Chapter 2
Issues and Problems Regarding Water in Developing East Asia

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Abstract In this chapter, the concepts of water circulation on the earth and scarcity of water resources are explained first. Then, water problems and issues are summarized, including the fact that polluted water does not function as a water resource. In addition, a number of water problems and issues (i.e., flooding, water scarcity, sea level rise, and water pollution) are systematized. Then, the impact of such issues on the degradation of water quality and difficulty in accessing potable water are treated. Finally, the deficiencies in existing legal systems, financial predicament, and poor governance are explored as trigger elements. Most Asian countries are subject to monsoon rainfall patterns, and many have tropical climates. These, of course, are completely different from the climates found in Europe and North America. Accordingly, Asians need to develop our own methods to cope with Asian climate, particularly with typhoons (cyclones) and periods of heavy rainfall. In conclusion, the notion of Integrated River Basin Management is explained to promote the wiser use of water.

Keywords Water resources • Flood • Drought • Water pollution • Water problem • Water issue • Asia • Population increase • Urbanization • Economic development • Climate change • Sanitation • Integrated river basin management

2.1 Introduction

Clean, freshwater is essential for human survival and activities and the maintenance of ecosystems on land. Fresh water, however, makes up less than 3 % of all the water on the globe. Moreover, only 0.01 % of all water is in lakes and rivers available for use by humans and other living things. For marine organisms, clean seawater is also essential.

Water is a circulating substance, meaning that, on the human scale of time, the supply can never be exhausted. Evaporation of a small portion of the seawater on our planet (total volume 1338×10^6 km^3) provides 87 % of total evaporation, which is the major source of fresh water. Water conveys substances through circulation,

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from the hydrosphere via the atmosphere to the geosphere. The hydraulic retention time of water in the atmosphere, slightly less than 10 days, suppresses atmospheric pollution. On the other hand, the retention time in the sea, about 3000 years, brings about pollution of the abyssal regions.

The circulation patterns of water sometimes bring about floods and, at other times, droughts. Human beings have struggled to cope with such extremes since time immemorial. Recent extreme weather conditions have obliged us to experience what we have not ever before experienced. Increasing human population and activities, rising living standards, poor governance, and enclosed water resources also lead to new experiences regarding water stress.

Water usage does not mean real consumption because it cycles, but pollution does. Polluted water does not function as a renewable resource. Polluted water can be made clean again; this is technically possible, but too costly on massive scales to be sustainable. Even in the future, development of more suitable technologies may not make it economically viable.

The importance and roles of water in societies are exemplified in the following visionary statements in history: "To control China, one must first control water" – Guan Zhong, a politician and statesman during the Spring and Autumn period of Chinese history (c 720–645 BC), and "He who solves water problems in the world deserves two Nobel Prizes, one for Peace and one for Science" – former President of the USA, the late John F. Kennedy (1917–1963). Water is necessarily a major and increasingly important concern in any movement toward a sustainable society.

Due to the UN MDGs (Millennium Development Goals 2000), which we are required to achieve by 2015, about 500 million people on earth lack access to clean drinking water. About 1.2 billion people lack basic sanitation services, that is, provisions for treatment of wastewater and solid wastes. More than 200 million people regularly suffer from flooding, and most of these people are concentrated in Asia and Africa. Even though the current MDGs have not yet been achieved, we are still in need of new goals for the more distant future.

2.2 Structure and Elements Regarding Water Issues and Problems

2.2.1 Current Water Issues and Problems

There are a number of issues and problems regarding water. Regarding quantity, we must be concerned with flooding and lack of water resources; for storage, we face challenges from rising sea level. With transport, access to water resources, transport of pollutants and sediments, and the spread of pathogens complicate our lives. A number of social problems (e.g., poor governance, poor sanitation, insufficient capacity building) complicate all other problems. We face pollution factors including acid rain, eutrophication, and oligotrophication (excessive and inadequate nutrients, respectively). All these, singly and in concert, result in major ecological problems, leading to the degradation of biodiversity. Direct influences on water problems may lead to secondary problems in chain reactions.

Most of the countries in the world, apart from those in Asia, have ever experienced precipitation levels of 2000 mm per year, nor a true monsoon climate. In worldwide congresses and conferences, the intrinsic problems of water in Asia are sometimes not reflected in the main themes. Countries in Asia have social problems regarding population and economics that are different from those on the European and American continents. Countries in the monsoon and tropical zones where the climate is different from European and American countries have gotten news out reporting their water issues and problems, especially flooding.

2.2.2 Structure of Water Issues and Problems

Problems regarding water emerge in those areas where people live and/or items exist upon which people are working. The places where people cannot get any water have no problems regarding water, because there are almost no living things. Numerous life forms may exist within a given environment with dynamic stability. Even if the local environment undergoes change in its water balance, it would not cause severe problems so long as it changes within the limits of the physical and social resilience of its inhabitants. Changes that go beyond these limits would be expected to cause problems. This means that problems regarding water do not result from the total quantity of existing water, but from changes in the quantity. The characteristics of issues and problems regarding water depend on climate, morphology, and history of social conditions.

There are various factors that could cause the impacts we fear from changes related to water. In the future, factors causing impacts will likely include:

Rapidly growing populations
Urbanization
Uncertainties about the impacts of global climate change and weather extremes
Unexpected change in atmospheric and surface water circulation
Possible conflicts regarding overuse of freshwater and natural resources in coastal zones
Enclosure of water resources, especially on transboundary rivers, such as construction of reservoirs immediately upstream of the border
Poor governance
Lack of investment funds for management, construction, rehabilitation, and research

Looking toward the future, we may be able to solve such problems with technology. New applications of technology may reduce water problems, perhaps by better construction of reservoirs and purification followed by reuse. Taken together, these may decrease water scarcity. However, the technological development is supported by investment arising from the benefit of economic development. It also seems that it is not easy to solve all problems in this way, because economic development itself may bring about pollution in its growth stage. Industrialization is deeply concerned with economic development and just as deeply impactful on the environment. An economic surplus produced by development should be invested to improve the environmental situation. Thus, degradation of the environment can be reduced by means of economic development, which itself is one of the causes of the degradation of the environment.

Past experience indicates that a time lag exists between causes and the emergence of resultant impacts. To avoid following in the steps of our predecessors (advanced countries), we need a new advanced paradigm to prevent pollution in the early stages of development. This will require a lower level of total investment to maintain a good environment, as future development proceeds. Taking late countermeasures to pollution may result in higher GDP, but taking preventive measures brings about a better society where people will not have to experience heavy pollution. We would like to construct a society where pollution is not a by-product of economic development.

2.2.3 Characteristics of Water Issues and Problems

Water issues and problems have some fundamental characteristics that may provide means to provide simple solutions to at least some of them.

1. Locality

   The fundamental area unit of a water issue or problem is a river basin or a watershed. The circumstances of any one river basin regarding climate, population, land use, and industry are always different from those of adjacent river basins. The fundamental area unit is enlarged, in cases where the water provided is conveyed a long distance, across the boundaries of multiple basins, as is the case in San Diego, USA; Beijing, China; and Fukuoka, Japan. Generally speaking, specific issues and problems regarding water are local, but they are regarded as a global problem since there are numerous similar incidences all over the world.
2. Water shortage

   Water shortage results from an imbalance between existing water resources and water consumption and is not a direct consequence of the absolute amount of water present. When assessing the risk of water shortage, usage of more than 40 % of precipitation and a water supply of less than 1700 m^3 per capita per year in a region indicate a high probability. As a general rule for water basins occupied by humans, a water consumption ratio of 70:20:10 (for irrigation, industry, and daily living, respectively) is typical. Reallocation of water resources (among the three major categories) is one solution regarding drinking water shortage problems.

3. Conflicts

   History is littered with examples of competition and disputes over shared freshwater resources. It seems inevitable that tensions over water resources will increase as more and more people compete for a fixed water supply. Improving standards of living increase the demand for freshwater, and future global climate changes will make supply more problematic and uncertain. About 240 rivers, or other sources of fresh water, are shared by two or more nations or regions. This geographical fact has led to a geopolitical reality of disputes over shared international rivers such as the Mekong in Southeastern Asia; the Amur (the Heilong) in Eastern Asia; the Indus, Ganges, and Brahmaputra in Southern Asia; the Nile, Jordan, and Euphrates in the Middle East; and the Colorado, Rio Grande, and Paraná in the Americas. Problems regarding water quantity and/or quality of international rivers crossing national boundaries are called "transboundary problems," or in other words, "upstream-downstream problems."

   While regional and international legal mechanisms can reduce water-related tensions, these mechanisms have never received the support or attention necessary to resolve the numerous conflicts over water. Not all water resources disputes lead to violent conflict, but they have occurred in certain regions of the world, including Southern Asia and the Middle East. Chemical accidents that contaminate transboundary rivers can cause similar problems. The Danube River, under initiatives by the EU, has a water commission that coordinates the activities of all the nations inside the basin.

4. Dependence regarding economics

   Economic development followed by environmental degradation is not an example to be followed. This lesson has already been learned: water pollution should not be a by-product of economic development. Economic development with preventive measures aimed at preventing environmental degradation in advance is the example to be followed. Simultaneous investment in both economic development and environmental protection is a better way to reduce the total amount of investment required.

2.3 Development of Water Issues and Problems in Asia

2.3.1 Population

Asia is the world's largest and most populous continent. It covers 8.7 % of the Earth's total surface area and includes 30 % of its land area. With approximately 4.3 billion people, it hosts 60 % of the world's current population (2010). In 1950, the world population was 2.5 billion people and that of Asia was 1.4 billion people. Asia has had a high growth rate in the modern era. During the twentieth century, the Asian population nearly quadrupled.

According to the United Nations, many East Asian countries have experienced a decline in their total fertility rates over the past 50 years. In the period from 1965 to 1970, the average family had five or more children. From 2005 to 2010, the average shifted to less than 2.1 children per family. Based on historical growth rates and national calculations, it is estimated that between 2000 and 2050, national populations are expected to increase in every country of East, Southeast, South, and Central Asia, apart from Japan and Kazakhstan. Populations will double or nearly double in Pakistan, Nepal, Bangladesh, Afghanistan, Cambodia, and Laos. Growth rates will also be particularly high in India, Indonesia, Iran, Malaysia, Mongolia, Myanmar, the Philippines, and Vietnam.

2.3.2 Urbanization

Mainly because of rural-to-urban migration, Asia is the fastest urbanizing region in the world. According to UN estimates, the urban population in Asia will have nearly doubled in 30 years. By 2030, more than half of Asia's population will live in cities: a projected 2.6 billion people. The urban population of Asia will be higher than the urban population of all the other regions of the world. In 2025, the proportion of urban population is projected to be 52 % in East Asia, 53 % in Southeast Asia, and 45 % in South and Central Asia. More than half of the national populations will be urban in Brunei, China, Indonesia, Iran, Japan, Kazakhstan, Malaysia, Mongolia, North Korea, Pakistan, the Philippines, Singapore, South Korea, and Turkmenistan. This urbanization of national populations is reflected in the growth of Asia's largest cities. In 1975, there were only five megacities (with a population of more than ten million) in the world, and only two of these were in Asia. In 2015, 15 of the world's 23 megacities will be in Asia. This rapid and largely unplanned expansion of urban areas has resulted in serious problems of air, soil, and water pollution. Despite rapid urbanization, Asia's rural populations are also projected to grow. Most of the region's rural areas are already densely populated.

2.3.3 Economy

Asia has the second largest nominal GDP of all continents, after Europe, but it is the largest when measured in purchasing power parity. As of 2013, the largest economies in Asia are China, Japan, India, South Korea, and Indonesia. It is forecast that India will overtake Japan in terms of nominal GDP by 2020. By 2027, China is expected to have the largest economy in the world. The rapid, largely unplanned expansion of urban areas has also resulted in high rates of unemployment and underemployment.

2.3.4 Climate

1. Climate changes

   The water-retention capacity of the atmosphere increases by about 5 % with every 1 °C rise in temperature. Increasing temperatures are expected to make wet regions wetter and dry regions drier. Anticipated changes in atmospheric circulation patterns will push storm tracks and subtropical dry zones toward the poles. Most regions, as a result of rising temperatures, are losing snow cover on the ground (small area of deposit and earlier melting). Global warming may increase extremes regarding climate, including torrential rain, heavy snow, and drought that could lead to desertification.
2. Monsoon zone

   South and East Asia consist of tropical and temperate zones, part of which is in the Indian Ocean monsoon zone. The Asian monsoon zone includes subsystems, such as the South Asian monsoon, which affects the Indian subcontinent and surrounding regions, and the East Asian monsoon, which affects southern China, Korea, and parts of Japan. Since the monsoon zone has both rainy and dry seasons, the annual availability of water depends on the capacity of reservoirs.

2.3.5 Floods

As mentioned above, climate change will mean that floods and flash floods increase in magnitude and frequency. Single typhoons in Southern Asia have killed hundreds of thousands of people in Bangladesh through flooding of low-lying lands. Recently a large number of floods have been observed, such as that in Australia (23 January 2011); in Thailand (22 August 2011); in Myanmar, Thailand, Cambodia, Laos, Vietnam, China, the Philippines, and Indonesia (22–25 September 2013); and in the Philippines (11 November 2013).

2.3.6 Groundwater and Water Resources

Precipitation strongly affects existing water resources for people, but not directly. Between precipitation and supply of water to people, an infrastructure exists to purify and convey it. Regions where fossil groundwater is the predominant source, like the Loess Plateau in China, will face water shortage as the aquifers are depleted. On the Loess Plateau, the water table has been receding by more than 60 cm/year and is currently at a depth of several tens of meters. Such depletion of fossil groundwater makes society in these areas unsustainable.

2.3.7 Water Supply and Water Scarcity

Water scarcity has three aspects: lack of water resources (physical scarcity), greater demand than supply (social scarcity), and inadequate supply due to a lack of investment (economic scarcity). Water scarcity may occur in areas where there is plenty of rainfall or freshwater. Allocation of water resources and quality of water are also of importance. In China, to compensate for water shortage, water from the Yangtze River is transported across the Yellow River to the capital area.

From 1990 to 2010, millions of South Asians gained access to improved drinking water sources. However, this still leaves some 170 million people not using drinking water from improved sources. These unreached masses, mostly in rural areas, continue to rely on unprotected surface sources and unimproved sources. More people would be using improved drinking water sources if not for the fact that, at any given time, up to a quarter of South Asia's public water supply systems are not operational. This is due to breakdowns, poor maintenance, declining water sources (now exacerbated by climate change), and generally aging infrastructure.

2.3.8 Wastewater Treatment and Sanitation

In South Asia, the pace of sanitation improvement has not kept up with population growth. In 2010, the region had about 1057 million people without improved sanitation, some 30 million more than in 1990. Even worse, 692 million people in South Asia have no toilets at all and defecate in the open. In India alone, some 625 million people practice open defecation. From 1990 to 2010, South Asians increased sanitation coverage from 22 to 38 % of the population. During this 20-year period, 369 million people gained access to sanitation.

In South Asia, urban populations are twice as likely to have use of improved sanitation facilities as rural ones (60 % versus 28 %). Even so, urban sanitation coverage in the region has stagnated in recent years. The number of urban dwellers in South Asia having use of improved sanitation facilities rose from 134 million in 1990 to 196 million in 2010. While the richest quintile has 92 % coverage, the poorest quintile has only 4 % coverage.

For better sanitation and recycling resources, a toilet system with separate collection of urine and feces and a bio-toilet system for composting of raw sewage have both been commercialized.

2.3.9 Water Pollution and Sediment Transport

In Asia, rivers large and small are polluted with household wastes including pathogens, chemicals (e.g., detergents, pesticides, fertilizers), industrial waste, and oil. Lakes and coastal zones in Asia are often heavily polluted with a cocktail of harmful substances (dioxins, heavy metals, chemicals, fertilizers, industrial waste). The existing concentration of contaminants in the food chain brings about some health risks. In Japan, some semi-closed bays are so oligotrophic (poor in nutrients) that fisheries there are impacted. Lake Taihu in China exhibits pulses of extraordinary growth of phytoplankton, that is, algal blooms.

Rivers convey not only pollutants, but also sediments. Sediment transport in rivers is a significant part of an ecosystem, but natural (or accelerated by human activities) sediment deposition within rivers fills the drainage basins, thus increasing the risk of floods (e.g., Yellow River in China). On the other hand, sediment deposition in coastal areas provides essential littoral nourishment. In Japan, decreased sediment transport to the coastal zone causes environmental and ecological problems.

2.3.10 Acid Rain

Asian cities are among the most polluted in the world. Of the 15 largest cities on the planet with the worst air pollution, 12 are in Asia. Acid rain lowers the pH of surface water and has impacts on the biogeochemistry of ecosystems.

2.4 Integrated River Basin Management to Solve Problems and to Discuss Issues

Integrated river basin management (IRBM) has proven an effective management approach for solving the kinds of problems mentioned above and for providing forums for discussion of critical or significant water issues.

2.4.1 Elements of Integrated River Basin Management

The aim of IRBM is to provide effective responses to increasing demand for societies to develop economic (particularly industrial) activities while maintaining quality of life, accustomed activities, and aquatic environment in a desirable condition, at an achievable cost.

Effective basin planning requires as its foundation the intelligent use of information on the planning elements of population, land use, infrastructure, industry, and water circulation. These elements also include available technologies for water supply, wastewater treatment, disaster prevention, and protection of aquatic organisms. Also important are essential support, such as a legal system to control water quality and quantity; relevant technologies (GIS, modeling, measurement) for planning and estimation; involvement of stakeholders (agencies, businesses, and citizenry) and experts for decision-making; and capacity building for sustainability. Control of the amount of pollutants discharged from sources and water utilization considering water quality are also relevant elements.

2.4.2 Concepts for Management

To obtain solutions, it is necessary to integrate knowledge, effective action by organizations, and relevant legal framework (clear authority and enforcement). Seeking an optimum solution would seem the obvious target for management, but each element constituting the IRBM system remains dynamic, including the sense of value of the stakeholders, during any particular process. This means that "optimum solutions" are also dynamic or not stable. Usually we look for the least-complaint resolutions, which are also dynamic. There are numerous trade-off issues regarding water management, such as the human uses versus protection of biodiversity, allocation of water between categories (irrigation, industry, and daily life) and regions (upstream-downstream problems), cost allocation between present and future generations, and the higher income of inhabitants versus investment for construction of water pollution control facilities (often via taxation).

At present, the typical procedure by which water problems are solved occurs in the order drivers (causes), pressure on environment (pollutants), state change (pollution, ecological damage), impact to humans and ecosystem (consequences), and then response policy and countermeasures. A more modern and effective procedure would be drivers (causes), preventive measures (purification, effective allocation), and no state change. Concisely, the shift from DPSIR to DPN should lead to more efficient development.

2.4.3 Objectives of IRBM

The optimum solution for IRBM could be either a single one or a combination solution with weighted objectives:

Maximizing social benefit
Maximizing social fairness
Minimizing social loss

Minimizing social conflict
Maximizing biodiversity

In practice, effective solutions will likely be a combination of some of these objectives.

2.4.4 Management Procedure

To understand how water circulates in a basin system requires a broad range of expert knowledge (e.g., hydrology, hydraulics, sanitary engineering, urban planning, and wastewater treatment). To provide a context for the solution of water problems, a great deal of more information about conditions in the basin must be integrated (e.g., ecology, sociology, and economy). Finally, access to a wide range of technologies is required for effective IRBM.

A reasonable management procedure might involve the following objectives:

- To understand the natural water balance and artificial usage in the targeted watershed
- To monitor the environment long term and to provide the data needed to understand the current situation and future change
- To understand environmental conditions using modeling and analyses
- To understand social needs in the area
- To determine effective policy for management of the watershed
- To establish indices and criteria for decision-making
- To provide a future perspective on management using predictive models
- To acquire and/or modify the technologies necessary for management
- To explore management performance using simulation
- To build a partnership of stockholders within the basin and with relevant people and agencies outside the basin
- To arrange funding and/or investment to enable effective management

2.4.5 Calculation Methods

The following are the fundamental equations involved in IRBM. The objective function for maximizing social benefit is:

$$\text{Max } V = aV_{\text{pro}} + bV_{\text{ben}} - cV_{\text{risk}} + dV_{\text{ecol}} \tag{2.1}$$

where V is value; a, b, c, and d are coefficients of weight; *pro* is production; *ben* is benefit; *risk* is risk; and *ecol* is ecology, and the following assumptions apply (i.e., given that):

$$Q_{\mathrm{tot}} = Q_{\mathrm{agr}} + Q_{\mathrm{ind}} + Q_{\mathrm{urb}} + Q_{\mathrm{ecol}} \tag{2.2}$$

$$V_{\mathrm{pro}} = f_{\mathrm{pro.agr}}(Q_{\mathrm{agr}}) + f_{\mathrm{pro.ind}}(Q_{\mathrm{ind}}) \tag{2.3}$$

$$V_{\mathrm{ben}} = f_{\mathrm{ben.urb}}(Q_{\mathrm{urb}}) \tag{2.4}$$

$$V_{\mathrm{risk}} = f_{\mathrm{risk}}(Q - Q_c) \tag{2.5}$$

$$V_{\mathrm{ecol}} = f_{\mathrm{ecol}}(Q_{\mathrm{ecol}}) \tag{2.6}$$

where *tot*, *agr*, *ind*, *urb*, and *ecol* are total consumption, agriculture, industry, urban use, and ecology, respectively; Q is the water volume of net use; and f is the function.

In these equations, water quality is not considered. If necessary, the treatment cost to achieve a target quality could be added. Water draining from upstream farmland could be used again in downstream areas. The amount of water used in the whole basin is not equal to the summation of an amount in each plot. These equations are to be combined with the equations of water balance.

In the case of maximizing social fairness and biodiversity, V is read as fairness or biodiversity instead of value. In minimizing social loss and social conflict, Min V is used instead of Max V. In such calculations, each layer, or presentation for each element, is assigned a weight.

2.4.6 Simplified Methods on IRBM

When IRBM is too complicated to handle, or when the IRBM objectives are not integrated, the management method could be simplified by assigning at least some of the objectives to more specific, lesser categories (e.g., water resources management, water quality management, or coastal zone management).

2.4.7 Example: Case Study of the Yellow River

An outline is provided below; details are available elsewhere (Kusuda 2009).

1. Physical and hydrological characteristics of the Yellow River

   The Yellow River basin originates on the Tibetan Plateau, meanders through the northern semiarid region, crosses the Loess Plateau, passes through the Eastern Plain, and finally flows into the Bohai Gulf. The main stream of the Yellow River flows about 5500 km and drains water from an area of 753,000 km^2, of which farmland is 40 % (126,000 km^2). Moreover, irrigated farmland is 40 % of the total farmland, and the crop yield there is 40 Mton/year. The population density in this basin is 152 persons/km^2 and the average annual precipitation is 433 mm/year. The existing water resources are 49.1 billion m^3/

year and the river discharge was 36.3 billion m^3/year in 2008. The groundwater extraction was 12.8 billion m^3/year (2008), and sediment transport from the basin to the Bohai Gulf was 46 Mton/year (in 2008, but 1.16 billion ton/year from 1956 to 2000).

2. Data correction or adjustment

   The correction/adjustment factors used in relevant computations included land use, morphology (altitude, slope, slope length, soil characteristics, soil thickness, and vegetation), present and future distribution of the human population (based on National Plan), industrial products and the number of factories, climate data (precipitation, temperature, wind velocity, duration of sun light, evapotranspiration, and parameters on moisture content), water consumption (extraction, irrigation, and daily use), water table level, river flow rates, and water quality in rivers.

3. Conditions for calculation

   The targeted region was from the source to Huayuangou. The pixel dimension was 10×10 km. The number of grids was $182 \times 263 = 47{,}866$. The computation unit ($\triangle t$) was 1 h.

4. Basic equations

   For computation of the flow rate, the kinematic wave method and Manning equation were used; for soil moisture, the Richards equation and van Genuchten equation; and for groundwater, the Darcy equation.

5. Computation results

   Half of the observed data were compared with computation results for calibration, and the rest were used for validation (e.g., for such as the flow rate in rivers, the moisture content of soil, and the ground water level in each pixel). After validation, estimation was conducted by changing operational variables such as forestation, amount of irrigated water, irrigated area, irrigation efficiency, wastewater treatment ratio, water reuse ratio, and self-sufficiency of food. The operational variables were changed stepwise, except for self-sufficiency of food. The constraints used were stable water resources, arable land area, limited job-transfer ratio of farmers, labor share, and available water amount for agriculture, based on water quality. The five estimation areas were the upstream region, the middle stream region, the Wei River region, the Fen River region, and the downstream region.

6. Obtained results

   Based on the above conditions, crop yield, industrial products, costs of procurement, construction of infrastructure, and wage were estimated. Then, as targets, maximum benefit, wage increase, increase in employment, protection of ecosystem, and reduction of sediment were estimated via projections to 2030 and 2050.

   Progress in forestation, with consequent reduction of sediment loss, led to a decrease in arable land. This decrease could be compensated for by an increase in irrigated farmland and irrigation efficiency and by job transfer of less effective farmers from agriculture to industry. In addition, increased allocation of water to farmland allowed farmers to expect greater crop yield. However, in this scenario, effective mobility of farmers and preparation of farmland for them (presumably in new locations) would be required.

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