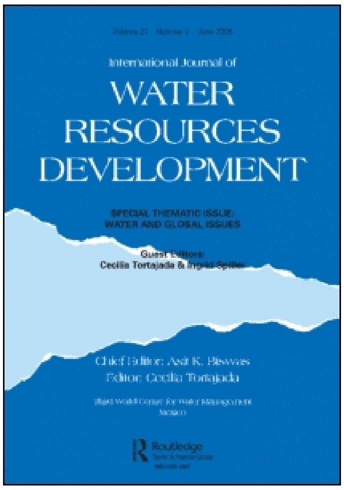


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# Towards a New Philosophy of River Engineering in Japan

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# Towards a New Philosophy of River Engineering in Japan

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ABSTRACT *Rivers are an important part of nature. River regime always changes in accordance with natural law. Rivers react to human activity including river works, often with an undesirable effect. River management must be planned sensitively from upstream to the sea. River basin management is necessary for flood control, water resources development and conservation.*

## Introduction

As a result of the field investigations carried out on the Shinano and Chikugo Rivers during the 1950s and 1960s, the interrelationships between river improvement works and the changes in river regime were recognized.

As an expert witness to a legal process in 1962 that arose because of the opposition to a dam project between the government and the affected residents, I realized the importance of good relationships between the two parties as well as of providing information to the public on a regular and timely basis. During the course of extensive research on Chinese rivers from 1979, I found several types of river regimes. Field studies of the qanat system in Syria and Algeria between 1978 and 1980 indicated the development of different lifestyles because of hydrological conditions. These experiences were most helpful to advance a theory of river regime. Later on, I realized the importance and relevance of the Asian monsoon had not been fully appreciated, not only climatically but also in cultural terms.

## What is River Regime?

During my student days at the University of Tokyo from 1947 to 1955, I was influenced by Professor Koichi Aki's concept of *Kasôron*. It is a river regime theory that emphasized the special characteristics of each individual river (Aki, 1951). This theory led to new ways of approaching river engineering. The main issues raised by the theory are as follows:

(1) Each river has unique characteristics. For the planning and design of proper engineering works, these must be compatible with the specific characteristics of each river.

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(2) A river always tries to reach an equilibrium with the changing conditions. Thus, for the design of engineering works, river regimes should not be considered to be stable. The regime invariably changes over time so that it can reach an equilibrium with the changing conditions.
(3) During the research investigations on the Shinano and the Chikugo Rivers, I applied the idea of *Kasôron*.

## All River Works Including Dams, Barrages or Flood Controls always Contribute to Undesirable Effects

For my graduate thesis at the University of Tokyo in 1950, I studied the adverse side effects due to the floodway of the Shinano River, which at 367 km is the longest river in Japan. Among such detrimental effects were the coastal erosion around the old river mouth in Niigata city, new accumulated sediments at the mouth of the floodway, and the constraints imposed on navigation and irrigation by the aggradation and degradation of the old riverbed, downstream of the weir. Although the floodway resulted in the protection of large paddy fields from flood losses, the impacts of the side effects were not predicted. It is thus essential that the river engineers should always forecast the type and magnitude of the side effects that may arise because of incurred damages to the large-scale river works.

The study of the Chikugo River after the 1953 flood found flooding was due to the rapid speed of the flood wave and also because of the higher peak discharge, which had not been observed since 1885. The changes in the intensities and the duration of the flood flows mainly depend on the types of river improvement works, especially with a higher continuous levee system and rapid development in the basin.

Similar impacts can be noted on almost all the major rivers of Japan, where high continuous levee systems were constructed. From 1945 to1959, almost all major Japanese rivers experienced levee breaks. Increases in the peak flood discharges meant that the probabilities of levee overflows became higher (Takahasi, 1971). This finding was contrary to the fundamental basis of Japanese policy since 1896, when the River Act was formulated. The alteration of the flood regimes by modern engineering works, which were carried out extensively in Japan, was caused by large-scale river control works. It should be noted that engineering works to control rivers are not single processes. Their impacts are hard to predict because of the dynamic nature of all river regimes. The limitations of current works to solve, or control, such problems must be acknowledged.

All rivers have physical characteristics and social implications. However, techniques invariably modify the physical characteristics of the rivers. After World War II, river projects in Japan were obliged to consider social issues and impacts. This was one of the main reasons why, because of changing social and physical contexts, the engineers and administrators faced difficult situations.

## Inter-disciplinary Research

In 1956 I was nominated as a special member for flood control and water resources of the Resources Council at the Prime Minister's Office. I was part of this Council for 35 years until 1991. The Council was established in 1948 after the recommendation to reconstruct Japan through resources development of the Allied Powers for the Occupation and Control of Japan.

Dr Edward Ackerman (1911–1973), a geographer, played a leading part to guide the Council through its work as a member. The Council presented many useful recommendations and official reports to the Japanese Government. Dr K. Aki was the first Director of the Council.

Work with the Council proved to be a considerable educational experience because there were heated discussions with the many different types of specialists. The members had backgrounds in geology, geography, hydrology, forestry and agricultural economics and so these interdisciplinary discussions were very helpful to plan flood control projects.

Through my work experience at the Council, I understood and appreciated the importance of the interdisciplinary training approach to river engineering. From 1956 to 1968, the interdisciplinary research was carried out for five river basins. They were the Chikugo River in Kyushu; Ishikari River in Hokkaido; Yoshino River in Shikoku; Mogami River in north-eastern Honshu; and Kuzuryu River in the Japan Sea side of Honshu.



## The Study of Chinese Rivers and Field Investigations in the Desert

China has many different types of rivers, ranging from those in the desert area in the north-western region to the humid monsoon areas in the south. Hydrological conditions primarily govern the river discharge regimes and China has numerous rivers with different types of flow regimes.

China has over 4000 years of history in flood control. In particular, the experience with the flood control of the Yellow River is unique. It has a difficult history where many engineering methods have been tried. This experience in China further broadened my knowledge and understanding of rivers.

Field surveys in the desert regions of Syria and Algeria also proved to be an extraordinary education. The lessons from the experience in China and desert regions in the Middle East made me recognize the essential relations between hydrological conditions and their relations to the day-to-day lives of the people (Kobori *et al.*, 1980).

## The Future of River Engineering

On the basis of these experiences in various parts of the world, the following recommendations can be made:

(1) River engineers must develop a deep historical view. Because a river is always changing, its regime must be integrated with history. To know the specific characteristics of each river, it is necessary to learn the history of that river. The history should include the human actions on the river, such as the improvement and flood control works, dams, barrages, intake canals, etc. They should also include the history of disasters such as flood damages, droughts, water pollution and ecological destruction. It is essential to learn the side effects contributed by the above-mentioned works.

For flood damage studies, it is also necessary to consider practices. This is because the extent of damages will depend upon how the land is being used. Regrettably, even now, research on flood control focuses primarily only on decreases. Without studying changes in land use, it will be difficult to find the true cause of the damages, particularly when the land use practices have changed and considerable developments have taken place.

(2) River engineers must carefully observe the river and understand it. The most important teacher for the river engineers is always the river itself (Takahasi, 2004).

Most regrettably, because of the advances in remote sensing and computer information technologies, the importance of actual field observations has been declining. This is sad. A river follows its natural laws and not computer analyses, views of scholars or engineering estimates. A river engineer should visit a river when it is flowing normally as well as during floods and droughts, understand and appreciate its unique characteristics, and become familiar with its ecological and social dimensions. One cannot fully understand the behaviour of a river sitting in an air-conditioned office and by modelling its regime through a computer.

(3) A river engineer must consider the entire river basin. Projects for flood control, water resources development, conservation and ecological measures must always be formulated by considering the river as one organic body, from its headwater to the sea, through the alluvial plain and deltaic areas.

Connectivity from the upstream to the downstream is the keyword for ecological conservation, and this must be considered to reduce the potential damages by the engineering structures. Such connectivity is not only important for its ecological integrity but also for sediment transport, consideration of water quality, and the historical diffusion of culture.



It is also necessary to find out the impacts on the river regime by development plans of the basin. For example, land development may cause an increase in flood flows, and inappropriate land management may cause considerable harm to the river. Development planners and water managers must be intimately familiar with the close interrelationships between the developments within a river basin and its implications to its flow regime.

These ideas were discussed in a book *Kasen Kôgaku* [*River Engineering* ] which was published in 1990 by the University of Tokyo Press (Takahasi, 2008). This book received the Book of the Year award in 1991 from the Japanese Society for Civil Engineers. It became one of the best-sellers among the academic books published by the University of Tokyo Press. It included ecological and landscape considerations in terms of river engineering, in addition to analytical methods based on hydraulics and hydrologic principles.

An important component of river engineering is to understand the historical view of rivers and to emphasize the co-existence of the river as an integral part of nature (Takahasi, 2007). River engineers must understand that rivers exist as a part of nature, and they are part of hydrological cycles. The most important role of river engineers is not to construct the river work without understanding the 'soul' of a river. Any construction must harmonize with the needs of local inhabitants in the basin and the laws of nature.

## Planning River Projects to Cope with Climate Change

It is now widely accepted that due to climate change, hydrological trends will change as well. This may mean the degree of safety in the current measures of flood control, water resources planning and protection from tsunami and storm surges may be severely reduced in the future. The river engineers thus must face major changes in existing policy measures to cope with the anticipated changes.

If the magnitudes of the floods and storm surges increase in the future, a fact that is widely anticipated at present, it will be impossible to protect all lands near rivers and coastal areas by only structural measures. The flood control policies must change completely by introducing controls that may have to be placed on new developments in flood plains. Unused lands, fallow areas and wetlands have to be considered as floodwater retaining basins to reduce the impacts of the future floods. These measures have to be taken in cooperation with the river authorities, city and regional planners and agricultural organizations.

Throughout history, a fundamental concept behind an enlightened flood control policy has been how best to harmonize structural and non-structural measures effectively. The key issue has been how to control land use so that flood damage could be reduced. If such measures cannot be taken, losses can only increase disasters in the future.

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