) (2001) and World Resources Institute (WRI) (2001).

on their means that both the timing and the total availability of water to the downstream states will change, a situation that will anger Turkmenistan and Uzbekistan. Moreover as population increases and water availability decreases the situation is likely to deteriorate further. Reduced water availability will also have implications within the republics themselves especially in the more densely populated areas, such as the Ferghana valley, the lower reaches of the Amu Darya and the Zarafshen valley, with conflict at the local level creating instability within the individual countries themselves.

The management of water resources in the Central Asian region represents an enormous challenge and one that is becoming increasingly more complex. Such complexities are partly historical in nature and partly a result of the activities of the CARs since independence. The almost total lack of cooperation between the five states coupled with a failure to tackle some of the underlying problems of the water management sector mean that the situation is likely to deteriorate further and will effectively undermine the social, political and economic development of the entire region threatening regional security.

Literaturnachweise können bei der Autorin eingeholt werden. ■



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Cooperation or confrontation?

Sustainable Water Use, Property Rights and Transboundary Conflicts

Die Autoren gehen in ihrem Beitrag davon aus, dass das weltweite Wasserdefizit weiter zunimmt. Bleibt dieses Problem ungelöst, könnten gewaltsame Konflikte in den entsprechenden Regionen das Resultat sein bzw. sind es bereits. In diesem Zusammenhang wird auf die Fallbeispiele «Mittlerer Osten» und «Zentralasien» eingegangen. ag

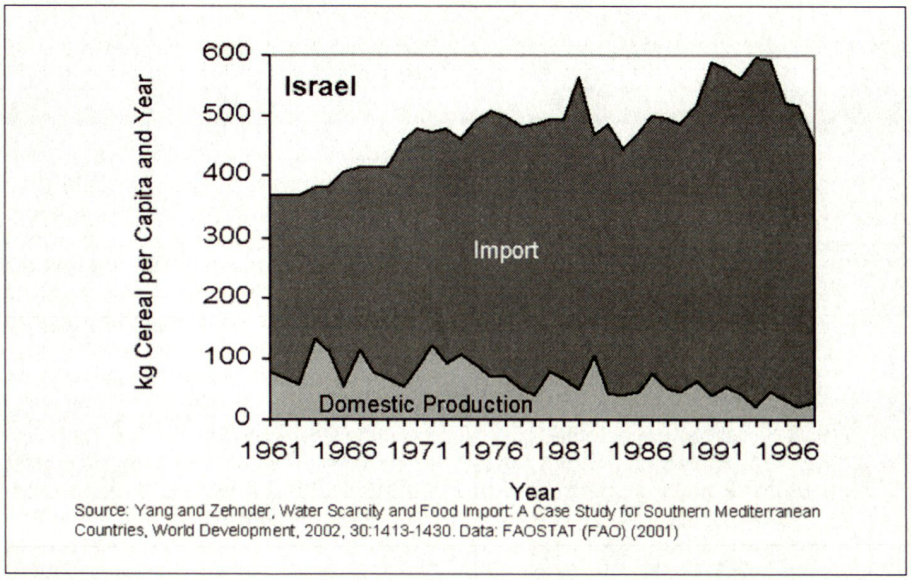
Urs Luterbacher and Ellen Wiegandt

The Project Goals and Approach

"The world is incurring a vast water deficit. It is largely invisible, historically recent, and growing fast." Social conflict, food shortages, disease are all potential consequences of water scarcities. Vulnerability of water resources is a thus major challenge to the international community. The problem is even more pressing because questions of future quantity and quality of water are linked to other critical issues such as climate change, property rights, and economic development. Numerous regions of the world are particularly at risk of potential shortages due either to physical or social causes or because of uncertainties about access generated by rapid and far-reaching political changes. The Middle East immediately comes to mind because water shortages are invariably linked to the broader conflict in which water has become a weapon. Similarly, Central Asia, particularly the Republics of Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan, is of particular concern because property rights issues related to water have emerged and become acute since the dissolution of the Soviet Union. Unresolved, these issues may provoke deadly conflicts in this volatile region.

Water availability is largely governed by physical processes, but water use is intimately tied to population size and density, technology, and life styles. Confronting scarcities thus depends first on understanding the evolution of social, economic, political, and environmental conditions as they affect water use. In this context, Switzerland has a special role to play because of its long experience in managing the vast water resources held within its mountains and because of its historic role in conflict resolution.

In this spirit, the project that we have undertaken examines current water use in the Central Asian republics and examines how it will evolve under various demographic, economic, and environmental scenarios. The analysis of factors that will influence



Source: Yang and Zehnder, Water Scarcity and Food Import: A Case Study for Southern Mediterranean Countries, World Development, 2002, 30:1413-1430. Data: FAOSTAT (FAO) (2001)

Changes and sources of per capita cereal supply, 1961–1998 (kg/per capita).

future levels of water use are also put in the context of the institutional and regulatory structures that determine its distribution, both within and between the Central Asian republics. **Our first objective is to understand what factors are the primary determinants of water use in the different regions of Central Asia and to predict how this water use is likely to evolve. The main goal is to provide tools to achieve peaceful distribution of scarce water resources throughout the region and to remove potential sources of conflict among the republics.**

To achieve this, we have developed a model of water use and management that includes not only social and economic factors influencing water use but also incorporates aspects influencing supply, such as geographic and climatic factors that determine the physical availability of water. The general model structure already exists and has been used to explore various resource and society interactions. In particular, it is been adapted to analyze the complex situation of the Jordan River Basin and can be applied to other specific examples, including but not limited to the Central Asian case that we propose to study here. The underlying notion is that it is necessary to provide an accurate representation of the evolution of water use in each case in order to develop scenarios of different population, climate or technology trajectories. The main value of the approach is that it allows for the introduction of different policy choices. These can then be evaluated in terms of their effectiveness in producing an optimal distribution of water in the region or on the contrary, their aggravation of water-related transboundary conflicts.

The ultimate goal of the project is to provide decision-makers with the means to prevent conflict through the design of management, regulatory, and pricing strategies for efficient use and equitable distribution of water. To this end, a comprehensive view is essential: climatic, economic or demographic conditions influencing the physical supply of water must be seen in the context of socio-political factors determining how much water is available and where. The conjunction of these two processes will determine the future peace and prosperity of the Central Asian region as well as others faced with grave water shortages.

Characteristics of Water Resources

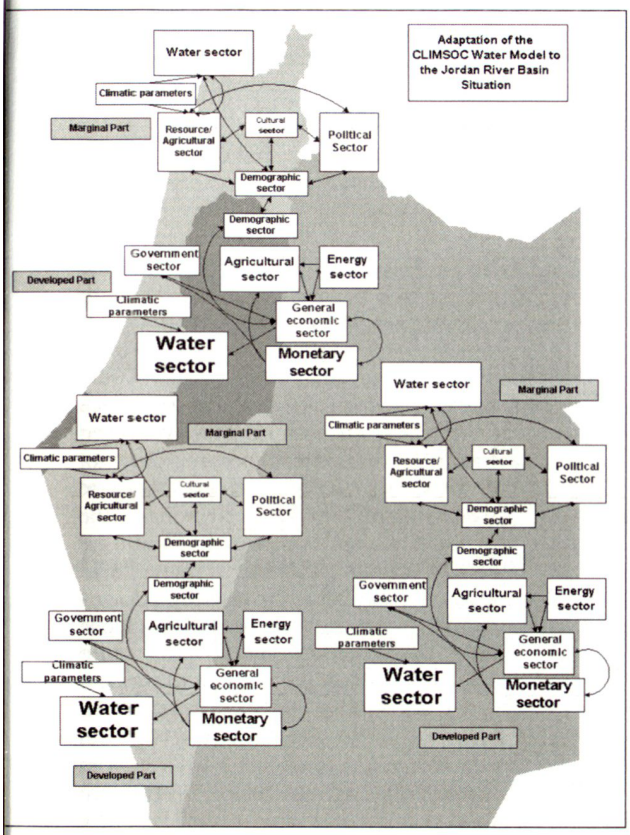
Because water is essential for survival and nothing can be substituted for it, societies have always been concerned with the best way to allocate it. Its very nature poses particular management problems, however. It is difficult to define it as a separate commodity and assign private property rights to it because as water flows, it is in a "constant state of diffusion" or movement and therefore a precise unit cannot be allocated to a single individual. Moreover, upstream regions have an advantage because they can help themselves first, leaving downstream users with insufficient quantities. Or, water may be found in pools of underground water, which means that property rights can be defined as an area of land above it, but it will not be clear whether the water extracted really comes from the area below this surface given the fluid nature of the resource. As a result, arrangements must be devised to prevent some groups or individuals from over-using water resources at the expense of others. Frequently the solution has been to define water as common property and to have a collective or central management structure. This poses its own problems of "free-riding" when users take the benefits from access to this common resource without paying their fair share of the costs. These kinds of problems become particularly acute when they are intermingled with other kinds of unequal economic or power relations. This Middle East situation is one example. Our model has proved capable of describing the complexities of the existing situation and providing scenarios that could reduce conflict over water between Israel and the Palestinians and Jordanians.

It is our contention that Central Asia is poised to become another region where structural problems become mixed with environmental issues related to water to set the stage for intense conflict. Adapting our model structure to this case will provide a tool for conflict resolution in the region.

In our proposed research, we apply a simulation model called **CLIMSOC** to the specific example of the Central Asian Republics. The model provides a general framework linking societal and environmental processes that has been expanded to include a sector-specific model, **CLIMSOC-Water.** It describes relations between climate and societies, derived from the general CLIMSOC model, and allows an analytical exploration of various issues related to water use. Underlying the model structure are several hypotheses concerning social systems, global climate change, and water resources. The model can thus capture the crucial interactions among both social and natural processes and can be used to examine various scenarios about future use. These scenarios in turn highlight implications for future conflict, economic development, and environmental degradation.

The Tools: Simulation Models

The hydrological system and its interactions with society's use of water are highly complex and contain many uncertainties. Therefore, the description of the key processes and interactions preclude use of empirical or statistical models. Instead, we construct *quantitative simulation models,* i.e. those that use mathematical formulations to express key relationships within the system. Theories about the function of physical and social systems are the basis upon which these models are developed. They are elaborated in quantitative terms so that it is possible to test hypotheses about the importance of changes in key variables for the evolution of other aspects of the system and to explore different trajectories they may take in the future. Such an approach can provide important insights for decision-making about global environmental change because it permits an analysis of impacts of physical change for social processes and vice versa. Modeling policy alternatives also allows for the assessment of consequences of political and economic



measures on the physical system and on society.

Therefore, in contrast to simple empirical or statistical testing procedures, simulation has the advantage of providing the decision-maker with a tool that can be adapted to answer specific questions about the effectiveness or consequences of policy choices.

Its features are particularly important when looking at the interactions between social systems and the environment. Many environmental changes cannot be based entirely on extrapolation from empirical observations. Modeling plays an important role in the prediction process itself, which is highly dependent on assumptions about some physical aspects but especially about social trends. Such social trends are often considered exogenously within natural science models of global environmental change but are best analyzed in terms of their feedback structures with natural processes.

The CLIMSOC-Water Model

The model's basic approach is to link water resources to climate change because alterations in temperature and precipitation affect the hydrological cycle as well as water use. It is a paradox that fresh water usage tends to increase when temperatures are high and in periods of drought. The study of water resources is thus closely tied not only to climate but also to all aspects of global environmental change. These resources are affected in both rural and industrial regions, and affected in different ways, by their consumption and thus degradation, which will eventually become part of the water cycle. General water consumption can be decomposed into three parts that affect rural and industrial regions differently:

- Consumption by households.
- Consumption by agriculture, mostly in the form of irrigation.
- Consumption by industry.

These three types of consumption take fresh water as an input and emit degraded forms of water in a variety of ways that then make their way into the water cycle. Each type of consumption is described in terms of the factors which influence its levels and evolution: 1) Population, 2) Economy and Resources, 3) Cultural organization, and 4) Government.

A demographic structure (1) divides population into age cohorts. Birth, death, and migratory processes drive the evolution of this structure. Births and migration are partially influenced by economic and resource conditions and by the cultural organization of land structures and institutional arrangements that include or exclude outsiders from the use of local resources.

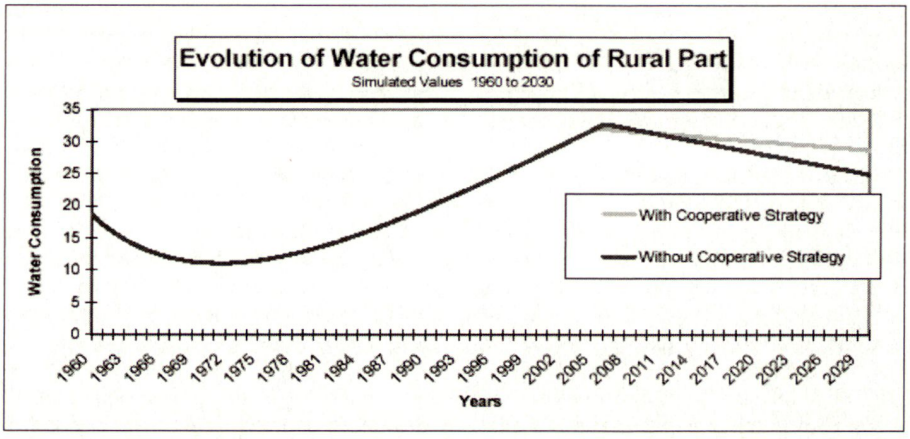
The economy and resource sector (2) describes, on the one hand, a traditional mixed agricultural system that includes both grain and animal production. This type of system is dependent on the establishment of relatively large inventories for survival and to some extent on the availability of government subsidies. Land, agricultural capital, the size of herds, manpower, and technology constitute the inputs for potential agricultural production. Manpower provides the link with the population sector since it is made up of the cohorts that are of the age to work (the active population). Actual agricultural production also depends on climatic factors such as moisture, temperature, and solar exposure. These data are derived from climate models. On the other hand, an industrial region is also modeled, focusing on the way water is used for energy, its direct role in industry, and domestic consumption. The two sectors are linked to provide a comprehensive view of the role of water in the economy.

Cultural organization (3) accounts for property and land tenure arrangements determined by inheritance rules and cultural factors that shape the size and distribution of plots of land and establish rules of access to land and water resources. Water rights, for example, are an essential resource that may be regulated locally or at higher levels of social integration. Availability is partly due to climatic features but more important for our study are the competing uses for water among different types of use: domestic, agricultural and industrial. This distribution is determined by property arrangements, prices, and regulations. These forms of distribution can vary over time. Even if rules themselves do not officially change, their enforcement can vary, so practice as well as theory must be carefully studied.

The government sector (4) collects taxes, distributes subsidies, and spends resources on some types of capital (such as collective equipment). It is obviously connected with the economic and resource sector. It also has the power to modify some forms of property arrangements and therefore influences water availability not only internally but also internationally given the fact that water flows across international borders.

Simulation and validation runs using this model show that it can track demographic evolution and water consumption rather well (See sample output presented below). Agricultural production is subject to diminishing returns and tends to level off. Population growth and migration obvious-

Jordan River Basin



Central Asia.

ly affect water use but the shift between production sectors and policies on industrial development have a particularly strong impact. Thus, the model will identify weak points in the system where conflicts among uses and, therefore, users could erupt.

As illustration, we present an example of how the model was previously applied to the Jordan River Basin. In this case, we analyzed water needs and water consumption in Israel, the Palestinian regions of the West Bank and Gaza, and Jordan, representing the empirical situation and suggesting ways to avoid conflicts over water (siehe S. 11).

Central Asia

Reports from Central Asia regularly alert the international community to worsening ecological conditions, the dire social and economic status of its population, and the ensuing potential for serious civil and interstate conflicts. The situation is particularly complex and delicate because familiar problems of over-extensive irrigation agriculture and population increase have become mixed with interstate politics as a result of the collapse of the USSR, as a consequence of which, "a very complex water management problem became a very complex transboundary water management problem".

Riverine water resources, especially from the Amu Darya and Syr Darya rivers play essential roles in the economy and society of the Central Asian states of Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, and Kazakhstan, all dependent in varying degrees on irrigated crops for survival. Cotton, for example, the most important irrigation crop, is the major source of income and employment in Turkmenistan and Uzbekistan. In direct conflict for this same water is energy production. Kyrgyzstan and Tajikistan rely on hydropower for 50% of their electricity production.

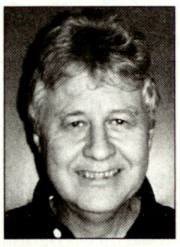
These competing water uses are aggravated by demographic pressures.

Although tensions over water allocation are not new, they have taken on new significance since the collapse of the Soviet Union. Previously managed from Moscow by a centralized administration, water systems have suddenly come under the control of separate sovereign states that have no history of agreements or coordination structures. This poses important allocation problems because of the nature of water resources and the weakness of new state institutions in the Central Asian republics.

Indeed, there are important downstream/upstream issues that have emerged since the regions have gained the status of independent republics. Upstream states Kyrgyzstan and Tajikistan need water for hydroelectric production as well as irrigation, while Kazakhstan and Uzbekistan use water mostly for irrigation. The upstream republics have held up release of water or threatened to charge for delivery downstream in order to pressure downstream users to compensate for energy production forgone when water is released for downstream irrigation. It is important to note that despite their control over the source of water, upstream states are implicated in allocation schemes that oblige them to provide water downstream. In breaching their commitments, which they do or threaten to do, they become vulnerable to reprisals from downstream states that can, and have, refused to provide energy in the form of natural gas and coal in return for water.

It is common wisdom that resources whose allocation proves problematic because of the difficulty of assigning clear, unambiguous property rights are generally managed through common or centralized property institutions. This was the case under Soviet rule. The central state was able to enforce exchanges of water and energy between upstream and downstream users. At present, the previous patterns are maintained but they are not perceived to be equitable. Kyrgyzstan and Tajikistan would like to expand irrigation agriculture as well as electricity production. However, even their dominant upstream position does not permit them to achieve their goals because of their political weakness in front of the downstream users' control over coal and gas and the energy produced by these fuels. However inequitable an upstream/downstream relation may be, it will be stable unless the downstream user has other resources or power with which to pressure those upstream that control access to water. The asymmetric distribution of resources in the Central Asian republics is just such an example of an unstable relationship between users of a same natural resource with unclear property rights. **There is no obvious solution that is both equitable and efficient. Management schemes must therefore be negotiated and again here use of techniques outlined above will be very helpful.**

Literaturnachweise können bei den Autoren bezogen werden. ■



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