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# Comparison of Water Resources Community Self-Management Mode between China and Tanzania

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## Abstract

Due to limited rainfall and uneven spatial and temporal distribution of water resources, water has become a restraining factor in agriculture and livestock production of China and Tanzania. As it is most considered as common-pool resource, the management of water resources is a complex issue in agricultural and pastoral industry. Traditional water management modes include nationalization and marketization, but complete market-oriented or government management could not reach the sustainable use of water resource due to nonexclusive and interconnected features of water. Therefore, China and Tanzania introduced water resources community self-management in rural arid areas. Farmers as resource users in community conducted mutual supervision and mutual benefit to realize reasonable, fair, and sustainable use of water resources. However, community self-management is restricted by formal institution from the government of China, and Tanzania's community self-management relies on the financial and technical support from foreign NGOs; the communities' ability to obtain benefit needed to be improved. We compare water resources community self-management mode in China and Tanzania through case studies, put forward the differences of self-management mode in two countries, and analyze the characteristics of successful water resources community self-management mode.

**Keywords:** water resources use, community self-management, farmers' livelihood, China, Tanzania

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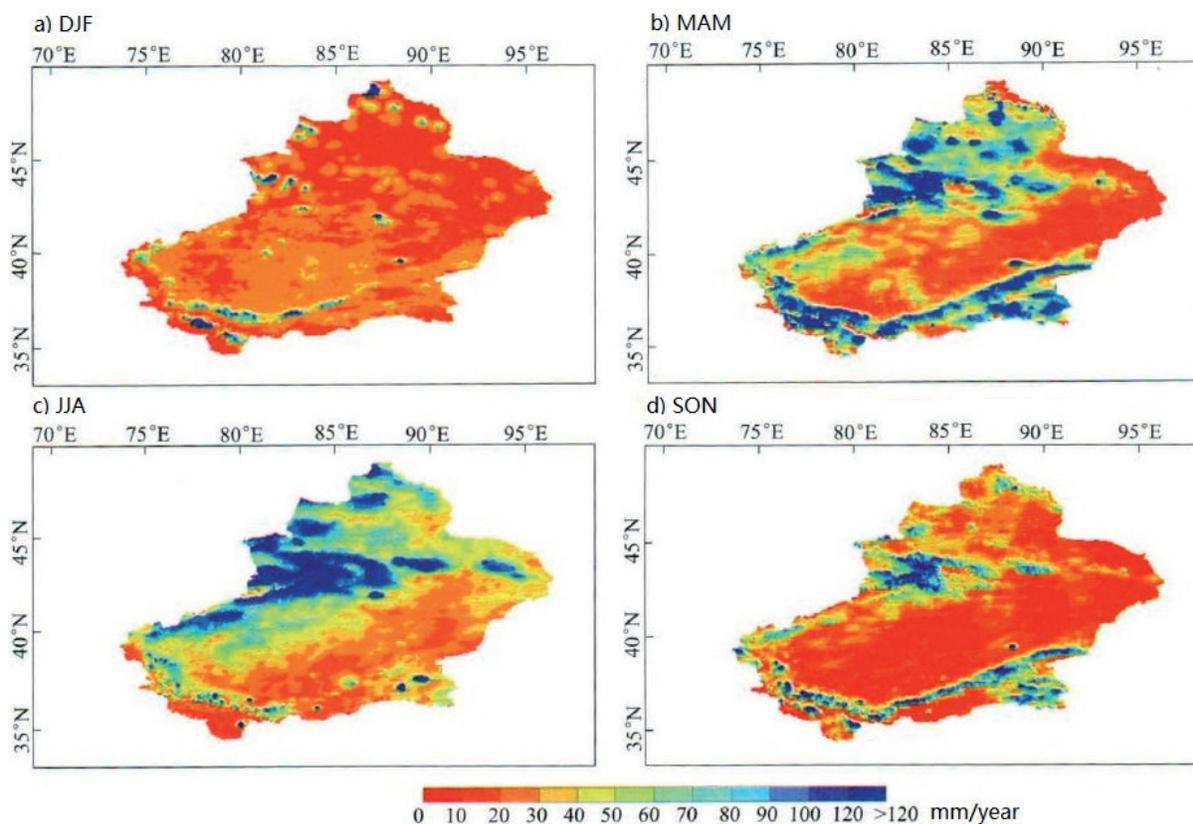
## 1. Introduction

### 1.1. Water resources in arid regions in China and Africa

Water is the basis for the survival and sustainable development of the human society. With the development of the society and economy, the water crisis caused by the lack of water resources and water pollution has become one of the key factors restricting the economic and social development. Nowadays, arid and semiarid regions in the world account for about 40% of the total land area, while the freshwater resources on the earth only account for 1.6% of the water resources on the earth's surface. About 40% of the global population in more than 80 countries is facing serious water crisis [1]. With the trend of global warming, the area of arid and semiarid regions will accelerate its expansion, which is expected to account for more than 50% of the global land surface by the end of the twenty-first century. In addition, three-quarters of the arid and semiarid region expansion will occur in developing countries, exposing developing countries to the risk of further land degradation and aggravating the poverty of people in arid and semiarid regions [2]. The United Nations Water Conference pointed out that the next crisis after the oil crisis is the water crisis [3].

The inland arid zone of Northwest China is located at the north of the 35°N and the west of 106°E, including Xinjiang, the Hexi Corridor in Gansu province, and Inner Mongolia region, west of Helan mountain, accounts for about 24.5% of the total land area of China [4]. The northwest arid region consists of mountains and basins. Rivers originate from the mountain area flows to the basin. The distribution of water resources determines that the surface runoff and groundwater resources of the area are the key factors and ties to maintain the economic development and ecological environment balance of the middle and lower reaches. The climatic conditions of inland drainage area show a significantly difference, with precipitation ranging from 300–1000 mm in the alpine region to 100–200 mm in the plain region, and seasonal variation was obvious. Precipitation is mostly concentrates from June to August, and drought was common in winter and spring (**Figure 1** [5]). Under the constraints of water resources distribution and climatic condition, the inland river valley ecological environment system usually forms the argo-pastoral transitional zone with pastoralism and irrigated agriculture, which is the fragile ecological environment zone. With the increase of population, the development of social economy, and the exploitation and utilization of soil and water resources, a series of hydrological and ecological environment changes have been occurred. As a result of the drought caused by the reduction of water resources, grassland reclamation, and overgrazing, the grassland area in river valley is reduced and seriously degraded. Grassland degradation caused the decline and disappearance of some dominant herbage species and thus the decline of biodiversity [6]. From 1958 to 2005, the forage yield in Northwest China decreased by 75.4% [7].

In sub-Saharan Africa (SSA), drought area accounts for 20% of land but accounts for over 80% of the affected population [8]. Much of the continent is dependent on rain-fed agriculture, which makes it particularly susceptible to climate variability. Almost 70% of the labor force is engaged in agricultural work, and agriculture contributes to about 25% of average gross domestic product (GDP) across the continent [9]. The limited water resources have direct

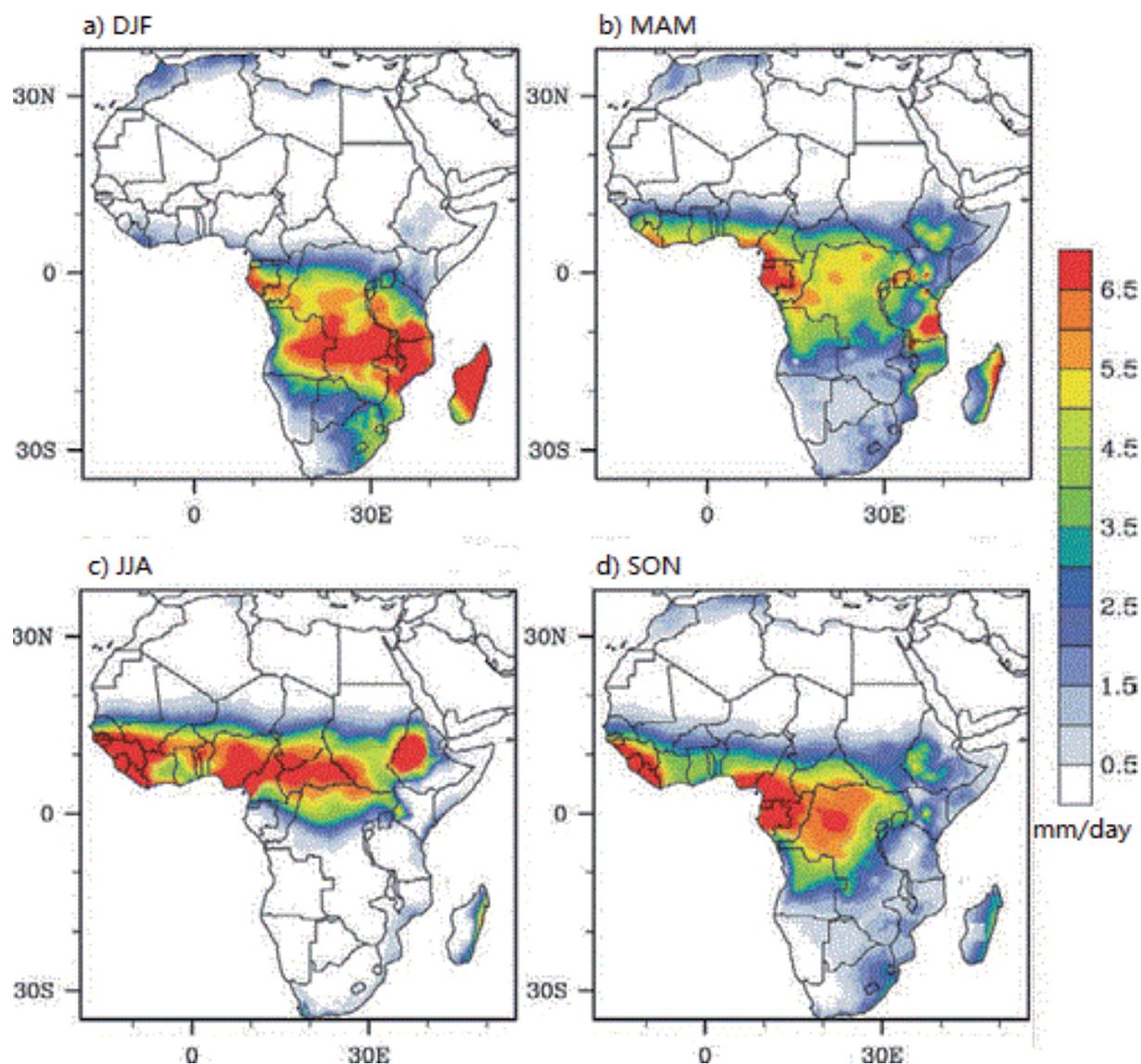


**Figure 1.** Seasonal mean precipitation (1950–2008) in Xinjiang, China, for (a) December–February, (b) March–May, (c) June–August, and (d) September–November.

impacts on agriculture and livestock grazing over large space and time scales. The impacts are driven by the high vulnerability of the natural environment and are exacerbated by prevailing local and external economic and political conditions [10], which can be associated with development of famine and may be accompanied by the spread of disease. The population of SSA is over 870 million people and is expected to at least double by the mid-twenty-first century. Coupled with expected overall drying with climate change, in particular in Southern Africa and parts of West Africa [11–13], there are worrisome implications for water resources sustainability use and food security.

Water resources in SSA is linked to the high seasonal and inter annual variability in rainfall (**Figure 2** [14]). In general, seasonal rainfall higher than 500 mm is required to sustain healthy agriculture, highlighting the tenuous nature of agro-pastoral livelihoods in the transitional regions between semiarid and arid regions in some parts of SSA. In northern Tanzania, the rainy season is generally from November to April, and well-defined dry season is in July–September.

The shortage and the imbalance of spatial and temporal distribution of water resources have become the bottleneck of economic growth and social development in arid regions. With the increase of population and the expansion of industrial and agricultural production and urbanization, the residents in arid regions have an increasing demand for water resources. Many ways have been taken to expand the scale of water resources development. While obtaining



**Figure 2.** Seasonal mean precipitation (1950–2008) in Africa for (a) December–February, (b) March–May, (c) June–August, and (d) September–November.

temporary economic benefits, it has caused serious negative impacts on the ecological environment. Understanding the ecological environment and the farmers' livelihood needs and changes in arid regions; managing limited water resources scientifically and rationally developing the maximum economic, social, and ecological benefits of scarce water resources; and ensuring the sustainable use of water resources have always been the key concerns of the arid region research.

## 1.2. Management of water resources in arid regions

Water resources management can be divided into government regulation, water rights trading market, and community self-organization management according to the different distribution modes of water resources property rights.

Due to the mobility, recycling, and public characteristics of water resources, most national laws stipulate that the ownership of water resources belongs to the state, and the state has the right of allocation and final decision-making of water resources. In fact, the ownership, management, and use of water resources are separate. The ownership of water resources in China belongs to the government, the use of water resources by industries and agriculture should be under administrative permission, and the water use license cannot be traded on the market [15]. The government allocates limited water amount by administrative means, and researchers explore various methods to optimize water allocation, in order to maximize the economic, social, and environmental benefits. However, due to the conflict of interests among the water use stakeholders, it is impossible to achieve the optimal allocation of water resources in practice. At the same time, the regulation of water price fails to reflect water value, and this rationing system eventually leads to the general expansion of demand, further exacerbating the contradictions between the stakeholders and increasing the difficulty and confusion of management.

On the other hand, developed countries usually adopt the method of establishing water resources trading market. Based on the clear definition and initial use right of distribution of the water resources, the use right of water resources exchanges among regions, basins, upstream and downstream, industries, and households through market mechanism. Under the law of value, water price and water resources value could be adjusted and matched, and the distorted situation that water resources are priceless or low could be changed. According to the development of the market economy, economic leverage is used to regulate water prices, and the government only carries out macro supervision in this process [16]. However, as water is an irreplaceable vital resource, complete marketization will also face many problems according to water resources characteristics, such as the definition of initial water resources allocation mode and water users' short-sighted behaviors driven by interests, which will cause the failure of water resources market.

Besides government and market, Ostrom proposed the third option in "Governing the Commons," namely the self-organization and management of common-pool resources [17]. Based on the analysis of several classic models including Hardin's "The Tragedy of Commons" and "Prisoner's Dilemma" and Olson's "The Logic of Collective Action," the conflict between individual rationality and collective rationality was drawn. According to Ostrom, the defects of traditional game analysis methods and the theoretical assumptions they rely on were deviated from the real situation, such as rational person assumption, complete information access, independent action, noncommunication, and first-order game. Ostrom took small-scale common-pool resources as an example and demonstrated that a group of limited rational person communicated and interacted with each other in the process of sharing natural resources. They could obtain more information on resources and other actors' behavior and develop effective common-pool resources use contract through self-raised funds. Ostrom analyzed the possibility of community self-management theoretically. In Ostrom's theory, although limited rational actor did not have complete information, they could increase their understanding of other actors through communication in the process of the game, fully understand each person's influence on common-pool resources, and then change their own strategies to obtain more benefits.

In Ostrom's Institutional Analysis and Development Framework (IAD), collective action of resources needed to solve three problems, such as the problem of supply of the current institution, the problem of credible commitment, and the problem of mutual monitoring. As for the supply of the institution, Ostrom believed that cooperation balance should be generated through multiple games among community members based on current institution, in order to form a series of mutual beneficial situation and an informal system of community mutual trust. As for credible commitment, Ostrom argued that self-management groups should develop effective regulations and take appropriate supervision and sanction measures to ensure that community members follow the rules. As for mutual monitoring, Ostrom believed that after the establishment of regulations and the commitment to follow the rules, the implementation of the regulation and the allocation and use of common-pool resources in accordance with regulation should be monitored.

Therefore, we compared two typical cases of water resources community self-management in China and Tanzania; described the details of the cases from the supply, credible commitment, and mutual monitoring aspects; analyzed the internal difference between China case and Tanzania case; and thus put forward effective community self-management mode that has a positive impact on natural resources and the livelihood of farmers.

## 2. Material and methods

### 2.1. Study area

#### 2.1.1. China

Xinjiang's Yili valley agro-pastoral zone is stratified by elevation, transitioning from low-altitude semiarid agriculture at elevations below 1000 m to humid alpine meadow pastoralism at elevations above 1000 m. The annual precipitation below 1000 m is 400–500 mm [18]. With relatively abundant snowmelt from the Tian Shan mountains, the valley's lowlands and riparian corridors provide a significant share of Xinjiang's irrigated agriculture, whereas the middle and upper regions of the mountains are humid alpine meadow grassland that has been used for extensive livestock grazing (mainly sheep but also cows, goats, horses, and some camels) for a thousand years.

M village is located on the western slope of the Tian Shan mountains in the headwaters of the Yili River, in the Yili Kazak Autonomous Prefecture. Pastoralism and agriculture coexist, and the former plays a dominant role. There were 558 households with 2273 people, of which 50% were Kazakhs (village statistics). Natural pasture area is about 9333 ha. Farmland area is about 504 ha.

#### 2.1.2. Tanzania

The study was conducted in Hai district specifically at Saaki spring as a case study. In the recent years, there has been a tendency of cutting trees around the Mountain Kilimanjaro on the side of Hai district which impact in the shortage of water around the district causing serious problem at Saaki spring and Hai district as a whole. Hai district which is situated in the

Northern part of Tanzania is among the six districts forming Kilimanjaro Region. The district is subdivided into three divisions which are Lyamungo, Machame, and Masama. The district has 14 wards, 60 villages, and 11 urban streets. Saaki spring is the biggest source of water which serves people who live in Hai town where the district headquarters is situated and is also serving people who live in the villages. Generally, the Saaki spring is approximated to serve the population of more than 58,003 people who live in the villages and streets.

S village is located in the middle of the district, which belongs to Masama division. The list of water user households was gathered in village registers. Most of the villagers participated in agriculture production. The population of the village was 3793 in 532 households.

## **2.2. Data and methods**

The study used a qualitative approach to describe the current status of water resources community self-management in China and Tanzania case. As supplementary, quantitative approaches help to measure data from the field work study. The two approaches complemented each other in gathering data to create valuable information for understanding community participation in water resources management.

Primary data on community participation in water resources management were collected from the respondents. Field research was completed using semi-structured interviews with households in 2015. Interviewees were selected by purposive and simple random sampling. Eighty-three households in M village (China) and 80 households in S village (Tanzania) were interviewed, more than 15% of the total household number in two villages. The purposive sampling technique was used to select the key informants from the village level who were knowledgeable and responsible for developmental issues and water resources management in their respective areas of work. Simple random sampling technique was used to select households in the study area to represent the specific and detailed information. Interviews focus on water use and management in agriculture and livestock production and the perceptions and opinions of interviewees on environmental and social changes. Additional interviews of local government officials, water engineers, and NGO technicians provided overall information.

## **3. Results**

### **3.1. Institution supply: use rights of water resources**

#### *3.1.1. China*

In the late 1970s, as China transitioned from a planned economy to a market economy, the Household Land Contract System (HLCS) was implemented. The land was contracted to individual households while formally remaining the collective ownership. According to the HLCS, all agricultural outputs are owned by the household except for the state agricultural tax (which was canceled in 2006). Land use privatization greatly increased labor productivity and rural economic development and thus helped numerous farmers climb out of poverty (Lin, 1994).

However, water resources have the integral characteristics. The law claims that water resources are owned by the state. The Chinese government has many departments involved in water resources management, but there is no independent and complete water resources management center, which lacks unified and coordinated management at the government level. Compared with industrial water use, agricultural irrigation water is generally dispersed, random, and low marketable. It is difficult to establish a standard water resources trading market, and under the premise of state-owned water resources, it is also difficult for farmers to obtain the independent water resources use rights and to be water resources traders. On the other hand, since ancient times, the nomadic Kazak people lived in tribes, shared information with their relatives, and helped each other in agricultural and pastoral production, providing a good cultural foundation for the community self-management model.

### 3.1.2. Tanzania

The land in Tanzania belongs to private landowners, and landowners were entitled to spring water on their land. Before African independence, the state played a negligible role in the allocation of water rights and the development of water resources [17]. After 1964 (Republic of Tanzania foundation), the water use rights were controlled and regulated by the state, but landowners still had the right to use public water in public streams.

The right of private owners to use water in rural areas which had its source on the land or flowed over the land was a direct consequence of their landownership. Although there was no finality over the ownership of water, the use of water was derived from and linked to the ownership of land.

China and Tanzania all experienced land use privatization. However, the water property has always been rather vague. Water resources was owned by village collective in China, but owned by landowners in Tanzania. China's government has much more authority in water management than Tanzania. However, water use rights need to be distributed to private household in practice. No matter in China or Tanzania, community is the actual main body of the water resources use.

## 3.2. Credible commitment: water use regulation establishment

### 3.2.1. China

In M village, rain-fed farmlands and livestock drink water use were mostly from river and precipitation, which did not relate to the allocation of water resources. The water resources community self-management was mainly reflected in the irrigation of irrigated farmland through water canal.

The Household Land Contract System was introduced in 1984, according to the privatization use of farmland, the sorted by position and used in turn allocation way of water resources for each household was formed. Due to the unstable water volume of the canal, farmers did not pay the irrigation water fee at first, and the water resources management was quite chaotic. The upstream households of the canal might use more water, and downstream households had no

enough water. Or, the imperfect rotation management mechanism led to missed watering of some households. Now, under the guidance of the village government, M village had gradually formed a mode of community self-management of water resources allocation. First of all, a water manager was elected on the villager meetings at the beginning of each year, and the farmers in village acted as water manager in turn. The water manager was responsible for collecting water fees and managing the canals, resolving farmers' water use disputes, and prohibiting water theft. The salary of water manager is 10% of the water fee. The water supply of the canal was from June to September. The water fee increased from 24.05 dollar/ha in 1984 to 72.14 dollar/ha in 2015. Each household paid 50% of the water bill in June and another 50% in September. Besides the salary of the water manager, the remaining 90% of the water fee is paid to the village cooperation for the reinforcement and seepage prevention of the canal. Households who paid water fee took turns to irrigate their farmlands from upstream to downstream, the diameter of irrigation pipes was fixed, and each household could irrigate for a maximum of 48 hours, after which irrigation water was rotated to the next household (Figure 3).

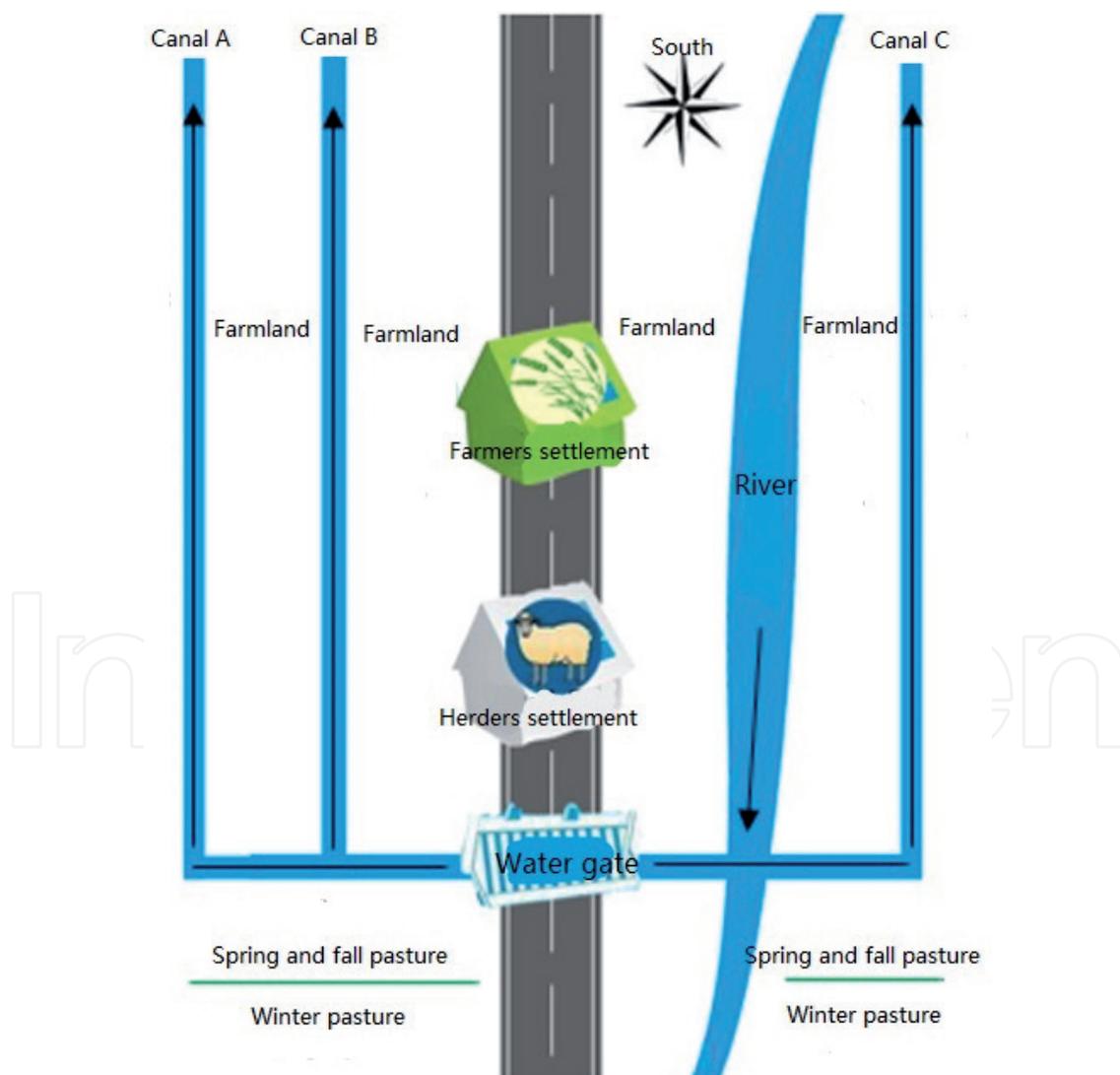


Figure 3. The canal diagram of M village.

### 3.2.2. Tanzania

Water resources community self-management was implemented in Tanzania by UBWS (Uroki-Bomang'ombe Water Supply). They sent technicians, made guidebook and gathered villagers' representatives to discuss the baseline environmental conditions, mapped and interpreted water resources present situation, analyzed resource user and stakeholder, and developed the action, monitoring, and evaluation plan. However, when the farmers were asked whether they knew who was responsible for the management of Saaki spring, 55% of the farmers had the idea that the one who is responsible for Saaki spring management is the water authority and district government, and only 12.5% had the view that it was managed by the community-based group.

More than 50% of the farmers claimed that they were not involved in the planning activities, but they were involved in planting trees, cleaning the water source, and securing the water source. No more than 10% of the farmers involved in and participating in water regulation discussion meetings. This shows that the community has not been adequately involved in the spring management meetings, which indicates the need to seriously address it.

Fifty-five percent of the farmers disagreed on the statement that Saaki spring was managed through information sharing. There is much to be done to improve the information sharing of community in the management of the spring. What is more is that some of the community members even did not understand the existing regulations governing the spring. About 30% of the farmers were aware that cutting trees nearby the source of water, farming around the water source, trespassing, feeding animals, dumping poisonous wastes, and washing clothes were prohibited by the laws.

## 3.3. Mutual monitoring performance: farmers' perception and water use efficiency

### 3.3.1. China

As for community self-management, after the establishment of the water resources use regulations, the effective supervision and punishment mechanism were particularly important. Eighty percent of farmers in M village believed that the existing irrigation water allocation and rotation system in village are effective in improving the water use efficiency. However, there is still a gap with the optimal efficiency, which is caused by the imperfect management system and serious waste of water. In particular, although the water manager was elected by all the villagers, he/she was also belonged to farmer households in the village. When irrigating his own farmland or the farmland of his relatives, his supervision might be ineffective and unfair. On the other hand, when the water disputes between villagers occurred, water manager had no absolute authority to judge the problem as national judicial departments and also had no right to enforce households who caused the problem to compensate for damage. The water manager was just a mediator, persuaded both sides to put down the disputation and carry out a harmonious solution. Most of the time, the disputation still destroyed social mutual trust between farmer households.

### 3.3.2. Tanzania

From the interview, majority (81.2%) of households were not satisfied with the management of Saaki spring, while only 18.8% were satisfied. The majority (63.9%) of people claimed that

they were not satisfied because they were not involved in decision-making. Moreover, 9.2% of the farmers commented that plans of managing the spring were not well implemented and the cost of connecting water was too high. In general, farmers held the view that there was poor community management of the spring water. They asserted that they want to get more involved in meetings and planning in the future.

The big challenge which faced community participation was limited involvement in the management of the spring. Other challenges included difficulty to protect the spring, poor supervision of water source, the cutting down of trees for firewood, and cleaning the spring.

#### **4. Discussion**

From the analysis of two cases of water resources self-management in China and Tanzania, the different property rights system of water resources in China and Africa leads to the different impeller of community self-management, and the final results are also different. The impeller of China is the village government, while the impeller of Tanzania is NGO. To form an effective water resources community self-management mode in arid regions, the following points need to be noted:

1. Full participation of the community member contributes to the rational allocation of water resources.

In Tanzania, the large community was not given the chance to participate at various stages like planning, implementation, and evaluation. Only few, especially village leaders, claimed to participate in all stages. However, every villager participated in electing a water use supervisor and agreed with the water rotational use regulation in China. People needed to be involved from the earliest stage to the upper one during the self-management procedure. Water resources managed without the participation of the community in decision-making, planning, implementation, and evaluation are often not properly maintained and hence lack sustainability (NAWAPO, 2002).

When carrying out community self-management, the majority of the farmers should be involved in participatory meetings, participatory planning, protecting the water source, supervising the water sources, and training on water source preservation. It is the responsibility of the local government to make sure that the large community is involved in the whole process. It will lead to community participation, pollution control and information sharing, and hence the sustainability of water resources.

2. Effective information sharing is conducive to the water resources use regulation.

Information dissemination was very crucial for the community in order to promote community participation in the process of water self-management. Adequate information sharing leads to optimal goal achievement and relationship building; hence, the effective and efficient dissemination of accurate information to the public is essential. Informing and educating those who participate in community projects could make them permanently able to defend their own interests (Abrahamsson, 1977). Thus, participation supports the

integration of interests through an intensive exchange of information among concerned actors and lays the foundation for cooperation and establishment of the sense of ownership for the sustainability of the water resources.

The local government could provide important technology guideline, database, experience, and ideas that could lead to practical, relevant, achievable, and acceptable community self-management solutions.

3. The combination of formal and informal institutions is conducive to the effective mutual monitoring.

Community self-management mainly relies on community informal management system. On this basis, appropriate intervention of formal systems may be helpful to water resources management. Formal institutions could ensure community members follow the rules and punish those who violate the rules more effectively. For example, the supervision and punishment in the water resources use regulations can be raised to the formal level. There are laws to be followed in the performance of the water management regulations, and an independent monitoring organization for villagers can be set up to strengthen the intensity of supervision, punishment, and mediation. On the basis of the complete participation of all members, communication, and information sharing mechanism, the involvement of the formal system can avoid the negative influence of the farmers' social relations on the mutual supervision performance within the community under the informal system.

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