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Scarcity within Opulence: Water Management in the Karakoram Mountains Revisited

Hermann KREUTZMANN

Centre for Development Studies, Freie Universitaet Berlin, Malteserstr. 74-100, Building K, D-12249 Berlin, Germany

E-mail: h.kreutzmann@fu-berlin.de; Fax: +49-30-838 70 757; Phone: +49-30-838 70 224

Abstract: Water management in general and in the Indus Basin in particular is concerned with the energy-efficient transportation of hydrologically exploitable resources from the upper zone to climatically favourable areas where irrigation helps to supersede arid conditions for the cultivation of crops and watering of meadows. In other words: Human intervention sets the stage for the allocation of water from a wider catchment area in a smaller habitat where this resource is deficient. Emphasis on mountain irrigation practices is counteracted with developments in the forelands where different frame conditions prevail and peculiar development problems occur. In dealing with the importance of water from the mountain regions three dimensions have to be evaluated: 1) natural factors and their validity for the environmental frame conditions and technological adaptation processes; 2) social factors and their impact on culture, economy and equitability; 3) institutional factors and their importance for sustainable growth and for the implementation of development projects. In the study of decentralized irrigation systems in high mountain regions of the Indus Basin a systems theoretical approach values the complexity of interrelationships between different systems elements. Human activities in arid mountain regions are restricted by limiting ecological factors and are characterized by certain utilization and adaptive strategies.

Keywords: Irrigation; Water management; Institutions; Development; Hunza Valley; Indus Basin; Pakistan

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Introduction

The recent floods in Pakistan have shown the extremes that occur within the Indus Basin. After devastating the Hindukush-Karakoram-Himalaya valleys, a combination of peak meltwater discharge and severe rainfall from monsoonal thunderstorms reached the plains of down country Pakistan. Saturated soils and high water tables in the extensively irrigated oases of Khyber-Pukhtunkhwa, Punjab and Sindh provinces were unable to cope with such a huge volume causing among others significant health hazards (Kreutzmann and Schuette 2011; Mustafa & Wrathall 2011; Warraich et al. 2011). Consequently, the surplus water remained on the surface, flooding village lands and destroying valuable crops before eventually entering the Arabian Sea.

In average years, the narrative of water scarcity dominates the discourse about the future prospects of people living in the densely populated river oases and canal colonies in the Indus Basin. In the case of Pakistan, access to irrigation water on national, provincial, regional, and domestic levels is a dominant discourse and a source of conflict among water users (Ahmed 2003). This paper draws attention to the frame conditions of water utilization in Pakistan and water management practices in the Karakoram Mountains. The debate on quantitative and technological aspects sometimes disguises the significance of the nexus with societal properties, institutional setups, and conflicting interests of water users. The main hypothesis put forward here is that although water volumes exceed overall demand for long periods, the situation at specific locations needs to be understood in the local context and cannot be extrapolated to the whole Indus Basin.

1 Data Sources, Methods and Hypotheses

The information used for the main arguments is, on the one hand, based on official documents,

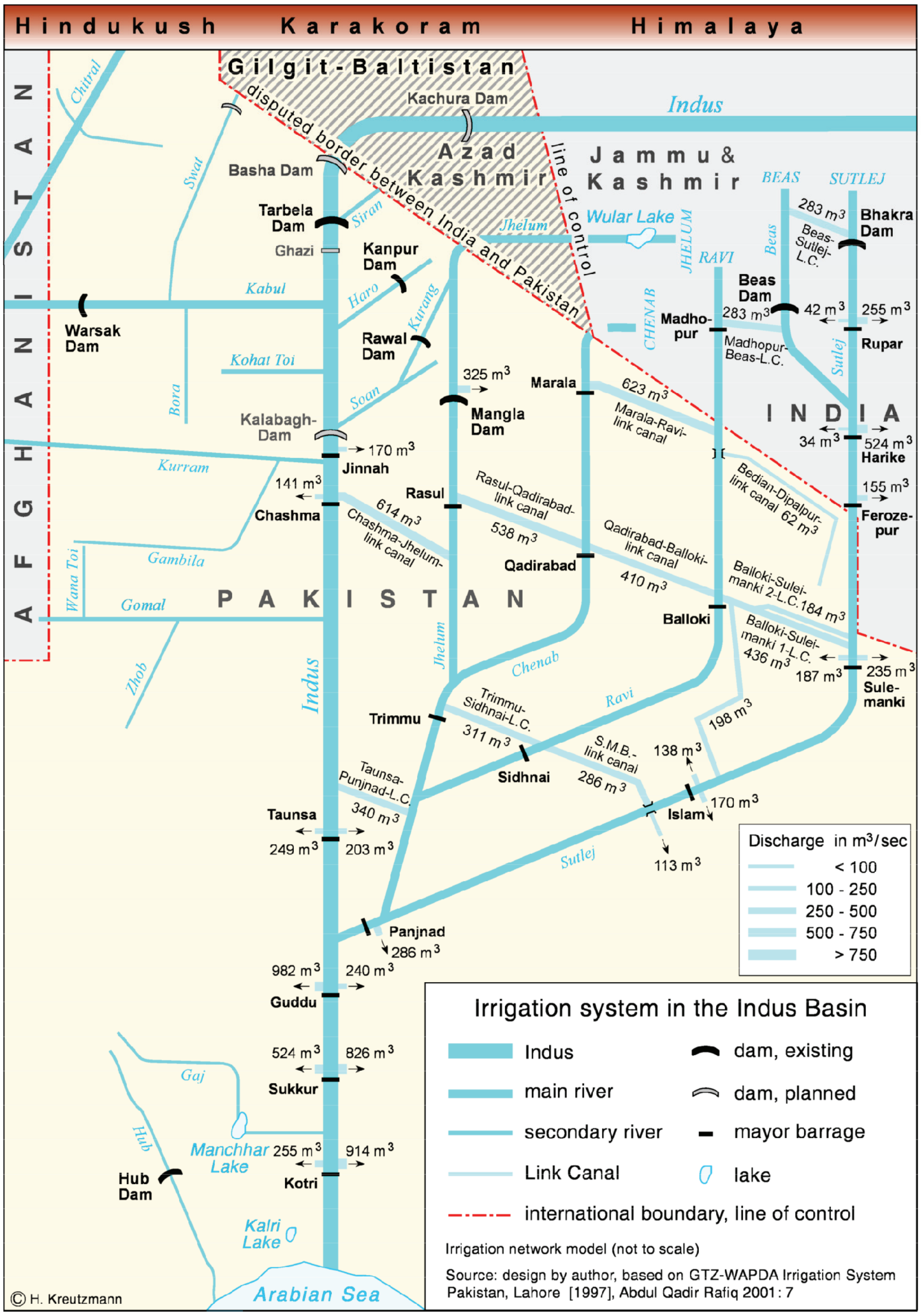

Figure 1 Irrigation system in the Indus Basin

critical reports and published literature on water management in Pakistan. On the other hand, data from the author's own fieldwork in the Karakoram Mountains and especially in Central Hunza are interpreted to explain how water scarcity is possible within the opulence of glacier melt, how mountain farmers deal with shortages, and what kind of adaptive strategies are applied. Development activities do not necessarily address the salient features and sometimes underestimate social institutions and societal change. The latter seems to be far more significant than climate change, at least for the time being.

2 Scarcity in Down Country Pakistan

More than 20 million hectares, 85% of which are irrigated fields, comprise the backbone of Pakistan's agriculture (MHDC 2010). Nearly half of all the labor force is engaged in agriculture, and one fifth of the GDP is generated from agricultural production (GOP 2010). The dependence on waters from the Indus Basin is the critical factor for a productive sector that dominates the country's exports. Water shortage can lead to distribution conflicts in all sectors. In Pakistan one single authority is responsible for coordinating energy production and irrigation: the *Water and Power Development Authority* (WAPDA). Agriculture uses as much as four fifths of available water. Disputes are almost inevitable between private irrigated farming (which includes smallholders, tenant farmers and corporate farming) and the claims of the state's power monopoly.

The canal irrigation system (Figure 1) was conceived as a diversion network based on the principle of continuous water delivery and equitable distribution. The reality differs from this principle in every respect, as a result of historical processes, modified regulations, and political power. The provenance of the irrigation water implies a seasonal availability, yet year-round cultivation is possible here. Shortfalls are more frequent during the winter season (*rabi*), when the quantity is comparatively limited. By contrast, runoff increases substantially in summer. In 2009 the *rabi* water availability was 26.9 MAF (1 MAF = 1 million acre feet or 1.234 thousand million m^3), only 71% of the average availability, whereas the quantity available in the *kharif* season amounted to 67.3 MAF, which is about the average amount (GOP 2010). What do these figures mean in relation to the volume needed for agriculture and to the quantity that is annually released? The 93.3 MAF in 2009 – or 103.5 on average – need to be compared with 206 MAF from annual river runoff, rainfall and groundwater harvesting (Figure 2). The system's requirements are roughly met by the diversion to the irrigation canals; that is two thirds

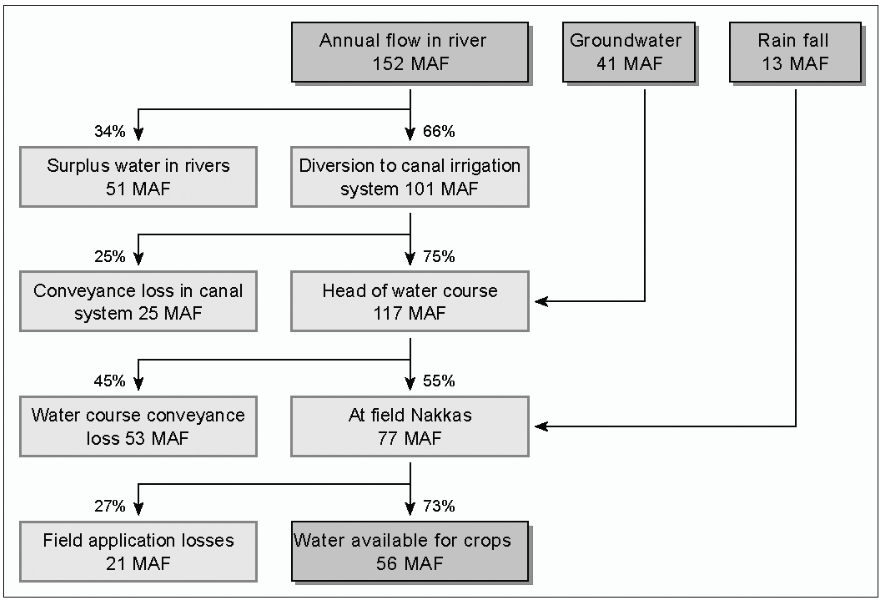

Figure 2 Indus Basin water flow chart (Source: abridged on the basis of Ahmed 2003)

of the river flow in the Indus Basin allocated to Pakistan. The other half of available water is lost along the course of its flow. The remainder will continue to be wasted if further regulation measures are not implemented. In sum, two thirds of the river waters are diverted by canal irrigation. The remaining 101 MAF are supplemented by 41 MAF of groundwater and 13 MAF of monsoon rainfall in the irrigation area (Ahmed 2003). After subtraction of wastage, 56 MAF are still available for irrigation agriculture (Figure 2). This low value is responsible for the continuous shortage of irrigation water in Pakistan as a whole and especially in tail-enders such as Sindh province. There is ample scope for harnessing the available water by improving the water courses, sealing the canal beds and making proper storage arrangements for times of want. In this case, there is definitely no need to go to war over water (Alam 2002; Stucki 2005; Barnaby 2009) because improving water management and irrigation practices is significantly cheaper.

Disputes over declining water resources, high wastage levels, and lack of productive utilization suggest that it is advisable to consider available optimization possibilities and existing conflicts of interest. Disparities between specific interests of individual stakeholders and the entirety of those involved in the system are visible at the following levels:

- International: Contradictory claims by India and Pakistan tapping the same water source have repeatedly led to crisis.
- Regional: Within India and Pakistan, conflicting interests occur between provinces and/or upstream and downstream users, or between user groups.
- Sectoral: Requirements and demands of irrigation agriculture and energy users show quantitative and seasonal disparities that can be resolved only by negotiations.
- Ecological: Massive technological interference with the natural balance affects the soil water budget, causes salinity, alkalinity, and water-logging of near-surface environments and has led to permanent ecological damage.

Evidence at all four levels is found in the forelands of the Inner Asian high mountains and especially in both Punjabs of South Asia (Michel 1967; Ahmad and Chaudhry 1988; Kazi 2003; Kreutzmann 2000, 2006; Sial 2003; Vaidyanathan 2006; Viviroli et al. 2007; Alauddin 2008; Ali 2008; Erenstein 2009). The scarcity here is largely a management problem with technological connotations, but at the same time it poses a challenge for social organization, institutional development, and good governance. Nevertheless, deficient water management systems do not seem to be a feature of considerations that are based on average values. Water management has to cope with extreme variations. Specific localities with their own entitlement to water resources and their sets of rules and regulations provide insights into the water economies of scale.

3 Opulence in the Karakoram – A Question of Scale?

The Karakoram Mountains are the mountain ranges with the most extensive ice cover outside the high latitudes. More than a quarter of their surface is glaciated. One third of the Hunza Basin is covered by glaciers (Hewitt 2005, 2006). Water should be abundantly available as this is the least densely populated region of Pakistan with fewer than ten inhabitants per km^2 in the Hindukush-Karakoram. However, the mountain settlements of the Karakoram are densely populated, sharply defined oases in an arid environment and represent quite diverse examples of varying water supply and utilization strategies. To further our argument, we present a case from the central Hunza Valley.

3.1 Water management in the Hunza Valley

On a smaller scale, intra-montane water use follows decentralized and localized practices of water management. Water is diverted from glacier-melt reservoirs across mountain slopes towards irrigated terraces. Steep gradients of water flow and limited space for cultivated fields at the upper limit of agricultural feasibility are characteristics of mountain irrigation.

In order to study environmental and societal change in mountain regions, an important perspective on these processes may be gained by examining the organization of water-user communities, their rules and regulations in a given watershed, and conflicts among different groups. First, however, the interrelationship between socio-economic and environmental parameters is highlighted. Frequently, a discussion of hydraulic resources within mountain areas restricts itself to the natural features and their quantitative properties. To assess the development potential within water communities, a broader perspective is required.

3.2 Observations and sensitizations

The inhabitants of arid and semi-arid mountain regions depend to a substantial degree on irrigated agriculture to safeguard their survival within their high-altitude habitat. Different approaches to the utilization of local water resources can be observed in remote regions. Some of the most ingenious and highly sophisticated decentralized irrigation systems form the basis of communal life at the upper limit of human habitations. Expertise about the techniques and social frameworks normally goes unrecorded and is common knowledge only among the user communities. Embedded in local oral traditions, specified rights and duties are passed on from generation to generation and modified according to circumstances. Water management forms an integral part of local culture, having evolved in a harsh environment and reflecting the social and communal structures. In a feat of modernization this knowledge was widely neglected in the early decades of development. In recent years, the circumstantial failure of these externally induced programs has stimulated awareness for the understanding of local conditions and traditions (Sidky 1996; Kreutzmann 2000). Nevertheless, the wealth of experiences encapsulated within existing small-scale irrigation systems and the associated methods of water management are prone to neglect when development projects act as an external force.

Technological progress, improved materials, financial aid, and the political backing of administrative bodies generate strong pressure on existing user communities to discard or to develop "their" agriculture. At the present time, stakeholders are confronted with different and competing approaches to development. The pace of change seems quite fast, and research operates between understanding local techniques and social organization, on the one hand, and the implementation of development programs and application of blueprint approaches, on the other. A three-step sequence seems to be symptomatic of the scenario in irrigation development. First, traditional water management strategies in remote mountain regions are the result of an adaptation process to environment and societal conditions. Second, growing socio-economic pressure on local resources and augmented exchange relations between highlands and lowlands enhance the permeability of local societies and their structural setups. Third, external funding from public and supra-regional resources in a wider community affects the system and enables projects to be implemented that would have been declared unfeasible on the basis of purely local considerations. The failure of these projects results in increased external efforts by NGOs and public institutions to produce new planning and development exercises.

Attempts to establish sustainable and equitable development by using appropriate technology go back to fundamental local knowledge. Some materials have been presented in scattered publications, but an overview of the spectrum of autochthonous methods of communal resource management and their interrelationship with, or impact on, social organization is still lacking.

In a first step, an analytical framework (Figure 3) for the study of irrigation systems is presented that has been applied and tested in the Hindukush-Karakoram-Himalaya region.

3.3 Elements of a conceptual framework for the study of mountain irrigation systems

Water management is concerned with the energy-efficient transportation of exploitable hydrological resources from the upper zone to climatically (i.e. more precise thermally) favorable areas where irrigation helps to overcome arid conditions and facilitate the cultivation of crops and watering of meadows. In other words: human intervention sets the stage for the allocation of water from a wider catchment area to a smaller habitat where this resource is scarce.

Six fields have been identified for the

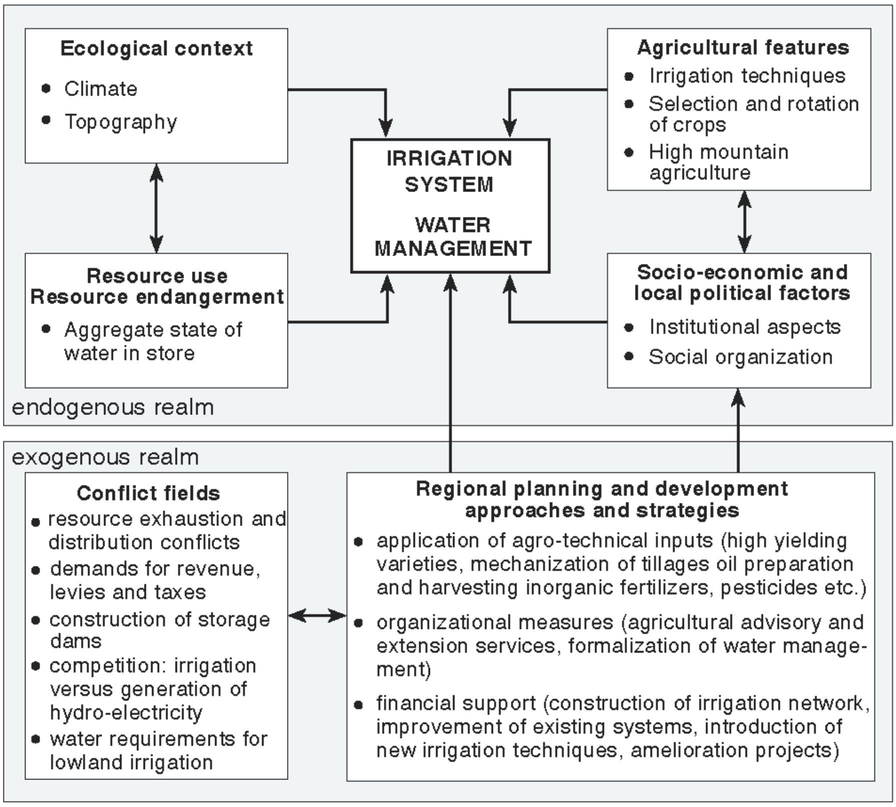

Figure 3 Water management in high mountain ranges: system elements (Source: Kreutzmann 2000)

description of relevant parameters influencing an irrigation system. Four elements belong to the endogenous realm. In the ecological frame, climate and topography are the basic factors in defining aridity and the duration of vegetation periods as well as localized features of water resources and their allocation in the cultivation zone. Resource utilization is driven by use and endangerment such as the aggregate state of water in store, its spatio-temporal availability, and natural hazards.

The other factors involve the agricultural sector. Irrigation techniques and the selection of crops connected with rotation patterns are key elements of mixed mountain farming in arid regions. Hidden behind these more obvious factors of mountain farming are invisible socio-economic features such as institutional aspects and local political constellations. They emulate norms, rules and regulations as well as sanctions. These four system components form the inner circle and are augmented by two exogenous boxes basically affecting the social side of water management. External influences appear in the shape of regional planning and development strategies brought into mountain regions through national development funds and aid supply. They trigger social change in the agricultural sector through agro-technical inputs, organizational intervention and, last but not least, financial support. These aspects should not be neglected as they constitute the enigma of modernization and produce the agents of significant change in high mountain agricultural systems. A second external factor is described as fields of conflict and contains a substantial group of relationships between mountain farmers and the state. Besides taxation and local administration, we find here so-called national interests, which often supersede local interests such as the construction of major water reservoirs and the generation of hydroelectricity for the lowlands. In our case mega hydro projects presently apply to Basha Diamir Dam Project (4500 MW) at a cost estimate of 8.5 billion US $ and the Bunji Hydro Power Project (7100 MW) at 2.9 billion US $ (GoGB 2010).

The systematic approach to analyzing water management in mountainous contexts was tested in different case studies in the Karakoram and Himalaya ranges and yielded results that have shown the importance and necessity of interdisciplinary cooperation in studying complex systems. Only a few aspects can be highlighted here. Four examples have been selected of predominantly agricultural relevance.

1) *Crop water requirements*: There remains the popular error that water shortage does not occur in decentralized small-farmer irrigation systems in a mountain environment where only 1 % of the available land is cultivated. In that case it is assumed that there are sufficient resources to irrigate these few terraces properly throughout the year. This assessment holds true especially for the Karakoram where the glacier cover is exceptional. Nevertheless, even here water scarcity is common and affects the selection of crops. Traditional crops well adapted to high mountain conditions include barley, wheat, millet and peas all of which require about 250 mm on average, whereas rice and “modern” crops such as maize need about 800 mm. Potatoes and beans are positioned in between. The latter were introduced much later.

2) *Seasonal water availability*: Even when these low-demanding crops are cultivated, water scarcity is well known in the Karakoram. In Central Hunza we find an irrigation schedule that is characterized by scarcity and surplus periods (Figure 4). The system of cultivation can only be grasped if the vegetation growth period governed by climatic factors is taken into consideration. Here the combination of ecology and farming practices becomes important. The existing system is a highly adapted strategy to mitigate water deficiency during the sowing seasons.

3) *Seasonality and scarcity*: Even when these properties are understood, it is not necessarily obvious what kind of development potential remains (Figure 5). The amount of water available in the growing season governs the development potential of areal expansion and increase of productivity. In one specific case, international experts promised to build a channel and subsequently double the cultivated land of a village. The only flaw was that there was surplus water for only a very short period as all the water had already been allocated according to traditional water rights. Not one single hectare of land was cultivated through this scheme; thus, it was not possible to increase the permanent basis for crop cultivation.

4) *Rules and regulations*: They are important to understand the tasks and social differentiation of water user groups (Table 1). They are the most hidden features, but nevertheless very important. Robert Netting (1974) called it "the system nobody knows" in one of his famous contributions to irrigation studies. There is some paradox in his

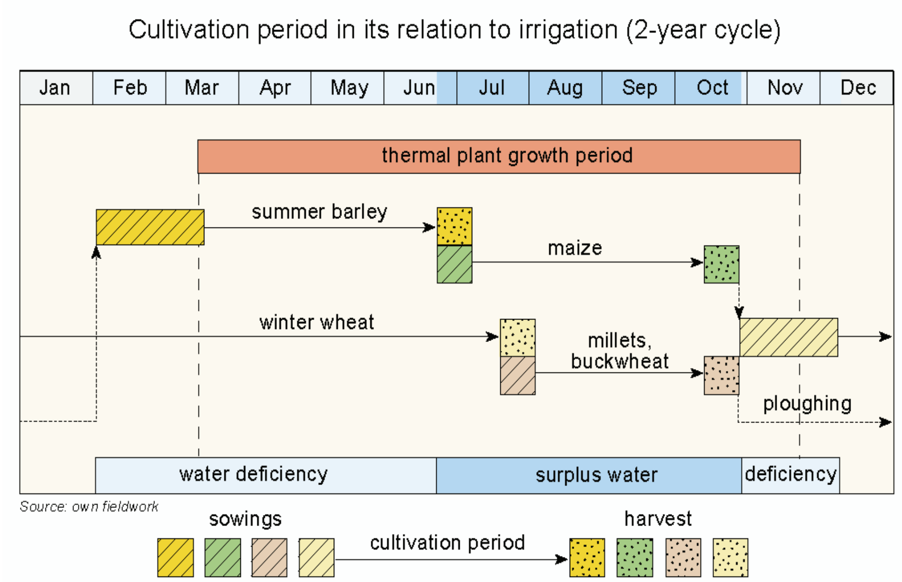

Figure 4 Seasonality of crop cultivation and deficiency of water supply. The diagram shows the relationship between thermal growth conditions for agricultural crops and its inter-linkages with water availability for a two-year growth cycle. Farmers have adapted to the conditions by splitting the sowing of crops between winter wheat and summer barley. Consequently less water is required for the sowing period when scarcity prevails.

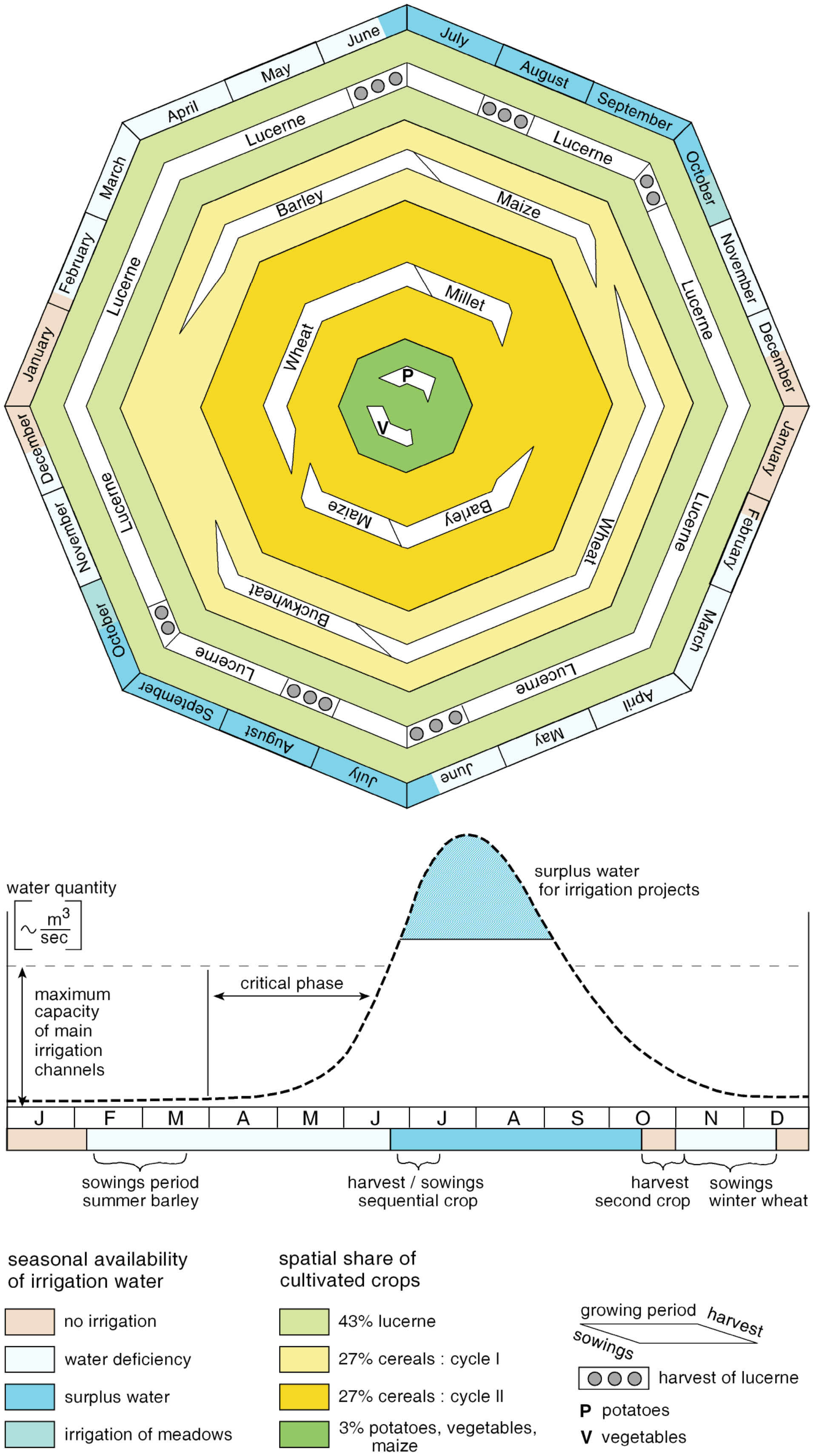

Figure 5 Irrigation and crop rotation in Karimabad, Central Hunza Valley (Source: Kreutzmann 1996)

Table 1 Institutional and organizational aspects of irrigation (Source: Kreutzmann 1999)

Institutional and organizational fields	Areas of responsibility	Activities	Groups involved
Tapping of water	extension of existing and construction of new installations	one - off	user groups
Water distribution	distribution of irrigation water according to agreed schemes, observance of the irrigation plan	regularly	responsible office-holders
Care and maintenance	cleaning and repair of the irrigation canal	regularly	neighbours / user groups
Mobilization of resources	assistance with catastrophes, control of unforeseen events acquisition of labour & capital for new projects	episodically	anyone entitled to utilization
Administration	allocation of tasks & offices, fixing contribution & charges	annually	anyone entitled to utilization (*jirga*)
Jurisdiction	arbitration in disputes, sanctioning, compensation of injured parties	episodically	responsible office-holders, village elders

statement; basically it is a system known to everybody who is concerned with it and who is an actor in practice. But as it is nowhere written down and fixed, it is difficult for researchers, policy-makers and development practitioners to grasp. We can find these features of irrigation societies globally in mountain irrigation networks and in High Asia and the Indus Basin (cf. for more detailed evidence: Sidky 1996; Kreutzmann 2000). The setup reveals the complexity of a system that seems easily understood at first sight.

4 Conclusions

The existence of locally designed irrigation systems within harsh mountain environments has been neglected over long periods owing to the attribution of backwardness and limited growth orientation to remote valley societies. Only within the last two decades has growing awareness been substantially enhanced and proper attention given. Accessible information about the cultural and socio-economic foundations of such societies is lacking everywhere. In recent years development agencies implementing integrated rural development programs have tried to build on local knowledge and emphasize cooperation with farmers in order to serve their felt needs (Malik 2005; Beg and Khan 2006; Wood et al. 2006). In sum, there appears to be an increasing demand to understand the complexity of locally adapted irrigation systems and the connected societies which could serve as a nucleus for regional development involving a shift from large-scale projects to decentralized activities. It should be kept in mind that complexity and variety within the mountain habitat constitute one of its principal features.

Scarcity can occur at every level. Proper understanding of the local and regional expressions of deficiency, resource pressure and societal challenges and constraints can be enhanced only by acknowledging local diversity and decentralized systems.

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