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Water Institutional Arrangements of Falaj Al Khatamain in the Sultanate of Oman

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Abstract: Oman, which is located on the Southern East of Arabian Peninsula, classified as holding a semi arid climate with an average annual rainfall of 100 mm. Therefore, agricultural production in Oman is fully dependent in irrigation. More than one third is supplied by the ancient aflaj (sing. Falaj), which provide 680×10^6 m^3 of water per year and irrigate of an area of 26,500 ha. There is two commonly known definition of the aflaj; the locally defined from the classic Arabic root as to divide the water among its shareholders. And the modern technical definition as trenches and tunnels, which are dug in the ground, to convey the accumulated rainfall water table to the irrigated area in the villages. This study explores some of the existing institutional arrangements found within Falaj Al Khatamain, at the village of Birkat Al mawz located in the Interiold region, sultanate of Oman. This study uses a serial of recorded rainfall data along of a serial recorded falaj monitored flow to examine to what extend the existed falaj institutional arrangements reflected to the water physical variability. The study concluded that there is strong relationship between Falaj Al Khatamain physical water variability and its institutional arrangements setting.

Key words: Aflaj, water rights, water physical variability, water market.

1. Introduction

Oman classified under arid and semi arid climatically zones which depend untily on groundwater and desalination plants to fulfill its growing water demand. Historically the Omani innovated a well-known ancient irrigation system locally referred as aflaj to manage their scarce water resources under a harsh environment. In past, the aflaj systems considered as the backbone of the village life, not only provided water for domestic and agricultural uses, but encouraged settlers to participate on day-to-day water transactional activities such as the weekly or annually traditional water market, selling of water rights and weekly or annually renting water rights. However, still some of these activities take place in Oman until present time. Hence, the main aim of this study is to document and explore some of these institutional arrangements. Falaj Al Khatamain, at the village of Birkat Al mawz located in the Interiold region, sultanate of Oman was taken as a comprehensive detailed case study to examine the theory that water institutional arrangements might be reflected upon watercourse physical variability [1]. Generally, aflaj water flow continuously day and night, however, it varies according to main rainfall rate on the flaj zone mountainous areas. Therefore, falaj institutional arrangement required to be initiated with accordance to this phonemia. To the extent such relationship extensively reviewed in the literatures, this study focused through the use of the above-mentioned falaj to document and explore this relationship. Thus, the main objective of the study is examine if relationship between the falaj al Khtmain water flow and its existing institutional arrangement and then to document these institutional using available watercourse literature review. Based on these two objectives, the further scope of the study are:

(1) To analyze the collected time serial date of the rainfall and falaj water flow;

(2) To present the primary data collected through introews;

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(3) To present the secondary recorded data obtained.

2. Theoretical Consideration

It is well recognized that water is considered as a prerequisite of all sorts of social as well as economic development. However, in the past water used to be referred as a free good, by which this has been replaced by new perspective that water can be treated either as social good or economic commodity [2-4]. First those who hold the view that water is a social good have looked into several factors including its necessity to life and perquisite of society social development [5, 6] and its association with agrarian and industrial revolution [7]. While those who hold the view that water can be considered as an economic commodity stem from the fact that water is becoming scarce and its demand is increasing. It is not the aim this study to debate which is right or wrong, it is surface to say that the economical argument in considering water as an exchangeable commodity is the fact that price of water will reflect its true scarcity and its opportunity cost, in other words, the price that the marginal user is willing to pay [2, 8].

Reviewing literature the issue of water management in general term extensively discussed by researchers. One can summarize this discussion into two main themes:

- Introducing what is known as "economical instrument" such as water prices or water market;
- The possibility to assert private ownership to water rights.

It is apparent from the fast body of literatures that these two issues discussed sometime within the context of (1) Common-pool resource and sometimes attempted to associate the historical matter related to the (2) Concept of "water appropriation" and associated rules [2, 9-12]. While the former was used to provide classified property rights which may be reflected by the physical variation of the resource, the historical water appropriation was used to analyze the associated water law within a legal context [3, 13]. Ref. [13] discussed the issue of private ownership within the context of differentiating between public goods and common resources on the ground that physical nature of the resources is to be blamed for the difficulty of asserting a private ownership.

We are fully aware that two main concepts exchangeable used as evaluative criteria to analyze any water cause. These are:

- fairness (equity) by which to distribute water among shareholders [11, 14];
- efficiency to the extent of how to utilize water productively [5, 15].

The aim of these two evaluative criteria is to find the most suitable water institutional arrangements [4]. It is well recognized that developing a weak institutional arrangements to regulate any watercourse rights can easily create a complex management problems. For instance, Ref. [6] pointed out that any possible divergence between social and private benefit result in the failure of a market system. Ref. [9] pointed out that the concept of Pareto optimally and economic efficiency analysis is not an adequate basis for guiding collective action. He is in favor to analyze the problem from social context. Therefore, establishing a fair system with well-defined property rights associated with community participation in decision-making is expected to be the most important priority of any institutional arrangements [14]. To do this some scholars have argued to incorporate knowledge relating to culture, beliefs [16, 17] and customs [18].

3. Water Resources Management in Oman

In the absence of alternative supplies of surface water in Oman, groundwater resources form the backbone of local farming economies. The current water supply and associated crop cultivation practices found within two main farming types, both of which use groundwater aquifer. The first and the most modernized type are practiced by digging a well

which is normally owned by individual farmers. The second is through natural flows by the use of man-made tunnels and channels known as falaj (plural aflaj) systems. This classification dictates details understanding of the two types as follows: A farm with its own private owned individual well is called *mazra* literately means a farm, while farms that receive water from a public falaj are called *amwal*. This Arabic word, *amwal,* which is literally means "public wealth" in its plural form, indicate clearly the *falaj* system operate within a community property structure. Second, the community assets and property can be considered as a legal boundary which includes walls, channels, bridges, building and gardens. Several regions over the northern part of the country rely heavily upon a single community-owned *falaj* for irrigating their date gardens and other annual crops. This requires a high degree of social control and cooperation to maintain the system, keep it running and to manage its distributive water rights.

Wilkinson [1] [19] provided a detailed illustrative settlement over arid region of the Arabian Peninsula using aflaj as an example, in particular Izki village. Later studies have touched upon other economic as well as technical aspects [20-22]. More recent studies incorporated more of the water management social issues; Refs. [20, 23] placed the system within the context of a competitive market and tradable water right. As far as Falaj Khatmain is concerned, Refs. [24, 25] evaluated water surplus vs. the region recorded rainfall for the Falak Al Khatmain.

4. Methods

This study is a part of a comprehensive research study included the largest and most famous aflaj in the area. It is believed that these hold some indigenous knowledge with regard to study objective on the issue of water institutional arrangements. This study went through several steps:

(1) Multiple visits to the study area. This has been carried out for two reasons. (i) To develop cultural understanding and norms of conduct with the Omani people whom will be interviewed for obtaining information fulfilling the study objective. (ii) Being able to develop the research field work framework in terms sort of question needed, type of recording instrument to be used, number of important associated personal to interview and any of the official governmental bodies associated to aflaj to be included.

(2) Obtained field work fund from the yearly funded Omani government project related Oman or the dry environment countries and managed by the "Thesiger Oman Fellowship, Royal Geographical Society, UK. (seeing the following site for the year 2009 and the title as shown." "An analysis of institutional arrangements of the falaj irrigation systems in Oman" An exploration of the distinctive institutional settings of the Omani falaj system, developed within a closed society, and the consequential demand for water as a result of the modern technology. http://www.rgs.org/OurWork/Grants/Research/Thesiger-Oman+Fellowships.htm.

(3) Because the district of Birkat Al Mouze away from the Capital (about 130 km) and several visits were required to collect the data, a communications office was required. The University of Nizwa administrative body was approached for a request of an office with modern communication facilities. It helped greatly in saving expanses which were calculated for transportation from the capital city (Muscat) over several trips. Also, created some sort of academicals face-to-face feedback, as Prof. Omezine, Abdullah, x. Dean and Prof. Powers, D., asst. dean were asked by supervisor to provide weekly session for answering questions raised from the field activity.

(4) One of the key private members as far as the field survey is concerned is the wakeel. A list of their

[1] It is worth noting that Wilkinson's analysis placed the system within an organizational framework and he stated that "the aflaj system is an organization for distributing water amongst those who have rights to it and to divide the property to water" (pg. 94). He also stated that "the word *falaj* is a generic term for a complete irrigation system" (Pg. 74).

contact numbers and names is normally available for each district's mayor (governor), locally known as "walis". Several official letters were sent through the head of the College of Commerce, University of Nizwa, to each associated local walis, who keeps details of the falaj wakeel, asking for permission to interview the wakeels and to obtain names and contact details.

(5) A complete set of questions was formulated for each wakeel covering the main topic concerning the classification of falaj property rights; in particular, how much falaj rights were devoted toward common rights, private and quasi- rights. They were also asked whether there was an auctioning water market and how often it is operated and where[2]

(6) After completion of the responses to all the questions, detailed records were obtained concerning a list of the property rights for all stakeholders, auctioning water prices and other related data. Some of the respondents were not ready at the proposed time of the first visit and in some cases data held by other members within the administrative falaj structure was obtained instead. Thus, names and contact address for other members of the local administrative committee were obtained. Due to difficulties in following up the list of property rights or understanding some of the auctioning terms used in relation to the water market, further visits were conducted to obtain clarification of these issues. Later on a great deal of material required similar clarification either from the wakeel himself or from other members, and in some cases interviews were completed via telephone calls.

The secondary data which for this study included official data on falaj flow, water auctioning prices and climatic data on rainfall and temperature. These were obtained from either the traditional recording books held by the wakeels or auctioneers

[2] Four interviews were conducted; two with the two wakeels Mr. Khamis Al Daishi, who responsible about one third of the private water right owners and Mr. Fahid Al Tobi who responsible with the other third and the governmental part-time employer who responsible about the bayt-mal water rights.

5. Study Area

Falaj Al Khatmain considered to be among the five Omani aflaj inscribed in the World Heritage List since July 2006. It was selected because it believed to hold ancient indigenous knowledge with regard to the water institutional arrangements in general, and specifically it is popular in its water flow[3] which may reflect the study hypothesis that there is strong relationship between watercourse physical variability and the development of institutions.

6. Results

Oman has almost two distinct topographic areas; the mountainous zone areas, by which reaching altitude of 200-300 m, and the coastal plain areas descending to the sea level [25]. It is the mountainous zone area where by most of the aflaj systems are found, specifically in the northern part of the country. It is well recognized that there are two important elements very much associated with the context of the systems, these are:

- The significance of the natural setting characterized by mountains and oases, of which have reflected upon the water supply.
- The development of legal and social organizational setting which based on belief and customary rules.

These have assisted greatly on the formation of what known as "settlements" or villages around legal known boundary. Hence Falaj Al Khatmain constructed at the foothill of the Jabal Al Akhdhar and it encouraged the formulation of Birkat Al-Mouz community.

7. Location and History of Falaj Al-Khatmain

Falaj Al Khatmain currently operated and considered to be the main water source at the daistric of Birkat Al-Mouz, which is located in the governorate (region)

[3] Because it is constructed on wadi Maiden, which spring from the foothill of Jabel Akhdar (green mountain) and this wadis flow during rainfall in a semi circle to the falaj tunnels.

Fig. 1 The Sultanate of Oman map and the location of the study area.

of Al-dhakhliya of which the city of Nizwa is the largest city. Tunnels According to the Ministry of Regional Muncipilty and Water Resource Report [26], this falaj is characterized holding a powerful water flow. This is attributed to the fact that its mother[4] well was constructed on wadi Maiden, which spring from the foothill of Jabel Akhdar (Green Mountain). In addition, this wadis flow during rainfall in a semi circle to the falaj tunnels [26].

The wakil Khamis b. Masour Al-Dhashi was the first administrative agent to be met at his home village; Bikat al-Moz. A detailed view of first interview was conducted by which provided some general insight of institutional arrangement of this falaj, as follows:

- The Al Khatmain water flow from the main aquifer over a tunnel of 2,450 meters long, two meter width and one meter height. The first opening point appears at a place known as Bat Radeedah, in which water rights ownership split into three equal parts. This division is assured spatially by cemented wall within the main channel (see Figs. 2 and 3).
- Currently there are two wakils, Mohammmed b. Abdullah Al-Saqri and "Khamis b. Masour Al-Dhashi" administrating day-to-day activities for the lower kiz, while only one wakil "Sayid b. Ali Al-Fahdi" managing upper kiz activities. One governmental part-time supervisor "Nasser b. Saif Al-Tobi" responsible of the bayt-al-mal property rights.

The wakil "Khamis b. Masoud Al-Dhashi" aurally stated some sort of a historical story concerning the construction of the al-khatmain falaj, stated stated when the Imam Sultan b. Saif Al-Yarubi during fifteen century decided to establish a new village named as "Burkat Al Mouz", called the Al-Rayami tribe (popular in the process of aflaj construction and they normally lived up of the Jabel Akhdhar. It came to the people during that time that this area which is the foothill of the Jabel has accumudated geart amount of the rainfall for long time. Now the constructions were too big as using some sort of large local stones arranged together (see Fig. 4).

Fig. 2 Al Khatmain splitting division point.

Fig. 3 Al-Khatmain splitting channel point, where as water coming from the main tunnel first divided into three equal parts, then one of the part remain along until reaching irrigated area while the two part joined into one channel, thus forming the two locally known Kiz; upper and lower.

Fig. 4 Falaj Al khatmeen large tunnel constructed using some sort of large local stones arranged together.

[4] Which is located at UTM coordinates 40 Q; 0569292 E, 2536908 N; and at altitude of 604 m [25].

The initial idea was to build a tunnel of 2,450 meters long with two meter width and one meter height. However, before the completion a disaster had occurred by which seven of the Jabel tribe workers died and burred inside. This had happened due to the claps of the large size stones and the heavy soil on top of them. Because of this all of the remaining workers ran way to the Jabeland left the work. The Imam followed them at their villages in the Jabel, in particular at a place known as "Al-Qazoud" shouting highly "Oh people of the Jabel come back to work I will serve you". While he was doing this, he was throwing by his hand a desert tree seeds "locally known as Sider" (currently very popular in the area and known as Sider Imam). After repeated emphasis by the Imam, they responded and said "we do not work on the paid basis but we work on the basis of rights participation". The Imam agreed to provide them with a right from the falaj water. This had reflected upon the water distributional institutional arrangements until the present time as we shall discuss.

(1) Falaj administrative structure

Generally speaking, the Omani aflaj normally administrated by what is known as "local management committee" by which consists of a heading administrative body called "wakil". An Arabic word literally means a deputy, delegate or agent who acts on behalf of a principle. (https://en.wikipedia.org). This is online with the falaj wakin as his act upon all shareholders on an attempt to administrated day-to-day activities such as budget and conflict solving [21]. For falaj al-khatmain there are three wakis each is responsible for kiz water flow division, mentioned previously.

It was very difficult to form a complete picture from the information revealed during the survey at the first site. This is attributed to the fact that information was scatted over different administrative agents. After interviewing the first wakil; Mr. khamis b. Masoud Al-Dhashi that introduced us to the second wakil Mr. "Mohammed b. Abdullah Al-Saqri" who is responsible for the downstream channel (the lower kiz) as Khamis told us. Now, we found each of these wakil hold information concerning the kiz they actually manage. They both orally stated that a nine raddat (turns) is commonly applied in rotating water among shareholders with each kiz. Furthermore, answered most of the questions during the interview. An attempt was made to illustrate the given information in a table format (see Table 1) using three columns; baddah, ather and percentage for each rights and against each kiz. More details of water rights structure shall be provided below.

Table 1 Al-Khatmain water right structure.

	Baddah	Ather	%
Upper Kiz			
Bayt-al-mal	12.95	310.7	72.16
Falaj renting rights	2	48	11.15
Private	2.99	71.86	16.69
Sub-total	17.94	430.56	100.00
Lower Kiz			
Falaj renting rights	2	48	11.15
Bayt-al-mal	3.63	87	20.21
Waqf			7.43
Special waqf	0.58	14	
Mosqus & schools	0.75	18	
Private	10.98	263.56	61.21
Sub-total	17.94	430.56	
Grand total		861.12	100.00

However, we still cannot come with a complete picture. How this applies and operated in the field was not given. Occasionally, they both introduced us to two important day-to-day activities persons; Mr. Saleh b. Nasser Al-Tobi, a part-time government employer to manage all bayt-el-mal day-to-day activities and the two Areefs[5]. Orally stated that for each of the two kizs, a distributing agent, locally referred to as the Areef, and is appointed by the owners of the water rights. The areef has two major functions. First, he is responsible for giving each holder of the water right ather Second, he is responsible for allowing the falaj water to flow to the next irrigation terms or code once he has delivered all the water (measured in whether day time baddah or night baddah as he ought to memorise the weekly scheduling) for all shareholder in the previous irrigating term is entitled to.

(2) Water circulation mechanism

Great deal of time was spent with these people whom hold knowledge on how water is circulated and what local terminologies actually involved. Raddah is a local customary term that means "number of turns" (plural raddat). It is considered as the main component of the distribution and allocation system known as dawrah, which means "rotation over a defined period", normally a week or more. In the literature it has been indicated repeatedly that dawrah forms the principle of the distribution of water in aflaj [19, 21]. In the interviews various words were used by the interviewees when referring to water and the conduct of exchanges involving water. They very often use the term "dawrah" or "raddat", which means circulation of the falaj water in each turn. They say "raddah" (turn) for day one and so on.

According to the Areefs, two measuring units are commonly used within the context of the falaj distribution/allocation system; qiyas [6] and ather [7]. Originally these units were as follows: A three-meter high stick is anchored at the centre of a flat area where there is little shade to prevent the sun from shining directly on the stick. Then the area to the west and east of the stick is divided into 24 sections; these divisions are equal to one ather (30 minutes). Now, each ather is divided into 24 qiyas. So each 24 hour period consists of 48 athers. To appreciate a full understanding of the use of these units, it is important to illustrate the complete picture that is understood by the local people during this study survey. In addition, information obtained was illustrated in the form of the two tables using the above illustrated conventional ather baddah timing units.

It was revealed through the survey several important institutions which used to distributed al-kht main water. These can be summarized as follows:

Historically, water flow distributed according well-known scheduling names over nine raddat (turns); these are (a)Reedadah (b) private right (c) bayt-el mal (d) remain of the bayt-el mal (e) Bani Ismali (f) third and fourth (g) baddah of ninth (h) Maklaf Saif (i) falaj renting right.

We observed that the two kiz irrigate two different areas as dividing the town currently into two, the lower part, which is irrigated by the lower-kiz and the far end part, the upper which is irrigated by the upper. It is clearly stated by most of the key administrative agents who were interviewed that in general the Upper kiz was initially designated to irrigate the bayt-el mal owned farms. According to supervisor "Nasser b. Sief Al-Tobi" that the Bayt Al-Mal "Al Aqabah" farm 14 ather are customary known provided from the Makalaf Saif and at the same time from it half of ather to irrigate the endowment waqf for al-khod farm.

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[5] This is an Arabic word which means well-knower because it is rooted from the person who knows well upon the things he is dealing with.

[6] Originally qiyas were derived from the process of measuring a thing so that it is used to reflect a volume, as in the past they tended to use a container made of copper with unit lines marked on the inside. Qiyas is considered as the smallest unit within the context of the falaj distributive system.

[7] Originally an ather was derived from the shade from a stick which is placed on a flat area. The movement of the shade over this area as reflected by the movement of the sun used to represent a water flow over the area over approximately 30 minutes.

Table 2 The 9 raddat with their known irrigation term for the upper stream channel.

		upsteam channel; Kiz_fawq		
		This week irrigation	next week irrigation	
Radat	Irrigation used terms	From 6pm to 5am	from 5am -6pm	hours
1	start for the private water rights	Night Baddah	Day time Baddah	24
2	start for the bayt-el mal	Night Baddah	Day time Baddah	24
3	remaining for the bayt-el mal	Night Baddah	Day time Baddah	24
4	Bin Ismail	Night Baddah	Day time Baddah	24
5	thrid forth	Night Baddah	Day time Baddah	24
6	badah & ninth	Night Baddah	Day time Baddah	24
7	makhlaf Saif	Night Baddah	Day time Baddah	24
8	Radeedah	Night Baddah	Day time Baddah	24
9	falaj qa'dah (renting)	Night Baddah	Day time Baddah	24
		9	**9**	**216**
	Total badah	18	18 badah (9 * 2)	
	Total ather		432	432

Table 3 The 9 raddat with their known irrigation term for the downstream channel.

		Downstream channel, Kiz_taht		
		This week irrigation	next week irrigation	
Radat	Irrigation used terms	From 6pm to 5am	from 5am -6pm	hours
1	start for the private water rights	Night Baddah	Day time Baddah	24
2	start for the bayt-el mal	Night Baddah	Day time Baddah	24
3	remaining for the bayt-el mal	Night Baddah	Day time Baddah	24
4	Bin Ismail	Night Baddah	Day time Baddah	24
5	thrid forth	Night Baddah	Day time Baddah	24
6	badah & ninth	Night Baddah	Day time Baddah	24
7	makhlaf Saif	Night Baddah	Day time Baddah	24
8	Radeedah	Night Baddah	Day time Baddah	24
9	falaj qa'dah (renting)	Night Baddah	Day time Baddah	24
		9	**9**	**216**
	Total badah	18	18 badah (9 * 2)	
	Total ather		432	432

They say today's turn for "private rights" by which many of the private and some of the endowment rights are attached to it and next turn, that is next day, will be re-scheduled for the Bayt-el mal and so on.

Suppose al khatmain water flow scheduled on Sunday for the "private right" shareholders then after nine days the flow will be re-scheduled to this group again.

Since Al-khatmain falaj flows continuously, day and night 24 hours day, this raddat name, say the private right group, is then divided into a day baddah and a night baddah. The main purpose of this division is to form a fair distribution among shareholders as water flow scheduled alternatively between these two day and night baddahs, which supposes a farmer receives his/her share at night this week then the next turn shall be scheduled during the day time and so on.

As water flow over the primary main channel until it reaches the division point where it diverted into two different sub-channel; locally known as upper kiz and lower kiz, However, since the radeedah farm located before the diversion point whole flow of water from the main channel use to irrigate it under one raddat. Supervisor orally stated that since the "redeedah" bayt el mal farm and surrounding farms located before the division point, received water from both lower kiz and upper kiz.

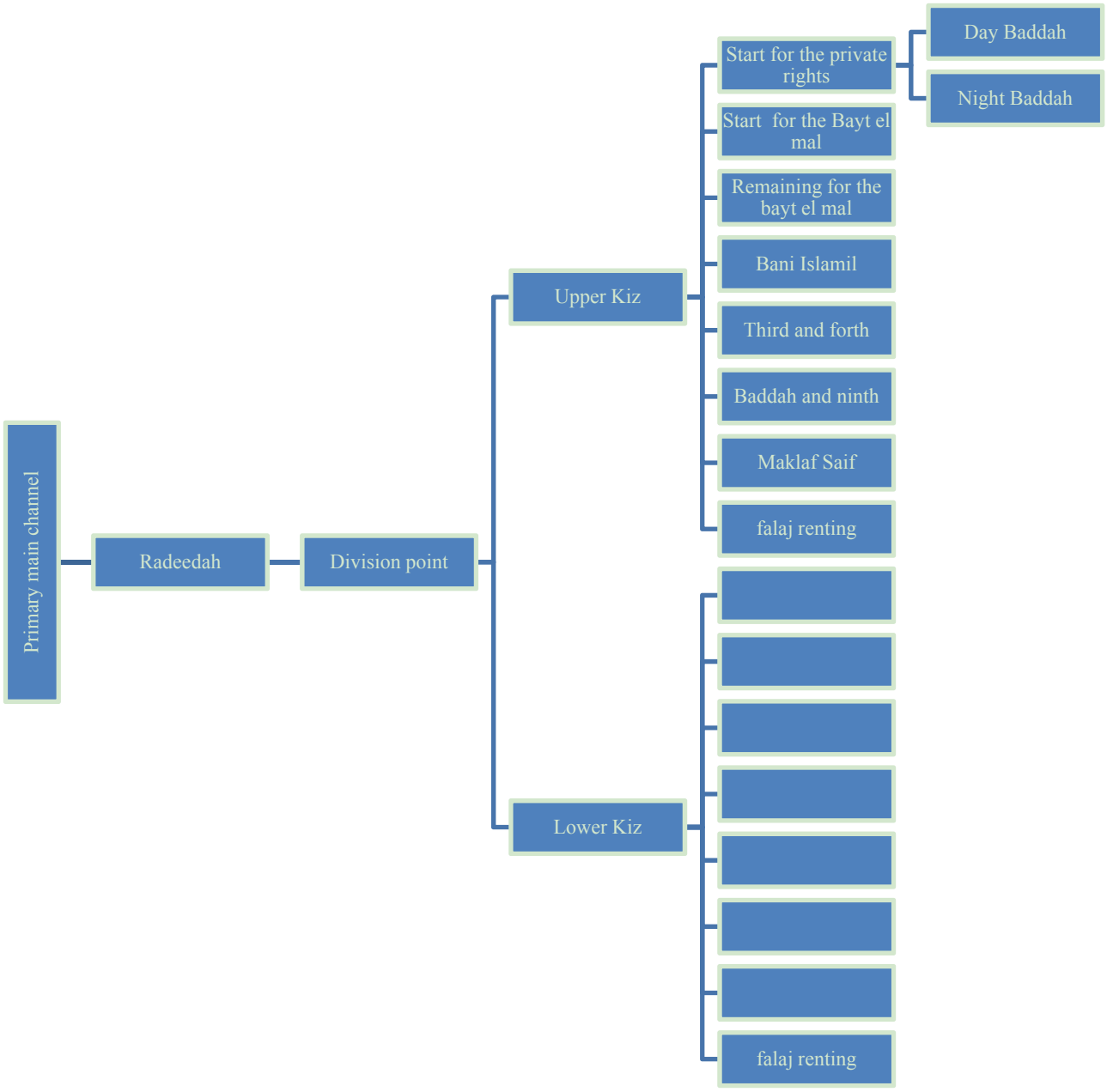


Fig. 5 The well known customary names for water distribution.

(3) Water rights structure

From Table 1, four main types of water rights exist which can be placed under the four known categories of property rights: common, quasi- public, public and private. This research will clarify some of the distinctions between these different categories.

(4) Falaj Khatmain common rights

From the interviews conducted with the two wakils, the lower kiz and upper kiz, one complete raddat (48 athers) was orally stated as being belong to the falaj common rights. After thorough investigation it appears that there are two raddat were designated for the falaj each for each kiz (see Table 1). The main purpose of these two raddat, as understood, was diverted to generate income for falaj maintenance. In addition, the survey revealed a very important aspect with regard to the Al-khatmain common right. The people in here very often refer to the most popular

neighboring two aflaj; Daris and Al-Malki, as they orally stated Al-Khatmain is not like these afalj because the former does have water market. We shall discuss the primary numerical finding in more details below but first we require to clarify the matter of why was not developed a water market for Al-Khatmain falaj while exist for the two neighbouring aflaj, Daris and Malki in the town of Nizwa and Izki respectively.

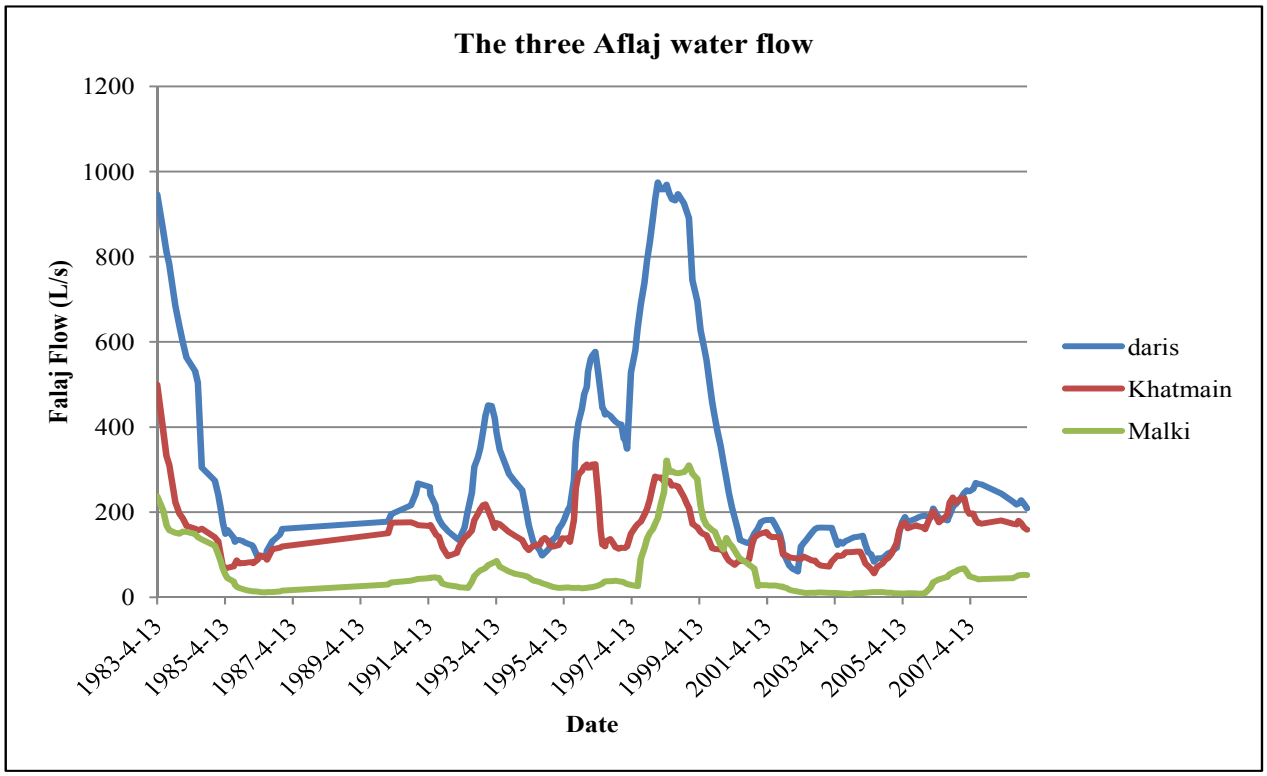
(5) The theory of not developing an auction market

Mr. Mohammed b. Abdullah Al-Saqri' (the wakil of the lower kiz) responded to our question 'why not establishing an auctioning water market like that existed for the two neighboring aflaj: Daris and Al-Malki' by directed our attention to a more of recent event. That is, in one occasion the government appointed Mayer, locally known as the wayli, had called upon a representative from the community to meet and discuss for a possibility of developing an auctioning water market for the Al-Khatmain falaj. He indicated that no one have turned out for this meeting. We belief this can be considered a very important finding. In fact, the interpretation of the local community of not allowing a water market can be explained from this study hypothesis stated previously by using the following economical and statistical parameters.

(6) Khatmain falaj and water flow

Al Amri et al. [24] studied the relationship between rainfall and wadi Maidan flow over 11 years. They proposed what they called "recharge dam" over a distance of 1.3 km from Falaj Al-Khatmain channel to collected surplus water during rainy season. This may provide some indication to our study hypothesis that Al-Khatmain falaj water flow may follow some sort of constant pattern and do not show some of the surfier drought period like other aflaj in Oman [19, 27] .

In fact, the water flow or the supply characteristic of this falaj is considered to be very high. This can be attributed to the fact that this falaj located under the foot hill of the Jabal Al Akhdar. Secondary recorded flow data for this falaj can be further investigated to see the relationship of the flow pattern and the existing institutional arrangement of not allowing a water market.



At present, the Aflaj Department, Directorate General of Water Resources Management, Ministry of Regional Municipalities and Water Resources [28] maintain frequent water flow records for most of the aflaj in Oman. Fig. 6 shows time serial recorded for the three popular aflaj; Daris, Al-Khatmain, and Al-Malki. The purpose of this is to show the pattern fluctuation of the three aflaj water flow over time. It is apparent from this data that flow rate vary significantly between the three aflaj.For instance, Daris and Al-Malki characterised by pattern of high flow fluctuation resulted in two disguised period, abundant flow and very low flow (can be called drought period. In contrast, Al-Khatmain tends to hold almost constant flow pattern not reaching below 100 litre per second on average over the recorded period (see Fig. 6).

Using another statistical test for further investigation, this time to measure the variation around the arithmetical mean, it is known as the coefficient of variance C.O.V. This is usually used to measure the extent and the distance of the value fluctuates about the arithmetic mean of the data by dividing the standard deviation over the average [29]. The standard scale use is that if value is less than or near 1.00, then data form relatively close group about the mean value, but if C.O.V value is larger than 1.00 data showing a great degree of scatter about the mean [29]. Table 4 summarizes the finding by using recording flow sample of 277 for daris, 248 for Al-Khatmain and 247 for Al-Malki. It is apperant from this analysis that Al-Khatmain C.O.V scaling value differ than the other two afalj scoring below 1.00. This can support the community view of not establishing an auctioning water market.

(7) Institution used for the common water right

Wakil “khamis b. Masoud Al-Dhashi” orally revealed two important institutional arrangements concerning the Al-Khatmain common water rights.

There appear to be institutions concerning the renting of the Al-khatmain common water rights, by which whenever a transaction takes place it must be based on an agreed annual contracted prices for particular local renters and not on buying and selling transaction biding prices.

The entry and exist of these renters should not be conducted through the transaction of buying and selling process. But, only once the existing renters clearly declared to release the holding number of athers then it is the responsibility of the administrative agent to search for new renters.

Based on these institutional arrangements, the operational mechanism for renting the common water rights is conducted. The both wakils stated from the nine raddat of the Al-Khatmain water flow, two raddat (two full day irrigation) 96 ather 24 hours from each kiz are assigned as common water rights. Thus, it is considered as the most significant outcome within the institutional arrangement context because it possesses two particular features. First, it is closely linked to the water distributional raddat circulation (see Table 5). Here a whole day is assigned for falaj income generation and is mainly used for its day-to-day maintenance. Second, its transaction of selling and buying should not be based on supply and demand principles.

This is interesting finding and can be interpreted as being in line with the demand-supply theory in the sense that they are trying here to make some sort of restriction on handling the income of these common

Table 4 Satirical result of the variation measurement.

	Daris	Al-Malki	Al-Khatmeen
Average flow Litre/s	0.32	0.07	0.16
Standard Dev	0.32	0.1	0.16
C.O.V	1.02	1.55	0.96
No. of observation	277	248	247

Table 5 Lower kiz contracted ather and prices for the year 2007.

	No. Ather	Total price RO		No. Ather	Total price RO
renter1	2	48	renter26	1.75	18
renter2	2	48	renter27	1.75	18
renter3	2	48	renter28	0.67	16
renter4	2	48	renter29	0.5	12
renter5	2	48	renter30	0.5	12
renter6	2	48	renter31	0.5	12
renter7	2	48	renter32	0.5	12
renter8	2.67	40	renter33	0.5	12
renter9	1.5	36	renter34	0.5	12
renter10	1.5	36	renter35	0.5	12
renter11	1.5	36	renter36	0.5	12
renter12	1	24	renter37	0.5	12
renter13	1	24	renter38	0.5	12
renter14	1	24	renter39	0.5	12
renter15	1	24	renter40	0.5	12
renter16	1	24	renter41	0.5	12
renter17	1	24	renter42	0.334	8
renter18	1	24	renter43	0.334	8
renter19	1	24	renter44	0.25	6
renter20	1	24	renter45	0.25	6
renter21	1	24	renter46	0.25	6
renter22	1	24	renter47	0.25	6
renter23	1	24	renter48	0.25	6
renter24	1	24	renter49	0.25	6
renter25	1	24			
Grand Total	**48.008**	**1080**			

Table 6 Upper kiz contracted ather and prices for the year 2007.

	No. Ather	Total price RO				
renter1	4	72				
renter2	3	72				
renter3	3	60				
renter4	2.5	60				
renter5	2.5	36				
renter6	1.5	24				
renter7	1	24				
renter8	1	24				
renter9	1	24				
renter10	1	24				
renter11	1	24				
renter12	1	20				
renter13	1.25	12				
renter14	0.5	12				
renter15	0.5	12				
renter16	0.5	12				
renter17	0.5	12				
renter18	0.5	12				
renter19	0.5	12				
renter20	0.5	12				
renter21	0.5	12				
renter22	0.5	12				
renter23	0.5	12				
renter24						
renter25	18	432	of Awqaf and Religious Affairs			
Grand Total	**46.75**	**1028**				

Table 7 Bayt al-mal owned farms.

	No. of plam tree	No. of athers	Kiz water supply
Radidah	490	13	Upper & Lower
Waqeef Amar	130	12.5	Lower
AlJaaz	34	4	Lower
alwalqah	126	10	Lower
akhnedak	230	20	Lower
alakebah	64	14	Lower
alaqoud	131	8	Upper
aljazeeraj	390	24	Upper
qatah alfarouth	99	10.67	Upper
qatah alfhoul	222	14	Upper
alntalah	100	9	Upper
qatah alshar	352	24	Upper
aljazenah	142	10	Upper
Jabel Aljarbi	179	12	Upper
alshqarah	104	17	Upper
Jebal alwasat	305	24	Upper
Jebal Alsharqi	273	33	Upper
Qatah Asmail	165	12	Upper
Total		271.17	

rights in order to maintain the demand and as a result to avoid market failure. Finally, the both wakils, the Upper kiz wakil and the lower Kiz, came with recorded details regarding the Al-Khatmain common right. This information then summarized in Tables 2 and 3. A number of aspects can be inferred from this Table. As follows:

Since there is no auctioning water market allowed, fixed known renters pay an annual agreed rented prices to the wakil.

An exact number of athers from each kiz was given

It appear an almost fixed contracted priced for all athers rented on each kiz

(8) Bayt-el mal public rights

Bayt-al-mal supervisor Mr. "Saleh b. Nasser Al-Tobi" was introduced during the field survey. He is regarded as part-time government employer to manage all bayt-al-mal day-to-day activities and associated water rights. Great deal of time was spent with him in providing information with regard to bayt-el-mal public rights. First, as mentioned above, this falaj hold high proportion of batyt-al-mal rights, approximately 72% (310.7 athers) from upper kiz and 20% (87 athers) from the lower kiz. According the above-mentioned supervisor the main activities of utilising Bayt-al-mal water right is to irrigate their owned existing farms. There are approximately 18 of these farms with various sizes; the largest known as the Radeedah, growing 490 palms tree, and the smallest known as Al Jaaz, growing merely 34 trees. These farms, as can be seen from Table 7, owned specified number of athers which distributed over customary known names.

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