WATER IN AGRICULTURE

CHALLENGES TECHNOLOGICAL SOLUTIONS & INNOVATIONS

Edited by Jiqing Song Wenbo Bai Maosong Li

Science Press
Beijing

Water in Agriculture: Challenges, Technological Solutions & Innovations

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Financially supported by the National High-Tech R & D Program (863 Program) for the 11th Five-Year Plan (2006AA100215), Nippon ShoKuBai Co., Ltd., BASF Co., Ltd., and Japan International Cooperation Agency (JICA).

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ISBN 978-7-03-027598-1
Science Press Beijing

Responsible Editors: Xiuwei Li, Jing Wang

Preface

Water resource is one of the most important natural resources that mankind depends on for survival and development, and one of the controlling factors of the ecology and environment. Global water use has been growing at more than twice the rate of population growth in the last century. Moreover, the water scarcity situation is being exacerbated by climate change, especially in the driest areas of the world. Agriculture consumes about 70 percent of all freshwater withdrawn and up to 95 percent in several developing countries. To tackle water scarcity even as the demand for food increases, we must support initiatives to improve water conservation and delivery systems, protect the earth's ecosystems, conserve rain-fed moisture and use water for food production more efficiently, or produce more food with proportionately less water. Coping with water scarcity requires addressing a range of issues, not all of them directly linked to agriculture. They range from protection of the environment and global warming to fair pricing of water services and equitable distribution of water for irrigation, industry and household use. This is why not only the agriculture sector, but everyone, international organizations, governments and local communities must share the responsibility.

As this situation, the international organization, company and Chinese government are dedicated to the exchange of recent advances in development of water-saving chemical materials, agricultural application technology and eco-environmental safety. The International Symposium on Water in Agriculture and Forestry: Challenges, Technological Solutions and Innovations aims to offer opportunities for participants to interact, present their most recent findings and to hold discussions with their colleagues from other countries, and provide a platform for potential future collaborations. The organizers of the International Symposium included: Institute of Environment and Sustainable Development in Agriculture (IEDA), Chinese Academy of Agricultural Science (CAAS), Tottori University, Japan, Chiba University, Japan, Nippon ShoKuBai Co., Ltd., and BASF Co., Ltd.

This volume is based on the invited keynotes and contributory papers presented at the 1st International Symposium on Water in Agriculture and Forestry:

Challenges, Technological Solutions and Innovations held during 21-24, October 2008 in Beijing, China.

Most authors produced high-quality manuscripts that included state-of-the-art knowledge on the subject concerned and made the needed revisions to improve scientific quality. The support and cooperation received from the members of the Organizing Committee and from all authors are gratefully acknowledged and greatly appreciated.

The financial support for producing this volume was provided by the National High-Tech R & D Program (863 Program) for the 11th Five-Year Plan (2006AA100215), Nippon ShoKuBai Co., Ltd., BASF Co., Ltd., and Japan International Cooperation Agency (JICA). The staff of Science Press was cooperative and very helpful in producing a high-quality volume.

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1 The Connotation and Extension of Agricultural Water Resources Security

Buchun Liu, Xurong Mei ,Yuzhong Li & Youlu Yang*

Abstract

The objective of this study is to define agricultural water resources security and its connotation and extension. The definitions of water security, water resources security, and water environment security were summarized, and their relationship was differentiated and analyzed. Based on these, the elements of the conception of agricultural water resources security were hashed and the conception was defined. Agricultural water resources security is the provision of water resources that ensure protection of agriculture against threat, hazards, destruction, and loss. Moreover, the connotation and extension of agricultural water resources security were ascertained. In detail, the connotation of the definition has natural attributes, socioeconomic attributes, and cultural attributes. The extensions of agricultural water resources security include both broad and narrow ones, as well as, food security, agro-environmental security, agro-economic security, rural society security, etc. The definition will serve as the frame of reference for developing the researches, limiting the frame of the theory, and founding a appraising system for agricultural water resources security.

Key words security; water resources; water environment; agriculture

Introduction

The annual precipitation in China is 6.19 trillions m^3. The water resources in China amount to approximately 2.81 trillions m^3, the sixth highest in the world, which is calculated by deducting the sum of surface water and ground water successively. However, China is one of the 13 countries where there is rarely any scarcity of agricultural water resources, with only approximately 2,400 m^3 water

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resources per capita and 1/4 of the average water resources of the world. Agricultural water use accounts for 70.4% of the gross water use; therefore, the agricultural sector is the one where the largest amount of water is consumed. Challenges with regard to water resources security, e.g., water excessiveness, water insufficiency, water contamination, and water muddiness, have become a bottleneck, which have severely restricted the sustainable development of economy in China, as well as have impacted national security as an important strategic issue. On the basis of the fact that the agricultural water use is the predominant water use and that the term of agricultural water resources security have been singularly defined, defining the term of agricultural water resources security, its connotation and extension, for developing the researches, limiting the frame of the theory, and founding a appraising system for agricultural water resources security, would serve as a basis in this direction. For defining agricultural water resources, it should be necessary to realize water security, water resources security, and other relevant concepts. The problems with regard to water security and water resources security have been in the forefront and are the hot topics of studies in hydroscience and relevant disciplines, ever since these issues have been raised in the beginning of the 21st century. The background of these researches was based on the global changes affecting water resources, the problems with regard to water resources, which are showing a significant day-by-day rise, also influencing the food security and the energy security.

The term water resources security was coined based on the frame of reference for water security. The water security issues have been the focus in the research areas of hydro-science and relevant disciplines after the 1970s; however, until the recent few years, water security has been defined formally and has been understood as a system. The Second World Water Forum & Ministerial Conference was held in The Hague in March 2000. The terms of water security (Fang, 2001) and water resources security (Jia et al., 2002) was defined in the forum. Several questions were raised with regard to these definitions: what are the differences between the two concepts? Has a concept been defined by two methods? Other then, are they absolutely two different concepts? The definitions of water security were summarized and understood from the point of view of resources security by some scholars. They pointed out that the definition of water security was equivalent to water resources security to a certain extent. Some scholars believed that water resources security is an aspect of water security. Another view on water security was that water security should be merged with water resources security and water environment security (Chen, 2004). Another group of scholars believed water security was a combination of water resources security, water environment security, and water disaster (Cheng et al., 2004). Above all, since the beginning of this century, based on the definition of water security given in the hydrology

scientific community, the ongoing efforts of many scientists for developing the definition made it a scientifically new concept that has been perfected. At the same time, the concepts of water security and water security environment came into being. Because many scientists from different disciplines had different perspectives, for different research purposes, their interpretations of these concepts were different. In addition, there are inclusions, overlaps, and mutual influence and interaction among the definitions of water security, water resources security, and water environment security. Thus, it is not easy to clearly understand the three concepts. It is also difficult to clearly define the concepts. However, to provide a solid theoretical foundation to further elucidate the definition of agricultural water resources security, it is necessary that the three concepts defined by the earlier researchers were summarized and their relationships were discriminated. Moreover, the connotation and extension of the agricultural water resources security were ascertained based on the elements of the conception of the agricultural water resources security, which were studied in depth.

Progress in Defining Water Security, Water Resources Security, and Water Environment Security

Progress in defining water security

In March 2000, The Second World Water Forum & Ministerial Conference was held in The Hague, Holland. The theme of the meeting was Water Security: From Vision to Action. All the countries gave considerable attention to water security. More than 140 politicians or ministers and 3, 000 scientists from all over the world attended the meeting. In the declaration of this meeting, the following inference was drawn as that water security means ensuring that freshwater, coastal, and related ecosystems are protected and improved; that sustainable development and political stability are promoted; that every person has access to adequate safe water at an affordable cost to lead a healthy and productive life and that the vulnerable are protected from the risks of water-related hazards. At the same time, the declaration also made clear that to achieve water security, the forum faced the following main challenges: meeting basic needs, securing food supply, protecting ecosystems, sharing water resources, managing risks, ascertaining the significance of water, and managing water wisely (Fang, 2001). Clearly, the definition of security water is informative. It includes use of water resources, protection of aquatic environment, and control of water related risks, as well as economic, political, ecological, and sustainable dimension.

Back in 1998, Hong and Luan (1998) defined water security with respect to the water crisis as a starting point. They believed that the connotation of water

security includes the following: As a result of the unsustainable social and economic activities, the water body is attenuated or loses its normal function, cannot maintain its social and the economic value, and endangers the basic necessity for which it serves the humans. It generally refers to the sustainability of all lives on the earth through obtaining their water requirement, which maintains or improves their survival and development. With regard to the human system, water security is defined in terms of meeting water requirement of the entire population of the world, meeting basic physiological, or needs of life; with regard to the social and economic system, water security is considered the social-economic system such that sufficient water is obtained to maintain its sustainable development; with regard to the environment subsystem, water security is considered the environmental system such that sufficient water is obtained to maintain or improve environmental quality. Besides, they believed that the water security has three functional levels: individual physiological or basic needs of life; social, political, and stability of the existent conditions; development of economic sustainability. They also believed that the world is mainly faced with three water security challenges: the deficiency of water resources, water pollution as well as the degradation of aquatic environment.

Later, Hong (1999) further elaborated the connotation of water security. He suggested that the connotation included natural water security, e. g., drought, floods, river diversion, etc., as well as artificial water security, e. g., water scarcity, water pollution, degradation of aquatic environment. At the same time, he pointed out that the extension of water security refers to other security, such as food security, economic security, national security, etc.

Han et al. (2003) studied the dynamic attributes of water security. They interpreted water security as follows. At present or in the future, natural change of the water cycle or unreasonable change in the balance of water cycle caused by human exploitation or a combination of the two, may entail a disadvantage to humans by adversely affecting their livelihood or may have detrimental influences on human society. These influences include drought, floods, lack of water, water pollution, deterioration of the water environment, etc. They could also possibly lead to insufficiency of food production, societal instability, economic stagnation, local conflicts, and so on.

Cheng et al. (2004) were more progressive than their predecessors as they took into account the cultural attribute with regard to water security. They suggested that water security connotes the following social situations: accesses to safe water at affordable cost for everybody, the water available should be potable and fit for human consumption, besides meeting the needs of sanitation healthy, disease-free living, and food production, simultaneously ensuring that the water environment is protected. The connotation of water security includes three aspects. First,

water security has its natural attributes. It indicates that the direct factors challenging water security are qualitative, quantitive, and spatiotemporal distribution characteristics. Second, water security has its socioeconomic attributes. It indicates that the carrying body of water security problems is an aggregation which includes human, social and all resources. Third, water security has its cultural attributes. It indicates that the public as a security carrier, has different feelings to the factors of safety. Specifically, water security relates to abundant availability of water or lack of it, the dependence of human society on optimum availability of water, adequacy of availability of water to the society, the awareness about the characteristics of the water resources in their habitat, as well as the level of consumption of water by a population, so on. Water security embraces issues related to socioeconomic security and the conservation of the environment, as well as other security concerns related to their subsystems, such as the food security and political stability. Cheng et al. (2004) also pointed out that water security encompasses the factors of availability of water resources, protection of water bodies, and the prevention of water-related disasters such as drought and floods. By their viewpoints, it can be judged that water resources security or water environment security is a subset of water security.

Chen (2004) proposed a more general definition. He suggested that water security indicates that a region or a nation is equipped to withstand the disasters related to water and can use the water resources to ensure sustainable development of the society, in terms of both economy and ecology. He did not emphasize on the security of the water environment.

Progress in the definition of water resources security

In the Second World Water Forum & Ministerial Conference held in The Hague, Holland in March 2000, security of water resources was interpreted as accessibility to all people of sufficient water that is safe and of affordable cost (Jia et al., 2002).

Jia et al. (2002) provided a broader definition of water resources security. They believed that security of water resources involved security at the societal, the economic, and ecological levels. With regard to economic security, they emphasized that water resources can support economic development, which plays a dual role: on the one hand, sufficient water and water quality can be ensured, and on the other hand, the price of water supply can be maintained at an affordable level.

Guo et al. (2002) believed that the quality of water should be taken precedence over the quantity of water when they defined the water resources security. The connation of water resources security includes the two aspects of water quality and water quantity. From the perspective of the early warning mechanism for water security, the concept of water resources security is divided into three

levels: ①the first level is the safety of water quality, including that of surface and ground waters; ②the second level is the availability of water of sufficient quantity based on supply and demand; ③the third level is ensuring the safety of quantity of water based on the sustainable use of water. It means, limited by the reserve of water, in order to realize the sustainable use of water resources, water consumption cannot exceed its annual discount rate.

Zheng (2003) proposed both a broad and a narrow definition of water resources security. He believed that the broad definition signifies that national interests have not suffered adverse effects because of flooding, drought, and water shortage, water pollution, damage to the water environment, and so on; the natural water cycle and the available water resources have not suffered any destruction or serious threat; and the available water resources can meet the needs of sustainable development of the economy and society. The narrow definition signifies that the carrying capacity of water resources and water environment should not be exceeded, on the basis of safe quality and availability of water, ensuring that the supplied water meets the needs of human survival, social progress, and economic development, besides maintaining a sustainable ecological environment.

Xia et al. (2004) regard the water used for the ecosystems, as the premise for the safe use of water resources. They believed that the water resources security means that, under the condition of the water used for the ecosystems to be met, the available quantity water used for inhabitant life, industry, agriculture, and service industry, also can be supplied at an reasonable price, according to a special water quality criterion.

Progress in the definition of security of water environment

Compared with water security and water resources security, the definition of security of water environment is of recent origin. Very few studies have been carried out on this aspect. Zeng et al. (2004) have proposed a definition on security of the water environment. They believed that a water body maintains a certain balance in terms of availability and quality to sustain its ecosystem and its ecology, to protect the aquatic animals and plants, to maintain a pollution-free and sustainable environment, and to simultaneously meet the needs of humans and other living organisms, without causing any threat to humanity or transboundary disputes.

Differentiation and Analysis of the Concepts of Water Security, Water Resources Security, and Water Environment Security

By reviewing the research progresses in the definitions of water security, water

resources security, and water environment security, it can be concluded that the scope of water security is broad, whereas those of water resources security and water environment security are a subset of water security. Water resources security deals with water security in the context of availability of water resources. Water environment security places greater emphasis on water body as a carrier, for example, water body often carried waste and contamination, and water security is discussed from the perspective of the environment. Water security problems involve water crisis, namely water-related disasters. Water security encompasses the effects of water resources, water environment, and water disasters.

The Connotation and Extension of the Definition of Agricultural Water Resources Security

The use of water resources can be generally divided into water used for industrial purposes, for agricultural purposes, for sustaining life and ecology, and so, depending on its end use. Agricultural water resources security belongs to the category of the water resources security. The agricultural water resources security is the most important component of the water resource security because the largest share of the available water resources is for agriculture. Based on the definition of water resources security in The Hague Forum, Ye (2003) defined that the water used for agricultural purposes can be supplied at a sustainable, stable rate and at a reasonable cost. Its core content included three aspects: first, sufficient quantity; second, stable supply; and third, reasonable price. The safeguarding of water quality has not been emphasized in this definition. To carry out further research on agricultural water resources security and to enable this research to progress from the speculative to the quantification stage, it is necessary to promote the definition of the agricultural water resources security.

The definition of the agricultural water resources security

The integrated aspects of the concept of agricultural water are analyzed. The broad definition of agriculture includes farming; maintenance of forestlands, grasslands, and cattle herds; the affiliated; and the fishing industry. The narrow definition of agriculture mainly refers to cultivation of crops. Security implies that there is no threat, hazard, harm, or loss of environmental resources. Resources are the natural substance which can be used by human. The term of the water resources is freely long-standing, but there has not been a universal definition until the 9th Session of the 25th Conference of the Standing Committee of the National People's Congress was held in 2001. During this meeting, it was proposed that the delineation of the definition of water resources must be clarified