

WATER CRISIS IN THE EASTERN HINDU KUSH: A MICRO-LEVEL STUDY OF COMMUNITY-BASED IRRIGATION WATER MANAGEMENT IN THE MOUNTAIN VILLAGE KUSHUM, PAKISTAN

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With 9 figures, 2 tables and 2 photos

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Summary: Irrigation water scarcity is a rapidly growing problem in the Hindu Kush-Karakorum-Himalayan region. Water is depleting and becoming scarce around the world due to a lack of integrated water management. Researchers have focused on sophisticated irrigation water management systems as an integral strategy to address water scarcity. However, rapid population growth, climate variability, and changes in mountain regions are exerting increasing pressure on water resources. To cope with water scarcity situations, local communities have developed sustainable management mechanisms throughout the mountain regions of the world. These practices are considered as adaptive strategies to address scarcity situations. This article aims to explore the multi-stage, spatio-temporal indigenous appropriation mechanisms of irrigation water and to analyze the seasonal variation in water entitlements in a semi-arid mountain milieu, i.e., Kushum-Chitral. This study is based on a decade of research conducted in the study area. Data were collected in four phases from 2010 to 2018. The study indicates that the share of co-owners has decreased substantially over time due to demographic development and climate change but does not always lead to the tragedy of commons. The study reveals that the local communities have the capacity and capability to sustainably manage an important and scarce resource – i.e., irrigation water – without external intervention.

Zusammenfassung: Aufgrund mangelndem integrierten Wassermanagement wird Wasser weltweit zu einem knapper werdenden Gut und Wasserknappheit stellt somit auch ein wachsendes Problem für den Bewässerungsfeldbau dar. Ein rasches Bevölkerungswachstum, Klimaschwankungen und extreme Umweltbedingungen stellen die Bevölkerung insbesondere in vielen Bergregionen vor besondere Herausforderungen und knapper werdende Wasserressourcen erfordern besondere Strategien. Differenzierte Bewässerungswassermanagementsysteme als integrale Strategie zur Bekämpfung der Wasserknappheit stehen daher im Fokus unterschiedlicher Forschungsbestrebungen. Um mit Wasserknappheit fertig zu werden, haben lokale Bevölkerungsgruppen in vielen Bergregionen der Welt im Laufe der Jahrhunderte nachhaltige Bewirtschaftungsmechanismen entwickelt. Diese Praktiken werden als adaptive Strategien zur Bewältigung von Knappheitssituationen betrachtet. In der vorliegenden Studie wird ein mehrstufiges, raum-zeitlich differenziertes Bewässerungssystem am Beispiel des Dorfes Kushum in der semi-ariden Bergregion Chitral (Pakistan) untersucht. Die Daten für diese Arbeit wurden in vier Phasen in den Jahren von 2010 bis 2018 erhoben. Neben der Analyse der im Laufe der Jahrhunderte traditionell gewachsenen Wasserverteilung und Zuteilungsmechanismen, liegt der Fokus vor allem auf der Betrachtung der Veränderungen und der Stabilität des Systems unter sich verändernden Bedingungen. Trotz extremer und schwankender Umweltbedingungen sowie Veränderungen der Gesellschaftsstruktur durch Bevölkerungswachstum und Migration, weist das traditionelle Bewässerungssystem eine erstaunliche Stabilität auf. Die Studie zeigt somit, dass die lokalen Gemeinschaften die Kapazitäten und Fähigkeiten haben, eine zentrale und knappe Ressource – nämlich das Bewässerungswasser – ohne externe Intervention nachhaltig zu bewirtschaften.

Keywords: Chitral, cultural geography, indigenous knowledge, Pakistan, seasonal movement, water crisis, water management, water rights

1 Introduction

Water scarcity is a rapidly growing problem worldwide and is becoming a threat to sustainable development (JIANG 2009; KARTHE et al. 2015; POSTEL 2000; YOHANNES et al. 2017; UN 2018a). Water crisis is perceived as a global systematic risk (WEF 2019); currently, 2.8 billion people are living in water-stressed areas (MEKONNEN and HOEKSTRA 2016). It is estimated that half of the world's population

will face a chronic water crunch by 2030 (BADAWI 2019). According to the World Economic Forum (WEF 2015), water crisis has been placed at a higher rank, becoming the main global risk for the coming decade. Generally, water is being depleted and becoming scarce throughout the globe, which can be attributed to changing patterns of precipitation in a climate change scenario, coupled with the effects of demographic development. Additionally, there are substantial gaps in addressing this situation at policy

and governance levels regarding water-related issues, due mainly to a lack of knowledge regarding the existing water utilization patterns at the local level and to loopholes in the appropriation and management systems prevailing at the regional level. Moreover, inappropriate management of this scarce/valuable resource undermines the achievement of sustainable development goals and leads to severe conflict situations at various levels in the water-stressed countries of the world (FAN et al. 2018; PEREIRA et al. 2002).

Compared to other common property resources (ASHENAF and LEADER-WILLIAMS; SCHMIDT 2004a, 2004b), irrigation water management in the Hindu Kush-Karakorum-Himalayan region has many unique and distinctive characteristics (FAZLUR-RAHMAN 2009). Agricultural water governance has a very long history (cf. HUNT and HUNT 1976; NETTING 1974) and is thoroughly embedded in social and cultural institutions through local norms and creative adjustment practices. It forms an integral part of local culture and explicitly reflects the social organization and communal structure of a society (KREUTZMANN 2011). This relationship is popularly dubbed 'socio-hydrology' (NÜSSER 2017; NÜSSER et al. 2012; SIVAPALAN et al. 2012; SIVAKUMAR 2012), whereby the co-owner communities independently perform multiple tasks i.e., the institution, formulation, and implementation of rules and regulations; allocation of water; operation of the hydraulic works; construction, repair, and maintenance of the irrigation infrastructure; mobilization of the communal labour force; and distribution of duties and responsibilities amongst the shareholders. Most of these activities are performed on a reciprocity basis and require cooperation and coordination at various levels among water users, leading towards alliance-building and social networking (BECCAR et al. 2002; DITTMANN and NÜSSER 2002; HILL 2017). These autochthonous institutions and locally formulated rules and regulations are reflected through a formal and informal organization for implementing rules and regulations and form the normative foundation for integrated irrigation water management and subsistence survival (SCHMIDT 2004a; EHLERS 2008; KREUTZMANN 2000a). Moreover, these traditional institutions and inherited strategies of water management systems have proved to be robust and effective mechanisms that have successfully prevailed for centuries. Nevertheless, presently, these strategies are under increasing pressure and are expected to remain so in the future due to population pressure and environmental changes (JODHA 1992; NÜSSER 2000).

The agro-pastoral livelihood strategies of the dwellers of the Hindu Kush region depend heavily on irrigated agriculture (NÜSSER et al. 2012; STALEY 1969), which is an integral component of livelihood security in the high-altitude habitat (KREUTZMANN 2011). Agricultural activities and farming are impossible without irrigation. Therefore, irrigation water is an indispensable input and lifeblood (cf. PARVEEN et al. 2015; SCHMIDT 2004) of combined mountain agriculture (EHLERS and KREUTZMANN 2000). This is because the rainfall in this region is decisively below the agronomic limit for rain-fed agriculture. Irrigation water availability is usually determined by the spatio-temporal pattern of precipitation. Snowfall during the winter season is a potential water source for the forthcoming cropping season (FAZLUR-RAHMAN et al. 2014; WHITEMAN 1988). However, climate change places superfluous stress on irrigation water, increasing vulnerability and leading to severe irrigation water shortages (KARKI et al. 2011; UNICEF 2017). To cope with water scarcity, the inhabitants of the Eastern Hindu Kush have developed highly sophisticated irrigation governance and creative adjustment mechanisms through a trial-and-error basis over generations (DITTMANN and NÜSSER 2002). The indigenous institutions for water governance play a pivotal role in the sustainable management of irrigation water and the adaptive capacity of local communities for subsistence survival. Moreover, these indigenously formulated and locally developed institutions for water management systems are considered a mediating strategy in a water-stressed and uncertain environment (AHMAD 2014; ALI et al. 2017; KASPERSON 1993).

As in other parts of the northern mountainous belt of Pakistan, combined mountain agriculture (cf. EHLERS and KREUTZMANN 2000) is the mainstay of the economy in the remote villages of the Eastern Hindu Kush; over 90 percent of the inhabitants of the Chitral district engage in agricultural activities for subsistence sustenance. The acreage under rain-fed agriculture (*lalmi*) is very limited (<2%) and is located mainly in the southern part of the district (cf. HASERODT 1989, 1996; ISRAR-UD-DIN 1996). The remaining cultivated land (>98%) relies exclusively on a network of small irrigation channels taken out of the tributary streams¹⁾. These perennial streams are fed by snow/glacial melt and natural springs (cf. HEWITT 2005, 2011). Similar to the practices in the Hunza valley (cf. KREUTZMANN 2000b, 2011), the irrigation system in

¹⁾ Due to topographical constraints, the main rivers in this region have very limited utility for irrigation (cf. HASERODT 1989; BAIG 1997; ISRAR-UD-DIN 1992, 1996, 2000; FAZLUR-RAHMAN 2007).

Chitral is dominated by gravity flow techniques from source to command areas. These age-old systems are the remnants of indigenous technology and traditional knowledge transferred from one generation to another without written records (ISRAR-UD-DIN 1996, 2000). Nevertheless, many scientific studies regarding socio-hydrology and indigenous mountain irrigation systems have been conducted on the Eastern Hindu Kush; except for a few (NÜSSER 2001), most of the studies were conducted in relatively less water-stressed localities. There are numerous unexplored local idiosyncrasies of socio-hydrology with peculiarities of its own in this arid/semi-arid mountain milieu whereby highly complicated multi-tiered irrigation water appropriation systems have been developed based on specific environmental conditions and socio-cultural contexts. Therefore, a comparative analysis of the prevailing water management system is important for understanding and comprehending the locality-specific creative adjustment mechanisms in an extremely water-stressed scenario and also seems to be effective with regard to the future challenges of water management. This paper explores the multi-stage, spatio-temporal appropriation mechanism of irrigation water and analyzes seasonal variations in property regimes and changing access and withdrawal rights of the co-owner neighborhoods/households at different altitudinal belts in the study area. Additionally, this study highlights the complex four-tier allocation and utilization pattern in vogue for centuries without external patronage. Moreover, the findings of this study will help to achieve the objectives of the United Nations initiative for the International Decade for Action, 'Water for Sustainable Development' 2018-2028 (UN 2017, 2018b) in improving knowledge generation and dissemination for implementing and monitoring water-related goals and projects.

2 Materials and methods

The present study is based on a decade of research conducted in the study area. The overall data collection was conducted in four phases. In the first phase, preliminary survey was conducted in April-May and August 2010 to understand the indigenous appropriation of irrigation water (AHMAD 2010). Later, in 2013, extensive fieldwork was carried out (AHMAD 2014) based on the findings of the earlier study. This study focused on the allocation and management of irrigation water amongst individual neighborhoods and co-owner households. The appropriation and management of irrigation water at

the neighborhood and household level were highly complicated in the study area, which reflects the findings of NETTING (1974) and VERZIJL and QUISPE (2013). Seasonal and spatial variation in water shares was the main focus of that study (AHMAD 2014). In 2016, the study area was revisited to assess the local inhabitants' strategies in a chronic drought scenario (AHMAD et al. 2019). A number of tools were used to collect data on the traditional appropriation of irrigation water. The main tools included participant observation, focus group discussion, and key informant interviews. The principal researcher collected most of the data during the cropping season from April to November. This enabled the researcher to observe the ongoing utilization and management practices, including the method and mechanism of water share allocation to the main sections of the study area, i.e., Pakhturi (Western Kushum) and Nichagh (Eastern Kushum). Meanwhile, the divisions of water shares among the neighborhoods were also ascertained. Moreover, the changing day/night cycles of irrigation water with the season between the upper and lower parts of the respective village sections were also closely observed to appraise the creative adjustment of the inhabitants. To determine the water shares of the neighborhoods and related duties and responsibilities, focus group discussions were conducted in the neighborhoods. In these focus group discussions, the presence of the stakeholders was ensured. Typically, unstructured questions were asked in the local language; these discussions were properly recorded and cross-checked with information provided by respondents from other neighborhoods. This enabled the researcher to verify and validate data on the water rights of the individual neighborhoods, the management system followed by the villagers, and seasonal changes in access and withdrawal rights of the co-owner households. To properly understand and comprehend the management of water sharing at the household level, detailed information was collected particularly from water-stressed neighborhoods, such as Lafan-dur, of Kushum Nichagh (KN) through the purposive sampling method. To obtain more insight, the individual households were also interviewed through a self-administered questionnaire survey. In this survey, the census method was employed. The questionnaire comprised both closed- and open-ended questions and the interview was conducted in the local language. Information regarding seasonal changes in household water shares and management and utilization systems practiced at the neighborhood level during the cropping season was collected from respondents.

Finally, in 2018, additional fieldwork was conducted in the study area to observe the changes in the existing management strategies of the co-owner households to combat the chronic drought prevailing in the study area. This time, the main focus of data collection was the contingency plans of the water users to mitigate the situation. For that purpose, key informants were selected from each neighborhood and unstructured interviews were conducted with them. Questions regarding household-level water-sharing mechanisms and management systems were thoroughly discussed. This enabled the researcher to assess the respondents' capacity to respond to an acute water-stress situation. During this phase, data were also gathered from secondary sources. To describe the physical and anthropogenic characteristics of the study area, long-term time-series data about precipitation and temperature (1966-2017) were collected from the Regional Meteorological Center Peshawar. Population data were gathered from District Census Reports of Chitral, 1961, 1972, 1981, 1998, and 2017. Topographic sheets (42 D/7 and NJ 43-13) used to construct the study area map were acquired from the Survey of Pakistan. To highlight the amount and monthly distribution of precipitation and temperature conditions of the study area, data from the closest station, the Chitral town meteorological station located at 1500 m a.s.l., were used. The location and altitude of that weather station are not truly representative of the study area; however, the station reveals a very general pattern of precipitation and temperature condition. The long-term series precipitation data were analyzed through the standardized precipitation index (MCKEE et al. 1993; SÖNMEZ et al. 2005; HUANG et al. 2015) to evaluate the meteorological drought, seasonality, and periodic aridity of the study area.

3 The study area – the village Kushum

The study area is located in the newly created tehsil of Torkhow-Mulkhwa in the upper Chitral district, Khyber Pakhtunkhwa. This study area is located on the Mulkhwa-Terich divide and has a southern exposure. It consists of several neighborhoods dispersed over the entire area. Similar to other villages of Mulkhwa, the study area also covers a considerable vertical extent from the banks of the Mulkhwa River about 2050 meters to 3660 meters above mean sea level (a.s.l.) to the crest of the Mulkhwa-Terich divide (Fig. 1). Geographically, it is located between 36° 18' 08" and 36° 22' 14" north latitudes

and 72° 15' 32" and 72° 19' 44" east longitudes. The inhabitants of this village practice combined mountain agriculture (cf. EHLERS and KREUTZMANN 2000) and have skillfully integrated the spatially separated and seasonally productive resources (cf. EHLERS 1996, 1997) with the establishment of summer settlements and houses at various elevations. Land suitable for agriculture is abundant; however, water paucity is one of the major problems preventing the bringing of more land under the plow and the cultivating of suitable crops.

A stream flowing through the study area divides the village into two micro-relief sections. The area located on the right bank of this stream is locally known as Kushum Pakhtori (Western Kushum), while the area towards the left bank of the stream is called Kushum Nichagh (Eastern Kushum) (Fig. 2). Based on altitude, both Kushum Pakhtori (KP) and Kushum Nichagh (KN) have been further subdivided into two sections, i.e., lower Kushum Pakhtori (LKP) and upper Kushum Pakhtori (UKP) and, likewise, lower Kushum Nichagh (LKN) and upper Kushum Nichagh (UKN). There is no clear dividing line/boundary between the lower and upper areas of Village Kushum. However, the contour line of 2600 m a.s.l. is taken as an arbitrary boundary between subsections of KP and KN. Several small neighborhoods have been established in each section of the village. The settlement pattern is dispersed and most of the houses have been constructed close to the cultivated land (Fig. 2). Irrigation water is initially distributed based on these micro-physiographic units.

The climate setting of the Chitral District is characterized by the prominent gradient of decreasing annual precipitation from southwest to northeast and modified by the orographic structure and seasonally alternating circulation systems. The southern part of Chitral receives higher amounts of summer rainfall from monsoonal depressions. However, the middle and upper parts of Chitral show a more arid regime influenced by winter precipitation from western disturbances (NÜSSER and DICKORE 2002). Moreover, distance from the ocean and abrupt changes in altitude influence the climate of the study area, which is of the extreme continental type with long, cold winters and short, warm summers. According to the data from the nearest meteorological station, Chitral, the climate of the study area is semi-arid with a mean annual temperature of 16°C and precipitation of 460 mm. In lower parts of the study area, the temperature remains high through the summer season. A steep increase in tempera-

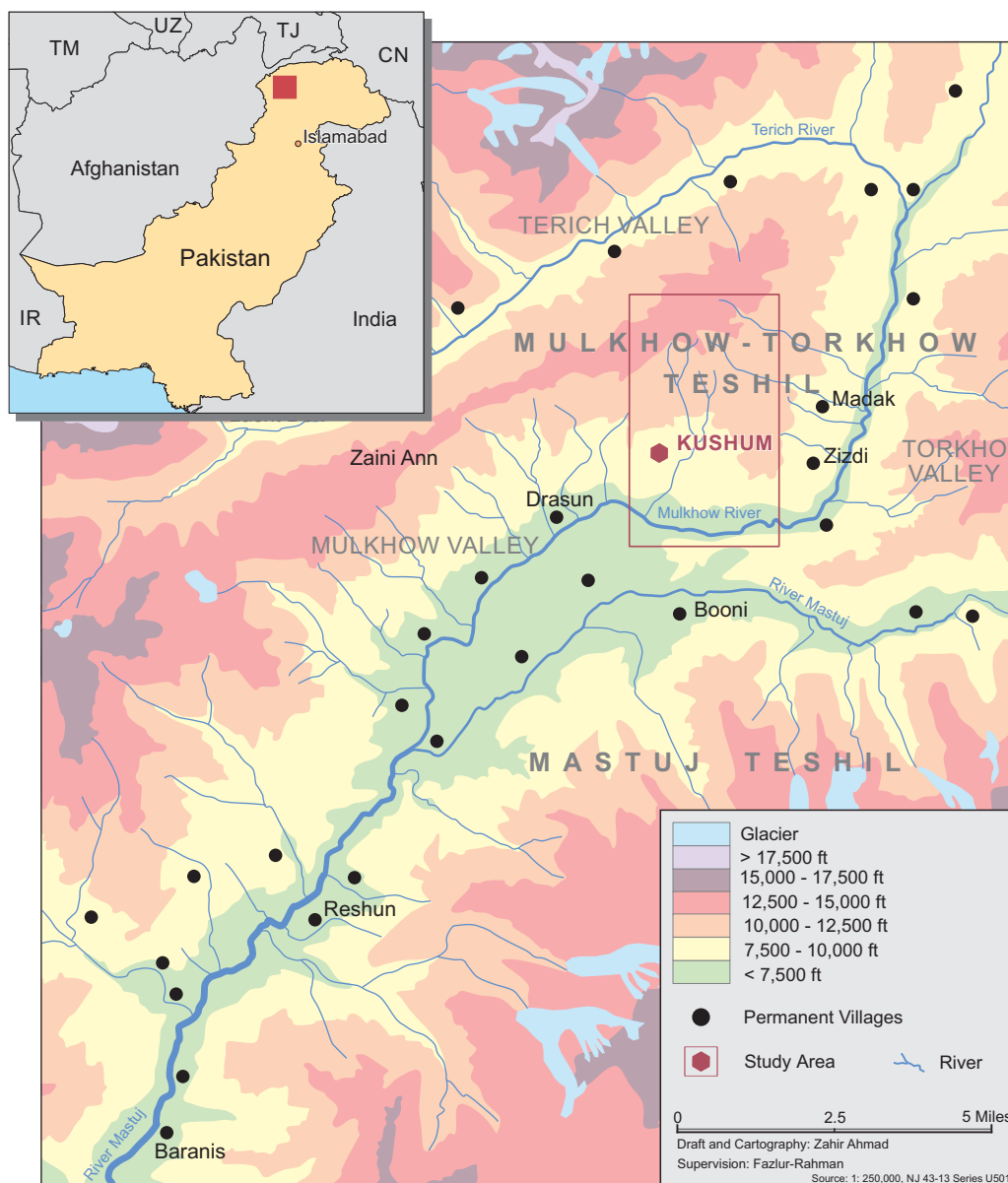


Fig. 1: The study area in Upper Chitral district, Khyber Pakhtunkhwa, Pakistan

ture is observed from May to July and a rapid fall in temperature is recorded from October to December. In the study area, July is the hottest month of the summer season; the 50-year mean maximum temperature for the this month is 36.1°C and the mean minimum temperature is 19.4°C (Fig. 3). The winter season starts in November and lasts until April, with January as the coldest month in this region. In this month, the temperature regularly drops below the freezing point. The mean minimum temperature is -0.7°C and the mean maximum is 9.9°C . In January, the nighttime temperature usually falls to below 0°C .

The study area is located at the rain shadow of the Eastern Hindu Kush Range. The total average rainfall at the Chitral station is 460 mm. Precipitation is inconsistent and unevenly distributed throughout the year (Fig. 3). The study area receives the highest amount of precipitation in the winter season, from December to April, in the form of snow through western disturbances. The average precipitation from December to April amounts to 337mm, which makes up 73% of the average annual precipitation. This is important because, firstly, it provides moisture to the *Rabi* growing season and, secondly, it

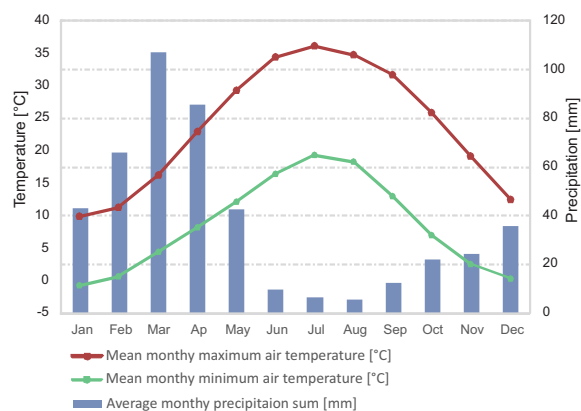


Fig. 3: Chitral climate station, mean monthly temperature and precipitation sums (1967-2017). Source: Pakistan Meteorological Department Peshawar, 2018.

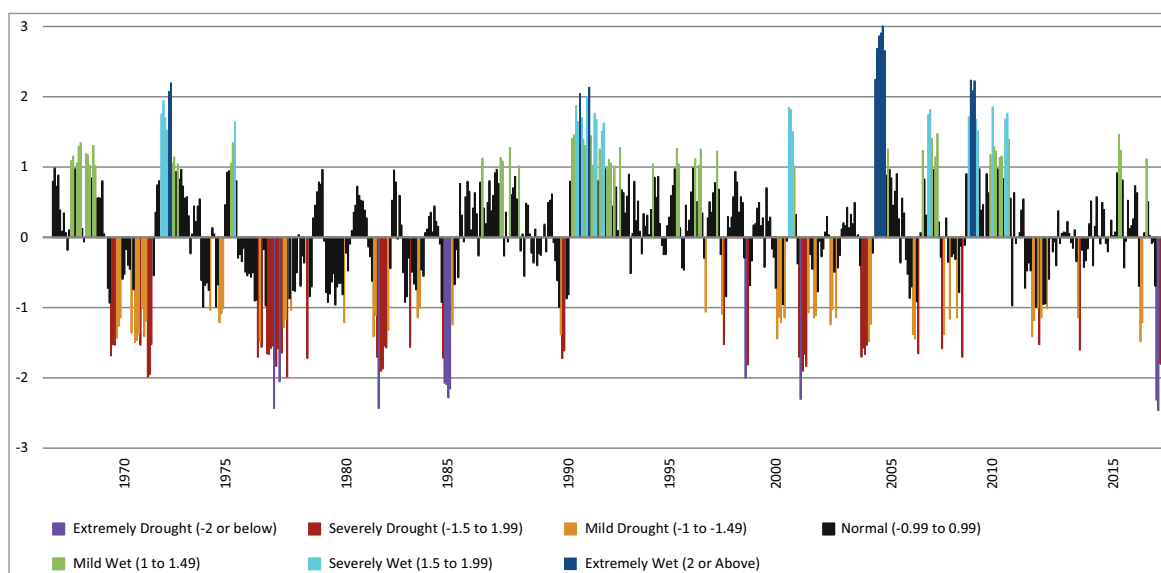


Fig. 4: Chitral climate station, standardized precipitation index (SPI-6) for a period of 1967-2017. Source: Pakistan Meteorological Department Peshawar, 2018.

three houses within the territorial limits of the village (AHMAD 2010, 2014). Generally, people dwell in the winter settlements from January to June, the summer field settlements in July, October, and December, and the summer pasture settlement in August and September (Fig. 5). Due to the topographically induced, seasonal temperature variation and growth conditions, migration is a common phenomenon in mountain regions; however, the unavailability of water in the lower parts of the study region during the summer season also compels the inhabitants to move to the upper sections. Most of the seasonal settlements are cultivated; however, in the higher altitudes, many summer settlements have been established without fields. The latter is usually used for keeping livestock

during the summer grazing season (Fig. 5).

The population of the study area is increasing quite rapidly. According to the census of 1961, the total population of the village was 1629. It increased to 3194 in 1981, which means that it took almost 20 years to double the population (GoP n.d., 1976, 1983). During the inter-censal period of 1981-98, the annual average growth remained low (1.37%) and the total population increased to 3938 (GoP 1983, 1999). However, according to the latest census of 2017, the population was 4412 persons (GoP 2018) and the population growth further declined (0.60%) due to out-migration. Many households had left the study area due to water scarcity and the hazard of land sliding. The inhabitants also participate in seasonal migration to the lowland urban centers for four to six months during

the winter. Moreover, several households have family in the Middle East to whom they regularly send remittances. Over time, employment opportunities in the off-farm sector have also increased (FAZLUR-RAHMAN et al. 2014). Nevertheless, agriculture and animal husbandry are still the main economic activities practiced in the study area.

The case study hamlet²⁾ – Lafan-dur – is a multi-ethnic neighborhood comprising three different clan, i.e., Boshay, Lafay, and Mosingay. It is a summer field settlement of upper Kushum Nichagh located at an altitude of 2744 m a.s.l. It consists of 24 households

²⁾ The words ‘neighborhood’ and ‘hamlet’ have been used interchangeably in this paper.

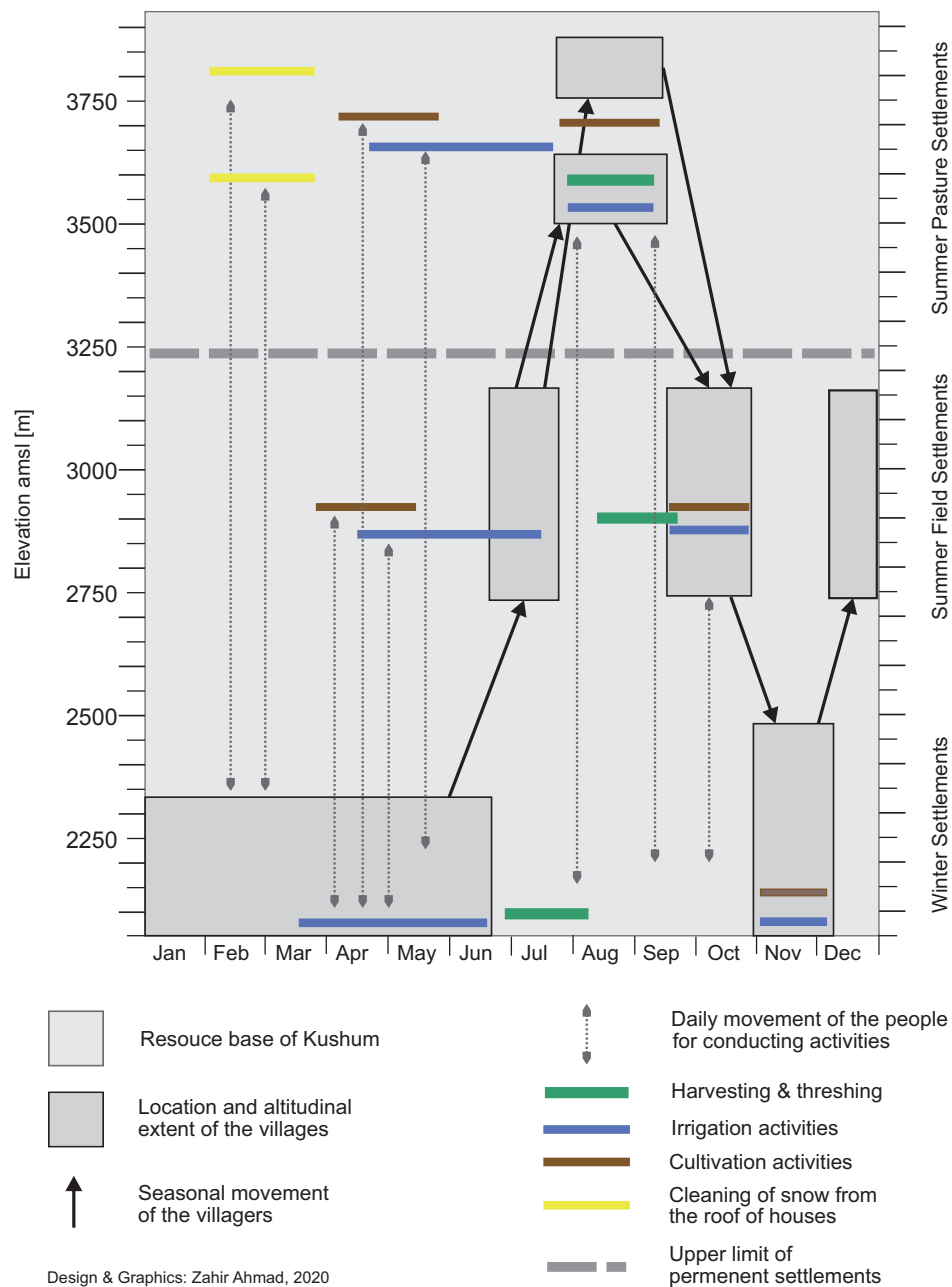


Fig. 5: Seasonal movement of people within the territorial limit of Kushum Pakistan

and its total population was 204 in 2018. Land and water resources are unequally distributed amongst the clans of this village; however, the Boshay clan possesses the lion's share of both water and land resources. Lafay and Mosingay are distributed widely and possess a limited share of both water and land resources. Moreover, the Lafay clan is the pioneer settler of this hamlet; the name of the neighborhood is borrowed from the name of clan Lafay (AHMAD 2014).

4 Results

4.1 Water allocation system

In the first stage, the available irrigation water of the study area is homogeneously bifurcated between the Kushum Pakhturi and Kushum Nichagh sections before entering the village at an altitude of about 3,050 m a.s.l. through a water distribution de-



Photo 1: Main *Nerwal* of Kushum - an unmodified indigenous water allocation device



Photo 2: *Nerwal* of Kushum Pakhturi

vice known locally as *Nerwal*. It is a plank of wood with two primary and two secondary holes for water distribution. It is fixed on the stream at a suitable location for dividing water equally (Photo 1). This is a traditional system for the fair division of water between the two sections of the study area. However, the water of Pakhturi is again passed through a second *Nerwal* for further sub-division amongst three localities, namely, Toson, Bohchain, and Thonio-Tack (Photo 2). Similar to other localities in Chitral (cf. SCHOMBERG 1935; ISRAR-UD-DIN 1992; BAIG 1997), few families in the study have special water rights. They have a specific unit of water known locally as *Chakbtogh* for the whole season. These water rights have been conferred by the former rulers (*Mehtar*) to the notable and influential persons of the village sections. Usually, the local representatives of the *Mehtar* or his nominee had granted these rights to the households. In some cases, they granted land and water to the households; however, in certain circumstances or on the request of the household, only water rights were conferred to them. Such shares are always taken out of the channel before any formal distribution takes place among the co-owners. In the study area, there are four *Chakbtogh*,³⁾ i.e., the *Chakbtogh* of Hoshi, Balyan-dur, Koniz, and Utropi. The *Chakbtogh* of Hoshi is given from the main channel before formal distribution, while the other *Chakbtoghs* have been granted from the shares of Nichagh and Pakhturi (Fig. 6). Following this division of irrigation water between the village sec-

tions and the special rights holder, the respective neighborhoods located in the village section manage and utilize their water share according to need.

4.2 Seasonal variation

The appropriation management of irrigation water between the upper and lower zones of Kushum varies from season to season (Tab. 1). From April to mid-July, daytime water is allocated to the upper part of village Kushum while nighttime water is allocated to the lower parts of village Kushum. From mid-July to mid-September, both daytime and nighttime water is utilized in the upper part of Kushum. However, a fixed amount of water, i.e., 48 hours at a periodic interval of eight days, is allocated to the lower part of Kushum Nichagh (LKN). From mid-September to November, both day and night water is utilized in the upper parts of village Kushum and no specific amount of water is allocated to the lower part of Kushum (southern Kushum). From November to mid-December, water is allocated to the hamlets of southern Kushum. From mid-December to March, water is open access. Nevertheless, this spatial and temporal distribution of irrigation is closely associated with agricultural activities, the cropping season, and the temporally dynamic property regimes of water (Tab. 1). In addition, reciprocal exchange and sharing strategies play a pivotal role in the sustainable management of irrigation water between the upper and lower parts of the village Kushum. Similar to other hydraulic mountainous societies (cf. JAING 2009), the irrigation regime is the key element of land use management in this region.

³⁾ This is a specific amount of water that has been granted to a household or a hamlet by the former ruler of Chitral. Its amount varies from place to place (AHMAD 2014; ISRAR-UD-DIN 1992, 1996).

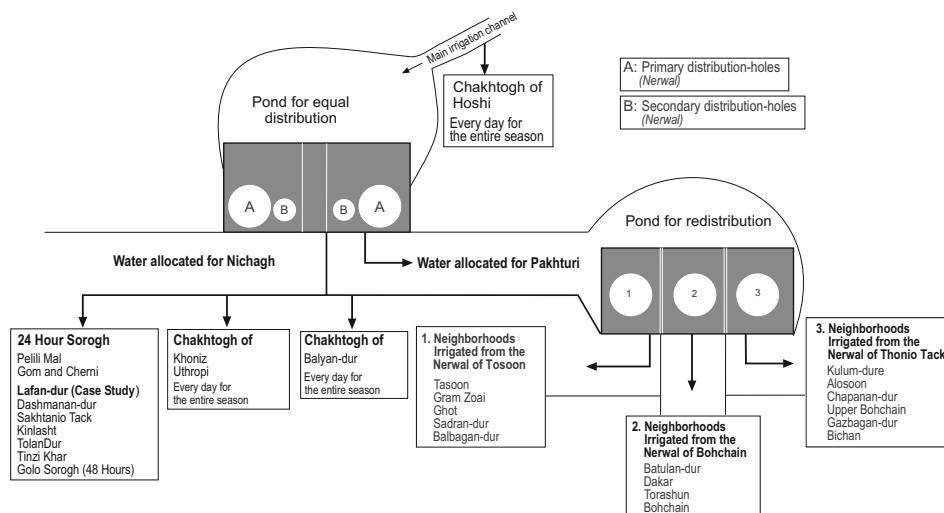


Fig. 6: Irrigation water allocation device of the village Kushum, Chitral, Pakistan

4.2.1 Water appropriation amongst neighborhoods

For efficient management and unbiased allocation of water among neighborhoods, the irrigation water is put on rotation, which is locally called *Sorogh*.⁴⁾ Neighborhoods of each zone have their own share in the form of *Sorogh* and practice an intricate system of irrigation management (cf. VERZIJI and QUISPE 2013) that varies from season to season. The seasonal mechanism of water distribution at the neighbourhood level will be explained below using the example of Kushum Nichagh (KN).

4.2.2 Crop growing season – April to Mid-July

At the beginning of the agricultural season, irrigation water is managed and controlled according to communal property rights (Tab. 1). During this time (April to mid-July), water is needed in both parts of Kushum Nichagh. Therefore, the agricultural water of Kushum Nichagh (KN) is further divided into daytime and nighttime water. For sustainable and unbiased management, daytime water is allocated to the upper neighborhoods of KN, while nighttime water is granted to the lower neighborhoods of KN. In this appropriation management, special care has been given to minimize the water losses through evaporation, seepage, etc., because the distance and length of the channel between the upper and lower parts of vil-

lage Kushum are quite long (approximately 12 km). Moreover, the channels are very rough, stony, and unlined; during the summer season, over half of the water is dissipated in the channel before it reaches the field.

From April to mid-July, irrigation water is predominantly recharged by the ablation of snow, accumulated in the high spur of the study area during winter snowfall. Similar to other villages of Chitral (FAZLUR-RAHMAN 2006; ISRAR-UD-DIN 1996), early snowfall in December and January is highly valued by the villager as the optimal potential water source for the forthcoming crop season. During this season, the volume of agricultural water remains very high and there is no scarcity of water, though the cleaning and maintenance of the irrigation channel is a difficult task. To ensure the cleaning and maintenance of the channel, every neighborhood is given equal rights to irrigation water in terms of volume and duration so that the channel can be maintained properly. There are eight neighborhoods in the upper part and 10 neighborhoods in the lower part of KN. Details about the shareholder neighborhoods of KN and their shares are shown in synoptic table 1 and 2.

4.2.3 Mid-July to Mid-September

Irrigation water in the study area is kept under the private property regimes during this irrigation period and is locally called *Padari*. The salient feature of this irrigation water is that the ration of a migrant household is given to the tenant. The water of this period can be granted to the people of other villagers and can also be sold (Tab. 1). During this season, both day

⁴⁾ According to BAIG (1997, 158), “Sorogh is a fixed volume of irrigation water with a time limit ranging from 24 hours or more to less than one hour”.

Tab. 1: Village Kushum, altitudinal appropriation and management of irrigation water, (January to December)

Temporal distribution dynamics	Date/month of irrigation season	Major characteristics of irrigation water	Dynamic in spatially distribution / allocation			
			Kushum Nichagh		Kushum Pakhtori	
			Upper	Lower	Upper	Lower
April to Mid-July	Name of water: Ochi o Ough (watering of crops for proper nourishment during the growing season)		Day water (12 hours) is used for watering of crops	Night water (12 hours) is used for watering of crops	Day water (12 hours) is used for watering of crops	Night water (12 hours) is used for watering of crops
	Property right: communal resource Allocated based on household, Every household has an equal share. No share of migrant household/ tenant land has no share in water but tenant household has share in irrigation water. A household cannot sell his share of water to other					
Mid-July to Mid-Sept	Name of water: Padari (Actual share of water according to inheritance and land ratio)		Continuously eight days & nights water is used for watering of the orchard	Specific share of water, i.e. 48 hours per eight days is allocated for watering of the orchard	Both day and night (24 hours) are used to irrigate crops	No water is allocated to this zone due to remoteness
	Property right: private resource Uneven distribution of water among households Share of migrant household's water is given to the tenant Water can be granted to the needy farmer or can be sold					
Mid-Sept to Nov	Name: Kishmano Ough (Water especially used for cultivation of crops during winter season).		Both day and night (24 hours) water is used for cultivation of winter crops	No Irrigation water due to Reciprocal exchange	Both day and night (24 hours) water is used for cultivation of winter crops	No water during this time period
	The property right: private Resource. Water can be sold but can be granted only to the household/ farmer of the same village, but cannot be granted to the other village's farmer. Reciprocal exchange custom/agreement between upper and lower parts of Kushum and among villages of upper parts as well					
Nov to Mid-Dec	Name: Kishmano Ough (Water specially used for cultivation of crops during winter season).		No irrigation water due to reciprocal exchange	Both day and night (24 hours) water is used for cultivation of winter crops	Irrigation water is channeled to down or lower villages therefore No irrigation water during this time period	Both day and night (24 hours) water is used for cultivation of winter crops
	The property right: private resource. Water can be sold but can be granted only to the household/ farmer of the same village, but cannot be granted to the other village's farmer. Reciprocal exchange custom/agreement between upper and lower parts of Kushum and among villages of upper parts as well					
Mid-Dec to March	Name: Hati (Every farmer can use without any restriction) Property right: open access		Due to low temperature, agricultural activities cease and irrigation water is no more needed in the whole village. However, in case of no rainfall, households irrigate their field and orchards to increase soil moisture and preserve it in early spring without following customary laws and rotation rules.			

Source: Field Survey, 2013, 2016

and night water is utilized in the upper part of KN; therefore, the ration of each neighborhood of the upper part of KN is increased from 12 hours to 24 hours per periodic cycle of 10 days. However, a fixed amount of water i.e., 48 hours at the periodic interval of eight

days, is allocated to the lower part/neighborhoods of KN (Tab. 1). From mid-July to mid-September, the water of the lower neighborhoods of KN is dubbed Golo Sorogh I and II. The share and ration of the neighborhoods of KN are shown in synoptic table 1.

4.2.4 Mid-September to November (crop sowings-Season in KN)

This period (mid-September to the end of October) coincides with the sowing season of the winter crops in Upper Kushum Nichagh (hereinafter referred to as UKN). During this season, much water is needed in the upper zones due to the short sowing period, as late sowing creates many problems, such as low production, crop failure, etc. due to the coupled effect of extreme cold weather and high altitude. To cope with these constraints, local water managers allocate both daytime and nighttime water to UKN (Tab. 2). Moreover, the fixed share (i.e., 48 hours) of the neighborhoods of Lower Kushum Nichagh (hereinafter referred to as LKN) is also utilized in UKN on a reciprocal exchange condition as per the customary law of irrigation water (Tab. 2). In return, the shareholders' neighborhood of LKN exclusively diverts the water to the lower part after the completion of land preparation (*Kishman*). This type of exchange of water is locally called *Badaldik*. The synoptic table 2 shows that the ration of every shareholder neighborhood of UKN is increased from 24 hours to 48 hours during this season. Actually, land preparation for the sowing of winter crop needs a significant amount of water; therefore, the shareholders neighborhood increases the period of the rotation cycle from 10 days to 20 days, to increase the length of the irrigation period and utilize the irrigation water more economically.

4.2.5 November to Mid-December (crop sowing season in LKN)

The sowing of winter crop starts in November at the lower part of Kushum Nichagh. Therefore, in early November, the irrigation water is entirely channeled down to the neighborhoods of LKN for the cultivation of winter crops. According to the prevailing customary law of the reciprocal exchange of irrigation water, the shareholders' neighborhoods of LKN receive both daytime and nighttime water during this season (Tab. 2). The hamlet shareholders of LKN utilize the agricultural water through an intricate turn-based system. However, priority in the first turn is always given to the high-altitude hamlets to avoid crop failure during this time. Interestingly, during the growing season (April to mid-July), the first turn of irrigation water is always allocated on a top priority basis to the low-lying hamlet.

At the micro-level, agricultural water management is highly complex and varies from one neighborhood

to another. Each unit has its own co-owners and independent system of water appropriation. This irrigation management system was developed many centuries ago and the management principle has been followed without any major alterations.

The entitlement of the individual stockholder to the amount of water and its duration vary seasonally and are both closely associated with the number of users. In many cases, the entitlements are very small and not sufficient for the owner's needs. In such cases, a secondary, tertiary, or sometimes quaternary complex turn mechanism is established within the primary cycle. The irrigation management system at the household level is highly complex. Therefore, a case study from a hamlet of UKN is presented below for an in-depth analysis of all three agricultural seasons.

4.3 Management and utilization of water at the household level: a case study of the hamlet Lafan-dur

In this hamlet, similar to other hamlets of Kushum, irrigation is an indispensable input of agriculture because precipitation is decisively below the agronomic limit for rain-fed cultivation. A highly sophisticated management system is applied for both the allocation and management of irrigation water in this hamlet. Irrigation is the symbol of survival in Lafan-dur, as agriculture is the primary source of livelihood. The agricultural land of the study area is very fertile and suitable for all kinds of crops, though water shortages cause the average production per unit area to be less than the standard of the country.

Lafan-dur takes its water share from the water of Kushum Nichagh. Its ration changes from season to season. From April to mid-July, it receives 12 hours of water per eight days. However, its share increases from mid-July to mid-September, when it receives 24 hours of water in a 10-day cycle. Due to the reciprocal and mutual exchange of irrigation water, it receives 48 hours of water per 20 days (Tab. 2). Therefore, the indigenous appropriation management of irrigation water with respect to different irrigation seasons is discussed below in detail.

4.3.1 April to Mid-July: management of water at the household level

During this season, the share of water in this village is 12 hours per eight days. The village consisted of 24 households in 2018. The allocation

Tab. 2: Spatio-temporal allocation of irrigation water amongst shareholder neighborhoods of Kushum Nichagh (April-Dec)

Spatial Distribution			Temporal Dynamic of Irrigation Water							
Altitudinal Niches	Name of Shareholder Neighborhoods	Mid-April to Mid-July		Mid-July to Mid-Sep		Mid-Sep to November			November to Mid Dec	
		Day Water	Night Water	Day water	Night water	Day water	Night water	Total share	Day Water	Night Water
I Upper Neighborhoods of Kushum Nichagh	Pelil Mal	12 hrs	00	12hrs	12hrs	24 hrs	24 hrs	48 hrs	No Water during this season: According to customary law of reciprocal exchange of water, the shareholders of upper neighborhoods give their ration to the lower part of KN.	
	Gom / Cheni	12 hrs	00	12hrs	12hrs	24 hrs	24 hrs	48 hrs		
	Lafan-dur	12 hrs	00	12 hrs	12 hrs	24 hrs	24 hrs	48 hrs		
	Dashmanan Dur	12 hrs	00	12 hrs	12 hrs	24 hrs	24 hrs	48 hrs		
	Sakhtaniotak	12 hrs	00	12 hrs	12 hrs	24 hrs	24 hrs	48 hrs		
	Kinlasht	12 hrs	00	12 hrs	12 hrs	24 hrs	24 hrs	48 hrs		
	Tholan Dur	12 hrs	00	12 hrs	12 hrs	24 hrs	24 hrs	48 hrs		
Lot Gadaee	12 hrs	00	12 hrs	12 hrs	24 hrs	24 hrs	48 hrs			
II Lower Neighborhoods of Kushum Nichagh	Koragh	00	12 hrs	A fixed amount of water (48 hours both days and nights) is allocated in eight days cycle for watering of orchard and irrigated plantations.		No water during this season: As per customary law, reciprocal exchange of irrigation water is practiced between upper and lower parts of KN. During this season, the shareholders of lower part of KN give their ration to the upper part of KN. In return, the shareholders of upper part of KN give their ration to lower part of KN from November to December.			48 hrs	48hrs
	Dokichan Dur	00	12 hrs						48 hrs	48hrs
	Gachatur	00	12 hrs						48 hrs	48hrs
	Granzhoi	00	12 hrs						48 hrs	48hrs
	Pewak	00	12 hrs						48 hrs	48hrs
	Dastoon	00	12 hrs						48 hrs	48hrs
	Lafan-dur	00	12 hrs						48 hrs	48hrs
	Dashmanan Dur	00	12 hrs						48 hrs	48hrs
Balyan Dur	00	12 hrs	48 hrs	48hrs						
Uthropi	00	12 hrs	48 hrs	48hrs						

Source; Focus Group Discussion, 2018

principle of irrigation water is based on the number of households. However, during this period, both the presence and occupancy of houses within the respective neighborhood (*Kosbon-ai-naek*) are the main prerequisites to obtain access rights to irrigation water. Out-migrant households are not entitled to irrigation water during this period due to their non-participation in life cycle events including cleaning and maintenance of the irrigation channel (FAZLUR-RAHMAN 2008). According to the customary law of *Ochi-o-Ough*,⁵⁾ all resident households have an equal share in irrigation water during this season, irrespective of their landholding size.

One-day water (12 hours) is distributed among 24 households equally. The actual share of each household is 30 minutes. The utilization mechanism depends exclusively on the volume of water. In a high runoff period, two groups, each containing 12 households, combine to form a double hexagonal irrigation group to lengthen the duration of

water from 30 minutes to six hours while dividing the water equally amongst 12 households (Fig. 7).

With the change of seasons, the volume of water shrinks and becomes inadequate to split into 12 equal parts among the households of the double hexagonal group. Therefore, each double hexagonal group is divided into two single hexagonal groups. The ration of each hexagonal group is three hours. Each member of the hexagonal group utilizes the water for three hours (Fig. 7).

Upon the arrival of July, a chronic irrigation crunch prevails, when all the accumulated snow in the spur has melted away and then only springs provide limited water for irrigation. In July, the volume of water in the channel has extremely decreased and become too limited to distribute among six shareholders. Thus, the households adopt another mediating strategy to more efficiently utilize the available scarce water. They divide the hexagonal group into triangle groups. Each member of the triangle group utilizes the irrigation water for one and a half hours. This strategy is practiced as a creative adjustment mechanism during chronic drought periods (Fig. 7).

⁵⁾ During this season (April to mid-July), irrigation water is dubbed *Ochi-o-Ough* and is treated as communal property.

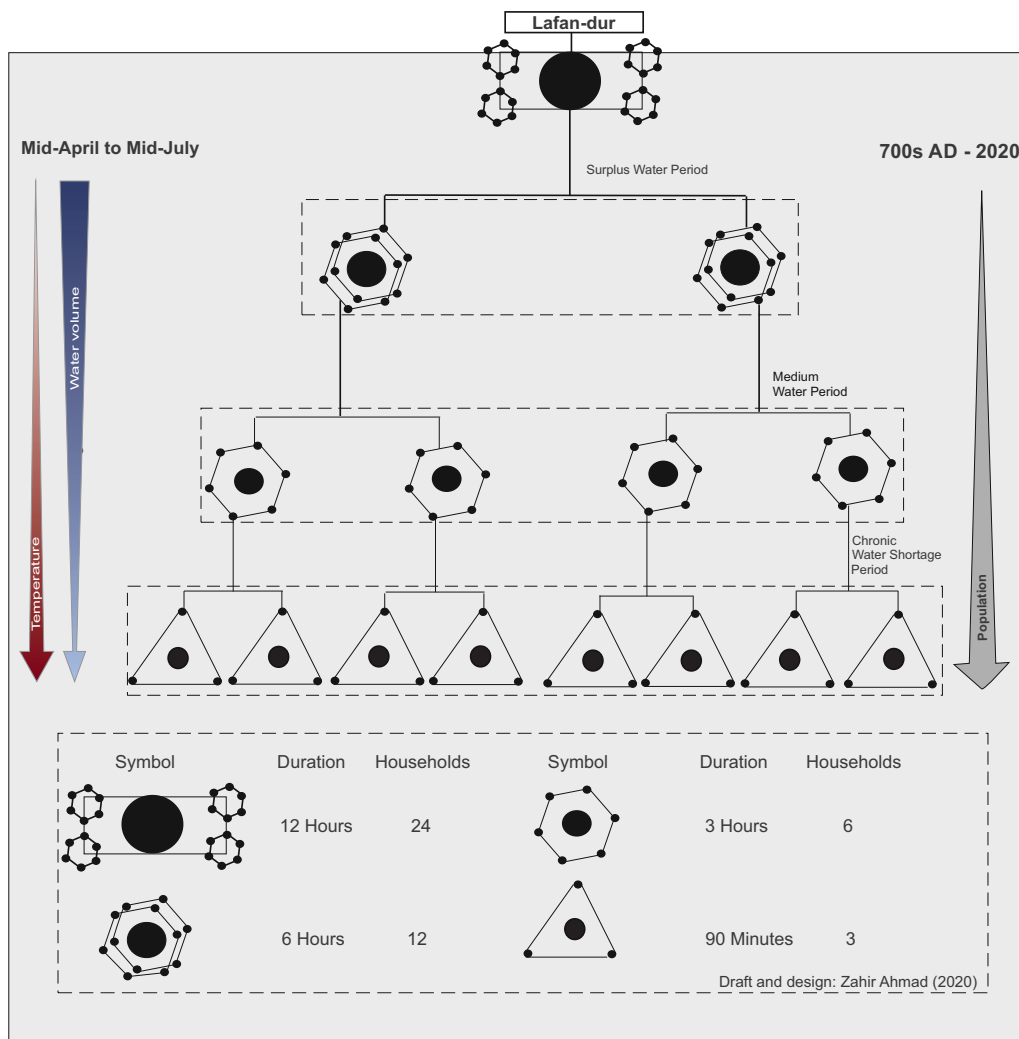


Fig. 7: Lafan-dur, irrigation water management mechanism amongst households from Mid-April to Mid-July

4.3.2 Mid-July to Mid-September: creative adjustment mechanisms at household level

From mid-July to mid-September, the ration of irrigation water of Lafan-dur is 24 hours in a ten day cycle and is distributed equally among the six primary user groups, which are symbolized as A, B, C, D, E, and F (Fig. 8). Seven to ten centuries ago, when the population was confined to six households and the irrigation water was equally distributed among them, the share of irrigation water for each household was four hours in a ten day cycle (Fig. 8). The descendants then followed the same general principles of management and equity. Today's inheritors still follow that old methods without any major modification. Each secondary, tertiary or quaternary subgroup takes his share from their respective primary group. For exam-

ple, according to figure 8, groups A, D and E have two sub-groups. Each of them has 2 hours of water in a 10 day cycle. The utilization mechanism of irrigation water is completely different than the individual ration of the possessor. Each and every end user-group does not use his specific ration separately. As a part of a creative adjustment mechanism, each secondary group establishes an irrigation group with his primary group in order to enhance the duration of the irrigation period from two hours to four hours (Fig. 8).

The allocation of irrigation water of group B and F is very complex because it must disintegrate a joint family into tertiary user groups. There are six tertiary user groups in each primary group B and F. Each shareholder has irrigation water for 40 minutes per ten days. However, each shareholder merges with his parental group and forms a triangle hydrological user

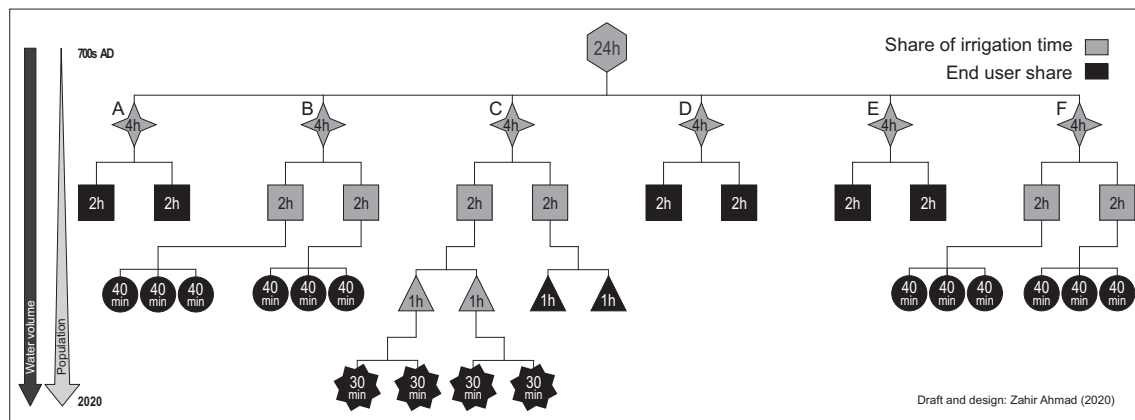


Fig. 8: Lafan-dur, water shares allocation system among co-owner households from Mid-July to Mid-September

group in order to increase the length of the irrigation period from 40 minutes to two hours while dividing the water into three parts homogeneously (Fig. 8).

The allocation and management of agricultural water of group C is very complicated because of the emergence of quaternary groups due to demographic development. There are four quaternary users and two tertiary users in this group. Therefore, the ration and share of end user groups varies from tertiary to quaternary. Every end user of tertiary subgroup has one-hour (60 minutes) water while each end user of a quaternary subgroup has 30 minutes of irrigation water per ten days. In a chronic period of water shortage, each shareholder uses his own share. However, in an surplus runoff period, the members of this group also practices a combined irrigation management system in order to enhance the duration of irrigation water.

4.3.3 Mid-September to November: coping strategy for the water of *Kishman*

The ration of Lafan-dur during this season is 48 hours in a 24-day cycle (Tab. 2). The irrigation water during the sowing season of the winter crop is locally called water of *Kishman*. The water of *Kishman* is equally divided among two primary groups, which themselves are divided into six secondary user groups: A, B, C, D, E, and F (Fig. 9). During the *Kishman* irrigation period, the share of each secondary user group is eight hours (Fig. 9). The distribution of water of *Kishman* among the end-user groups is highly complicated and unevenly distributed. The main cause of the uneven distribution of the irrigation of *Kishman* is unknown; however, out-migration of households and uneven demographic development might be the factors behind uneven distribution.

According to Figure 9, the allocation and management systems of secondary user groups A, D, and E are identical due to their having the same number of households. The irrigation water is equally divided between the shareholders of their respective groups. Each co-owner has four hours of water in a 24-day cycle. Unlike their actual ration, all shareholders in their respective groups form a hydrological group by mutually sharing their actual share to increase the irrigation period from four hours to eight hours.

Secondary user groups B and F have a similar irrigation management system and each secondary group has six end shareholders. The ration of each end shareholder is identical, i.e., 80 minutes (Fig. 9). However, three co-owners of each group combine to form a triangle group to increase the length of the irrigation period for land preparation.

Secondary group C has six co-owners. Four hours of water is allocated equally among four quaternary co-owners, while the share for each member of the quaternary group is two hours. Similar to other groups, the members of the tertiary and quaternary levels form an irrigation group (Fig. 9) to increase the length of *Sorogb*. This creative adjustment mechanism is very important as compared to the actual ration of the co-owner because watering with a high volume creates several problems, such as the erosion of fertile soil, the wastage of water, etc.

5 Discussion

The results of this study reveal that the indigenous community-based mountain irrigation water management system of the study area has functioned smoothly without external intervention over many centuries due to unbiased allocation at every stage

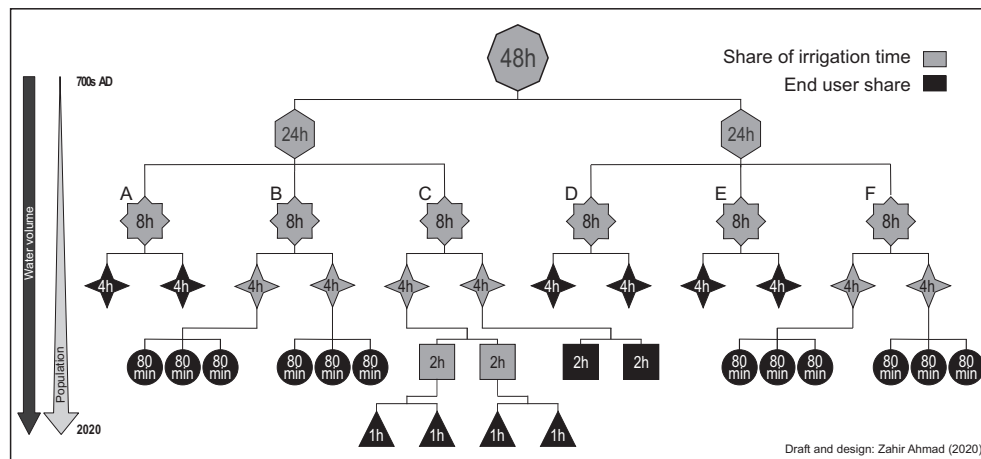


Fig. 9: Lafan-dur, water appropriation mechanism amongst households from Mid-September to November

of appropriation. In contrast to the Khot irrigation management system (ISRAR-UD-DIN 1992, 2000), there are four different stages and tiers of appropriation and management of irrigation water in the study area. During the first stage of allocation, irrigation water is bifurcated between the eastern and western sections of village Kushum through a traditional, indigenous allocation device (Photo 1). During the second stage of appropriation, water is allocated to the different altitudinal belts of the study area (lower and upper parts of eastern and western Kushum) on a diurnal basis. For homogeneous distribution of water between the lower and upper parts of the village, daytime water (12-hour) is allocated to the upper part of the village while nighttime water (12-hour) is allocated to the lower part of the village (Tab. 1) to minimize the evaporation of irrigation water. During the third stage, irrigation water is distributed amongst shareholder neighborhoods based on rotation (*Sorgh*) and an equal amount of water is given to each shareholder neighborhood (Tab. 2). During the last stage, water is allocated amongst households according to their actual share and ration. Similar to the findings of NETTING (1974) and VERZIJL and QUISPE (2013), the distribution of irrigation water amongst households is extremely difficult to understand.

According to DIECKHOFF and WEGNER (2008), water allocation to the field parcels in Shigar is carried out pursuant to the principle of “first come – first served”. This type of allocation may cause controversies and conflicts among the co-owners. Moreover, the irrigation system involves different stakeholders of the local community, such as water users, watchmen, or the local government; even the government and NGOs play supportive roles in the management

of irrigation (NÜSSER and SCHMIDT 2017). Contrary to FAZLUR-RAHMAN (2006) and SCHMIDT (2004a), different irrigation water distribution techniques and management mechanisms are employed in the study area to ensure fair and efficient distribution of water at all levels, from the village section level to the individual stockholder. For instance, *Nerwal*, *Sorgh* (rotation system), *Badeldik* (reciprocal exchange), mutual exchange, *Ghana* or the turn strategy (secondary, tertiary, and quandary turn system), *Wari* (diurnal rotation), hourly rotation, and water sharing are the major unique features of Kushum’s irrigation water management system. Moreover, seasonal and diurnal changes in temperature, insolation, sky cover, clouds, and albedo affect the amount of discharge, resulting in seasonal and daily fluctuations in the water supply in the study area. The local water managers also assign equal importance to daily and hourly fluctuations of water; hence, the irrigation water is kept to diurnal and hourly rotation (morning-time, noontime, nighttime water, etc.) amongst individual stockholders to ensure equality in all respects. This ensures the maintenance of equity and avoids conflicts amongst co-owners.

Contrary to the Hunza irrigation appropriation mechanism (KREUTZMANN 2000b; 2011) and other hydraulic societies (FAZLUR-RAHMAN 2006; ISRAR-UD-DIN 1996, 2000; NETTING 1974), inhabitants of the remote mountain village Kushum keep the irrigation water under three different dynamic property regimes during an irrigation season of one year for the sustainable management of water. 1) It is kept under the communal property regime from April to July. This period coincides with the cereal crop growing season – especially wheat crop, which is

the staple food of the local people. Every household grows wheat for subsistence survival, and irrigation is required for the nourishment of wheat. Therefore, during this season, irrigation water is kept under the regime of communal ownership so that every household has equal access and can grow crops for subsistence. 2) In the summer season, a chronic shortage of water prevails in the study area and agricultural water is treated as a private property regime. 3) In the winter season (mid-December to March), agricultural activities almost cease; therefore, irrigation water is considered an open-access property regime. These property-use rights and management regimes for irrigation water in the study area have evolved over the centuries in response to environmental, cultural, and political imperatives. This dynamic water tenure provides an opportunity to take a holistic approach to understanding relationships amongst irrigation water, water governance, and co-owners. The main strength of Kushum's irrigation water model is that it has a seasonally dynamic water tenure system, reciprocal exchange of water, secondary and tertiary turn mechanisms within the primary cycle of rotation, spatio-temporally dynamic allocation and distribution, and unbiased diurnal and seasonal-based management mechanisms.

The major weakness of this management system is that the establishment of a secondary, tertiary turn system within the primary cycle of rotation increases the cycle of rotation, resulting in a greater dryness condition in the study area on the one hand while, on the other hand, also enhancing the workloads of people whose primary source of livelihood is agriculture. With a decrease in water, farmers (mostly at the tail end of the water channel) must put more physical effort into irrigation. The situation worsens when one's turn for irrigation comes at night. Family members (both men and women) are assigned to different distribution points to ensure a supply of the quantity of water allocated and avoid loss through seepage or blockage.

6 Conclusion

This study highlights the four tiers of the appropriation and management of irrigation water and the coping mechanisms adopted by mountain peasants in response to an acute water crunch. The seasonal distribution and diurnal allocation of water to different sections of the village are among the creative adjustment mechanisms employed to sustain livelihood in a harsh environment. The management mechanism

of irrigation water had been formulated many centuries ago and has remained in practice without any major alterations. The main reason why this indigenous water governance system is practical is that it ensures accountability at all stages of operation and community members are fully involved in the decision-making process, which builds ownership and trust in the system. Moreover, this allocation system is unbiased and maintains equity at all levels of appropriation and management; consequently, conflict has been reduced to the minimum possible level. Unlike other irrigation water appropriation mechanisms (DIECKHOFF and WEGNER 2008; ISRAR-UD-DIN 2000; KREUTZMANN 2011; NÜSSER and SCHMIDT 2017), the property regime and management of irrigation water varies from season to season depending on the availability of the water. This temporally dynamic property usufruct is the prime mitigating strategy and creative adjustment mechanism for coping with the seasonal variability and paucity of irrigation water. From the micro-level case study of agricultural water, it is evident that mountain farmers change their coping strategies and utilization management mechanisms of irrigation water with the changes in temperature, water volume, and population. This study also shows that the co-owners' shares are decreasing in terms of both duration and quantity and that pressure on irrigation water has increased many-fold due to demographic development, the disintegration of the family, and climate change but does not always lead to the tragedy of commons. The mountain farmers have the capacity, knowledge, insight, and managerial potential to formulate mechanisms for the effective management of irrigation water.

Finally, this micro-level study provides valuable information and essential dissemination about the management and utilization of a scarce natural resource – i.e., irrigation water – in an arid and remote mountainous milieu. However, there is considerable variation in the management and utilization of irrigation water throughout the region, ranging from very simple to the most complicated systems depending on availability. Yet, the result of the present study invariably provides detailed baseline information about the functioning of a complex system. Moreover, these findings will help both government departments and non-governmental organizations appraise the functional characteristics of water management and provide guidelines needed for improvement of the existing setup. The findings will also help achieve irrigation-water-related goals/targets at the local and regional levels under the umbrella of the International Decade for Action, 'Water for Sustainable Development'.

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