The Role of 'the canalero' in the management of Irrigation Systems around the world

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Abstract

The canalero is a person employed to take part in field level activities of irrigation water management. Literature has a blind spot on the contribution this type of personnel provides for the performance of certain irrigation systems. This brings us to question the importance/significance of the roles and responsibilities of the canalero in irrigation water management in different agro-ecological, infrastructural and institutional conditions. Through literature research and interview responses from different international experts in water management it seems the canalero is most prevalent in manually operated open canal systems. Literature has also shown that they can also be present in other types of irrigation systems which include closed pipe systems and pressurized systems. The services of the canalero seem to be absent in automated irrigation systems. The canalero in a farmer managed irrigation system is more involved in irrigation water management activities compared to the canalero in a government managed system. In other areas their job is more appreciated during the period of water scarcity when everyone wants a share of water. Farmers can start stealing water at night, try to bribe the canalero to get more water or even use their influential positions within their social and political settings in order to get water. Cropping patterns can also have an influence on the job of the canalero. Thus the canalero has a crucial role in the management of water for irrigation.

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1. Introduction

The canalero is personnel whose tasks involve the day to day operation of irrigation systems. Some authors have described in detail their day to day activities but the question to bring to the fore is how they are portrayed by the rest of irrigation management literature. Literature has a blind spot on the contribution this type of personnel provides for the performance of certain irrigation systems. So it becomes interesting to see how important the role of the canalero is in water management activities in irrigation systems. An extensive literature search and study can be a relevant approach to tackle this situation and drag the blind spot from a grey area eventually into a clear and visible one.

Chapter 2 will give a description of the background information of the ‘canaleros’. In the background I will try to define what a canalero is and how he/she came into existence. This in some way will show why the canalero was not given much attention in the first place by researchers. I will also give a brief description of the different types of irrigation systems which exist and this will assist in showing where these types of personnel exist and where they do not. In chapter 3 the concepts will be discussed which will assist in showing the context or angle from which I will analyse the findings which I will obtain from different literature. Chapter 4 will describe the different roles in which the canalero is involved in. Chapter 5 will describe the existence of the canalero in different infrastructure, and how agro-ecological, and institutional conditions influence his role. Chapter 6 will be the concluding chapter which encompasses findings from both chapters.

1.1 Problem statement

Whilst irrigation literature has made an effort to show the contribution of the canalero in the performance of the irrigation systems, it still has a blind spot on the crucial role they play for the full functioning of these systems. There is still lack of knowledge on the relevance of this type of personnel. It is also still uncertain how widespread this operator is around the world and the conditions in which we find this type of person.

1.2. Research objectives

The problem stated above made me come up with the following objectives for my research.

- To determine the roles and responsibilities of the canal operators in irrigation systems of different parts of the world
- To determine the infrastructural settings of irrigation systems in which this personnel exists and why

Infrastructural settings can be in the form of closed systems or open canal systems or a combination of both. Closed systems can either pressurised systems like the sprinklers or a surface irrigation system with closed pipes

- To determine how institutional and agro-ecological changes in the irrigation systems influence their roles and responsibilities

These institutional changes may be as a result of irrigation management transfer (IMT) from the government to the farmers. Institutional changes may occur where the government may change from taking full responsibility of the management of the irrigation schemes and giving part of the responsibility to the farmers. Agro-ecological conditions can be in the form of water availability i.e situations of water abundance and water scarcity. These conditions can also be in the form of head-tail ender situations in an irrigation system.

1.3 .Main research question

How important are the roles and responsibilities of the field level personnel in irrigation water management in different agro-ecological, infrastructural and institutional settings/conditions?

1.3.1. Sub research questions

1. Which irrigation management activities are the canalero involved in different irrigation systems?

2. In which infrastructural settings does he exist and why?

3. How institutional and agro-ecological conditions do influences his role in irrigation water management?

1.4. Methodology

1.4.1. Research design

I did a literature research on the role of the canalero in irrigation systems. In order to achieve this I used different categories of literature from the following

1. SCOPUS
2. Google scholar
3. PhD and MSc thesis documents
4. Classical irrigation literature
5. Interview responses

I used SCOPUS and Google scholar to look for literature which contains information about the canalero. Key words and phrases were used in order quickly find information which is of relevance to my study from books, journal and articles.

I also used PhD and MSc thesis documents which talk about the canalero. This proved to be reliable sources of information because the authors had experience of working with these personnel. Some of the theses have been done in the recent years thus they showed what the recent situation in these irrigation systems.

Classical literature included books about irrigation water management which were written 30 to 40 years ago. This type of literature will show what the situation was like back then regarding the canalero. It also showed the types of infrastructure which was present in that time. This aided in showing if the role of the canalero is disappearing or if it was present in that time.

Interview responses from international experts who had an experience of working in these irrigation systems or have knowledge about them were analysed.

1.4.2. Data collection, management and analysis

I started by looking at the interview responses from the e-mail interviews that were conducted with different international experts about this topic. Some of them had suggested literature which can assist in answering the questions about the canalero. So I looked for the suggested literature and added it to the one I collected from different categories.

I recorded the details of the resources consulted in the form of

- Data base
- Written summaries

The data base indicated where in the world the canalero exist and a table including a map which shows where the canalero exists is in the annex. The types of infrastructure in which the canalero exist including the sizes of these irrigation systems are also on the table. I recorded the information which assisted in answering my research questions in the form of written summaries. All the summaries were in one file which I referred to when I was writing my final paper. The report on the responses from different international experts was also in a separate file.

I used endnote to compile, arrange and store the literature that I used to extract information for this study. The literature list was updated as I was looking for information from the sources.

After recording the information from consulted sources a text analysis was done in order to determine the common elements and differences about the canalero which are depicted by the literature.

There is evidence of the canalero type of personnel in different parts of the world. They are mostly found in the Asian part of the world in countries which are namely South Korea, India, Indonesia, Nepal to mention a few. They are also found in some countries in Africa, North and South America and in few countries in Europe. the table in a form of a database (see annex 1) including the map (see annex 2) shows how widespread they are around the world.

2. Background to the Study

The canal operators by definition can be described as personnel responsible for the distribution of water to individual plots in an irrigation system. They can also be regarded intermediaries between irrigation organisations and the water users who are the farmers in most cases (Rap and Van der Zaag, manuscript). The canal operator holds a different name depending on the country of origin. In Mexico they are identified as *canalero*, *tomero* in Spain and Peru, *ditch tender* in United States, *ghaffir* and *samad* in Sudan, *lascar* and *neerkatti* in India, *water bailiff* in Zimbabwe to mention but a few (Rap and Van der Zaag, manuscript). Despite the differences in how they are called in different parts of the world, it is still not certain if their roles and responsibilities are more or less similar. The most common roles and responsibilities which are depicted by literature are that they ensure that water is diverted from the main canal all the way to the individual farm plots. In addition to this they physically move the weirs and sluices. the experience they gain from doing this on a daily basis enables them to work out in their head the water distribution programme (Rap and Van der Zaag, manuscript). As was mentioned earlier they take a role of intermediaries between the farmers and the irrigation organisation. They are responsible for solving conflicts which might arise between or among the farmers in relation to water allocation (Rap and Van der Zaag, unpublished paper). Literature has presented these roles referring to the canalero of Mexico, and so it will be of interest to find out if the roles are the same for this type of field level personnel in other parts of the world. So it will be interesting to find out what the rest of the irrigation management literature says about them which is one of the objectives of this study.

The existence of this position originates from the governmental bureaucratic organisational structure where they occupy the lowest level in their structure. In the Chancay- Lambayeque an ancient irrigation system in Peru, the Ministry of Agriculture was responsible for its management and the '*tomeros'* as they call them were employed by this ministry. Even after the management of the irrigation system (IMT) was transferred to the water users in 1992, the role of the *tomero* did not disappear; instead it was perpetuated with the transformation (Vos, 2005). The story is also the same for the Autlán-El Grullo irrigation system in Mexico which until the late 80s water distribution and canal maintenance was the responsibility of the local office of the Ministry of Agriculture and Hydraulic resources (SARH). The canalero literary made the local authority to realise their responsibility and even after the irrigation management was transferred to the local WUA (Rap and Van der Zaag, 2011). In Zimbabwe after it attained independence in 1980 the government staff was responsible for distributing water to the farmers in surface irrigation systems. As mentioned earlier these were referred to as the *water bailiffs* and they worked under the government department of Agricultural, Technical and Extension Services (Agritex) (Manzungu, 1999). These three cases help to show how the role of a canalero seems to be a continuous factor in the management of irrigation systems. However there is still need see if the situation is the same in other parts of the world.

The canalero often is a native of the area of the irrigation system and literature shows that they do not undergo a lot of formal training in order to get the job (Manzungu 1999; Rap and Van der Zaag, manuscript; Schippers 2009). In some areas, it is through local connections that they get these jobs. Manzungu (1999) in his paper states that the *water bailiffs* are mostly general hands who are given this responsibility as a local arrangement. Rap and Van der Zaag also show this when they describe how one of the canaleros from Autlán-El Grullo got his job (Rap and Van der Zaag, manuscript). It was through his father who arranged a permanent job for him in the maintenance brigade from which he was asked to become a canalero. Although this seems to be a common way in which the canalero attains his position, this might be different in other places. They possess local knowledge about the area they come from and some of them are experienced such that they do not need to work on paper the rotational schedule.

The position of the canal operators mostly exists in almost all non-automated surface irrigation systems which is also a question in itself. Their area of command of surface irrigation systems ranges from as little as 100ha up to 100 000ha depending on the area and the types of farming practices done in different areas. They can be more than one in an irrigation system depending on the size of the system. Their work is depended largely on the types of irrigation infrastructure available on the system. This infrastructure in turn determines the types of water distribution schedules that can be implemented.

The type of infrastructure present in surface irrigation schemes is depended on the purpose of which the irrigation scheme was constructed especially during the colonial era. In Pakistan and India the irrigation schemes of about 20 million ha were constructed for 'protective' purposes (Jurriens and Wester, 1995). They were protective in the sense that they guarded against crop failure which in turn reduced famine. The infrastructure in these schemes was designed in such a way that it would provide a proportional share of the available water to each acre in the command area. Thus all the distributaries would be operated at full supply level and the outlets will be fixed and ungated structures (Jurriens and Wester, 1995). This type of water distribution schedule differs with that of 'productive' irrigation schemes which is demand oriented most of the time. The demand scheduling is made possible by having a network of open canals with flexible division structures like weirs and gates and stop logs (Rap and Van der Zaag, 2011; Vos, 2005)). These types of irrigation schemes are prevalent in places like Latin America and some parts of Africa. Some irrigation systems are gravity driven whilst some are pump driven or can consist of both depending on their design. Many surface irrigation systems are open canal systems whilst others have parts which have been transformed into closed systems (Schippers, 2009 in Rap and Van der Zaag, manusript).

3. Conceptual framework

In order to understand the roles and responsibilities which are undertaken by the canalero, different concepts will be used for analysis.

3.1. Water networks

According to Bolding (2009) an irrigation scheme can be conceptualized as a socio-technical network of relations that ties one or more farmers, their labour skills, a piece of land, crops , a furrow, water and other resources in some working order. This he calls a water- network. This network can also be looked at in a broader view of a water using system of agriculture which involves farmers combining water and land resources linked to other materials such as crops, fertilisers, pumps and legal documents. These can also be linked to less tangible resources such as unwritten rules, wisdom, knowledge and information flows and it can also link human actors as an intended strategy (Van der Zaag et al, 2001). I will use this concept in this research to understand the role of the canalero in this kind of network. Since this concept regards water as the main actor (Bolding, 2009) of this network it will be of interest to look at how this actor shapes the relations within this water using system.

Bolding (2009) also goes to say that the extent to which the water network honours or appreciates the behaviour of water, determines its strength or usefulness. One of the dimensions in which this can be assessed is by looking at the managerial aspects of the water, i.e. how the network deals with water scarcity or abundance. He also goes on to say that during the construction of a water network, different forms of expertise or knowledge claims are mobilised. This is because the knowledge, experience and expertise necessary to predict water flows and device some form of water control are critical (Bolding, 2009).I place the canal operator in this aspect since he is the one who works in close contact with the water and its infrastructure. So I will use this concept to also analyse the water management roles the canalero plays in situations of water scarcity or abundance. This concept will also assist in showing how the canalore's knowledge and expertise is used or mobilised to construct the water network in irrigation systems around the world.

3.2. Water control

The other concept which is going to be used in this research is that one of water control. It will not be regarded as a standalone entity as it is embedded in the water-network. Water control consists of three dimensions which are technical control, organisational control and socio political and economic control (Bolding et al, 2000 in Wester, 2008). The technical focuses on the regulation of physical processes through technical devices whist the organisational control focuses on the regulation of human behaviour, and lastly socio political and economic involves the conditions of possibility of particular forms of technical and organisational control. These three dimensions are seen as being interrelated and mutually constitutive of each other hence a change in one dimension influences the other two (Wester, 2008). It is of interest to see if this is true for the case of the canalero.

3.3. Water Institutions

An institution is regarded as social arrangements that shape and regulate human behaviour and has some degree of permanency and purpose transcending individual human lives and intentions. They can be in the form a rotational schedule for water distribution, market mechanisms for obtaining crop credits, membership rules of water user associations, and property rights in water and infrastructure (Merrey, 2007).

Irrigation systems are under different forms of management which are mainly the farmer managed irrigation systems and government managed irrigation systems. Farmer- managed irrigation systems are owned and managed by the farmers themselves. They are usually smaller in size compared to the government managed irrigation systems. Narain (2004) states that the farmer-managed irrigation systems are a coherent whole in terms of charter of authority, tasks, roles, size, and vertical organisation. It is not certain how far true this is so the research findings will confirm that. Researches show that farmer-managed irrigation systems were functioning effectively (Merrey, 2007).

Government managed irrigation systems were realised long ago when the governments of most countries decided to provide irrigation infrastructure and manage them for the public to benefit (Mukherji et al, 2009). However, most governments failed to effectively solve the problems of proper water allocation and too many of them underperformed i.e. physically, economically and financially. They also realised that the bureaucratic management of irrigation schemes was not the best solution (Mukherji et al, 2009). After recognising the high performance of the farmer managed systems (Narain, 2004) they thought it wise to transfer the management of the irrigation schemes to the farmers. This process of transferring the authority and responsibility to manage the irrigation system from the government to the water user's associations (WUAs) is called Irrigation Management Transfer (IMT) (Mukherji et al, 2009). The main objectives for this transfer process were to improve the financial recovery and irrigation system performance including the reduction of fiscal burden on governments (Narain, 2004).

The transformation in the management of irrigation systems from government owned to farmer owned systems commonly known as Water Users Associations (WUA) is accompanied by institutional changes within these organisations. Merry (2007) mention that Institutions are dynamic and emerge, evolve, and disappear over time. This in itself shows the dynamism of institutions and how they evolve over time. In this transformation process certain aspect might also change like in this case the operation and maintenance of the irrigation system. The canalero is very much involved in these kinds of activities and thus it is important to understand if their roles are constrained with these transformations.

3.4. Irrigation management

Irrigation management usually involves three sets of activities which involve namely I) water use activities ii) control structure activities and iii) organisational activities. Water is the main focus of irrigation to get the right amounts at the right time to farmers. Control structures are instrumental for getting and applying water. Organisations manage these systems farm level (Uphoff, 2004).

Figure 1 (Uphoff's matrix of irrigation management activities) shows that there are four major kinds of activities that are associated with each of these three focuses described above. The set of activities on water use include

I. Acquisition of water from a surface or sub surface sources through the creation or operation of structures like dams, weirs, wells or by actions to obtain for users some share of an existing supply
II. Water allocation which can be achieved by assigning rights to users, thereby determining who shall have access to water.
III. Water distribution from the sources to users at certain places, in certain amounts and at certain times
IV. Drainage of water to remove excess supply (Uphoff, 2004).

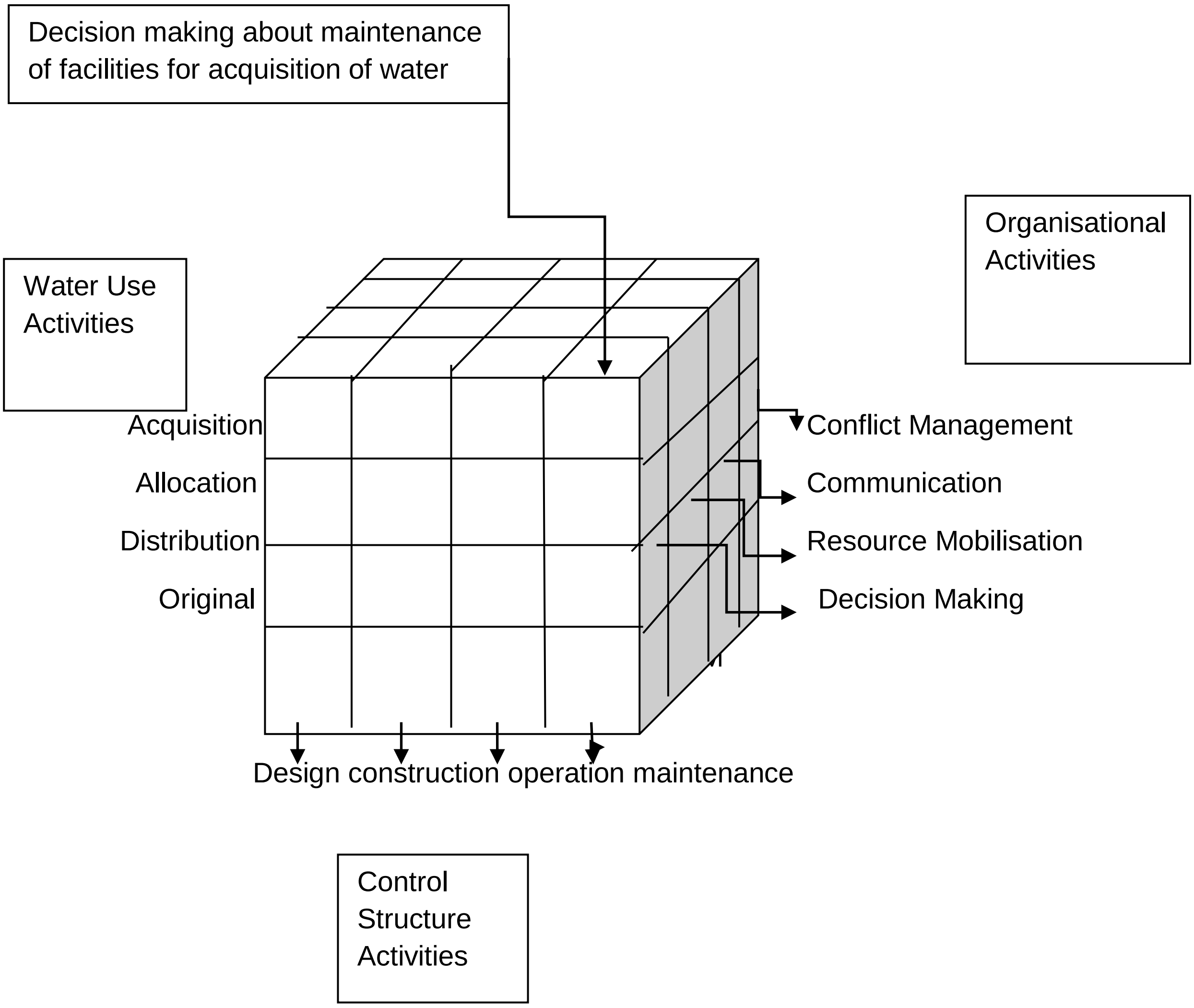

Figure 1. Matrix of Irrigation Management Activities

Source (Uphoff, 2004)

On control structure activities there must be the

i. Design of structures such as dams or wells to acquire water, channels and gates to distribute it, and drains to remove it
ii. Construction of structures (or implementation in the case of allocation systems) to be able to acquire, distribute and remove water
iii. Operation of these structures to acquire, distribute and remove water according to some predetermined plan of allocation
iv. Maintenance of the structures in order to have continued and efficient, acquisition, allocation, distribution and removal of water. (Uphoff, 2004).

All the four apply in appropriate terms to all four of the first set.

Pertaining to the organisations that manage irrigation at any level, there must be

i. Decision making for acquisition , allocation, distribution and/ drainage, to design, construct, operate or maintain physical structures, and regarding any organisational tasks
ii. Resource mobilisation and management, including the mobilisation and application of funds, manpower, materials, information or any other inputs needed

iii. Communication and coordination regarding any of the activity areas noted above, conveying information about decisions, resource mobilisation, conflicts to be resolved among other things.
iv. Conflict resolution, i.e. dealing with differences of interests that arise from activities of acquisition, allocation, distribution, drainage, design, construction, operation, maintenance, or from any organisational activities (Uphoff, 2004).

The four organisational activities are equally relevant in the formal and informal domains of irrigation management. Uphoff say that there is no social system that functions purely on formal modes. One has to consider both formal and informal processes for decision making and for resource mobilisation. He goes on to say that these four organisational activity areas can apply to intra and inter-organisational domains through decision making within and between organisations or within a field channel water user group and between this group and other similar groups or higher level groups. Resource mobilisation can be within an organisation or between organisations and the same is true for communication and coordination, and conflict resolution (Uphoff, 2004).

The concepts of water networks, water control and water institutions regarding the canalero can be combined and can be analysed using the Uphoff's irrigation management activities framework. As mentioned earlier a water network links the farmers with water which is the main actor in this network and other materials which include seeds, fertiliser, legal documents to mention a few. Also they are linked to less tangible resources such as unwritten rules, knowledge, information flows in which the canalero is part of this network. Uphoff's framework can be a useful tool to analyse the canalero's roles in different activities which are involved in irrigation management which thus facilitates the water network. Bolding (2009) has also mentioned that assessing how a water network appreciates the behaviour of water can be done by looking at the managerial aspect of how it deals with water scarcity or abundance. These managerial aspects can be analysed by looking at the water use activities and organisational activities which are mentioned in Uphoff's framework.

The three dimensions of water control(Wester, 2008) can also be analysed using Uphoff's framework. Technical control can be assessed through looking at the water use activities and control structure activities since it involves the regulation of physical processes. The organisational and socio-political control can both be assessed organisational activities mentioned and explained above. The relevance of the framework in formal and informal domains and its applicability to the intra and inter-organisational domains makes it a useful tool to analyse the organisational activities even in the event of the transformation of organisational settings. These transformations can be in the form of Irrigation Management Transfer (IMT). Thus these concepts can be integrated and be analysed through the use of the framework. In this way the role of the canalero regarding irrigation water management within these concepts will be explicit.

4. Roles of the Canalero

4.1 .Introduction

This chapter will give a detailed description of the roles of the canalero in different parts of the world. In this chapter I will try to answer the first sub-question which wants to find out the water use, organisational and control structure activities in which the canalero is involved. Some detailed cases of canalero in different irrigation systems will be described and analysed. These will show the similarities and differences of the roles of the canalero in different parts of the world. The three aspect of the irrigation water management cube by Uphoff will be used to analyse their roles in different irrigation systems. The concept of water control will be used as it encompasses all the three dimensions of irrigation water management. Cases from different countries like Tajikistan, Sri Lanka, Indonesia, Tanzania, Mexico, Zimbabwe, Peru, USA, Sudan, Malawi, South Korea and Nepal, outstanding cases will be presented to show how the canalero in different irrigation systems in involved in the different activities of irrigation water management. The chapter will end with a conclusion on the roles of the canalero.

4.2. The role of canalero in water use activities

Water use activities involve the acquisition, allocation and distribution of water from its sources to the intended users (Uphoff, 2004). These have been described earlier in the section of irrigation activities. Acquisition involves the abstraction of water from a surface or a sub-surface source through the creation of structures like weirs, dams or wells. Water allocation determines who has access to water, through for example the issuing of water rights. Distribution involves taking water from the source to the users in certain amounts at certain times (Uphoff, 2004). The sections below will describe the roles of the canalero in different water use activities.

4.2.1. Water acquisition

The canalero is not much involved in the acquisition of water. In most cases the government will employ a person who will be responsible for diverting water from the source which might be a river or dam into the system. For example in the Bima irrigation scheme of Indonesia there is a dam guard who is employed by the irrigation services department to operate three weirs which divert water into the main canal (Duewel, 1995) .There are exceptional cases where the canalero can be involved in the water acquisition. This is usually seen in farmer managed irrigation systems for example in Mozambique and Tajikistan (Bolding et al 2009; Bossenbroek 2011). In the Maira furrow of Mozambique the canalero had been hired by a family to guard the water along the furrow i.e. from the weir to the downstream end. The purpose for him to guard that weir was to prevent other farmers from abstracting water from it (Bolding et al, 2009). In Spienz and Shorhirizm systems in taajikstanthe canalero is responsible for distribution of water from the intake structures up to the farmers' fields (Bossenbroek, 2011).

4.2.2. Water allocation

In different irrigation systems the canalero is mostly involved in the allocation of water among the users. The canalero's involvement in the allocation procedure also differs with the type of management system that is in control of the irrigation system. These can be farmer managed, state managed or agency managed irrigation systems. In farmer managed irrigation systems which were purely constructed by the farmers, the canalero was in charge of water allocation. These systems include the Lower Moshi irrigation systems in its ancient times before it underwent a rehabilitation phase and the Spienz and Shorhirizm in Tajikistan. In these irrigation systems characters like the *mirju* (Tajikistan) and *mzee wa mfongo* (field Tanzania) were the field level personnel responsible for water allocation in their systems (Bossenbroek, 2011; Kissawike, 2008). What is common between these two farmer managed irrigation systems is that the canaleros in both systems would use rotation schedules to allocate water to the fields. The *mirju* allocated water through the use of a water graph(a book in which the *mirju* recorded information of water in relation to their water use) (Bossenbroek, 2011). Rotations of a 6 hour schedule were used by *mzee wa mfongo* to allocate water among the farmers. A detailed description of the roles of the *mirju* and *mzee wa mfongo* is presented in text table 1.

Government constructed/managed irrigation systems can be categorised into two groups depending on their management structures. The first category comprises of irrigation systems where that whole system from the main canal to the tertiaries is managed by a single management entity in this case the government. Mutema and Fuve Panganai irrigation systems from Zimbabwe are examples of such systems. The other category comprises of government constructed systems which are managed by more than one management entity. In these types of systems the upper part of the system i.e. from the main canal up to the secondary canals will be managed by the state while the lower part from the off take structures is in the hands of the farmers. In ancient irrigation systems the farmers would organise themselves usually within their communities on how to distribute water among the farmers. They would elect a person within their village who will be responsible for water distribution at tertiary level. Such systems include Gal Oya irrigation system of Sri Lanka and, Sedeku irrigation system in Indonesia including Bima and Tayuban of Indonesia to mention a few (Duewel 1995; Schrevel and Rowbottom 1988; Uphoff et al 1990). With the irrigation management transfer some systems formed Water Users Associations (WUAs) which were responsible for water management at the tertiary level. Examples of such systems are the Left bank in Mexico and Chancay Lambayecue of Peru (Rap, 2004; Vos, 2002)).These management structures determined the level of participation of the canalero in water allocation. In single management systems the canalero is responsible for water allocation. For instance in Zimbabwe the canalero takes the requests from farmers and makes a water schedule for water allocation (Chidenga, 2003). In two tired management systems it is the locally elected field personnel who do the actual water allocation among farmers. the irrigation headman in the Gal Oya irrigation system in Sri Lanka enforced water rotation and planned schedules at field level in the 19th century (Uphoff, 1990) whilst the village water master in the Sedeku irrigation project organised water rotation between villages and water distribution over the fields (Schrevel and Rowbottom, 1988). There are other systems like the Chancay Lambayecue of Peru which underwent an irrigation management transfer leading to the formation of the WUA. The operation and maintenance of the system at the tertiary level was transferred to the farmers. The farmers would hire a *repartidor* (NGO employee) to allocate water at the field level (Vos, 2002). Canalero's involvement in the water allocation process is dependent on the type of management which exists in the system.

4.2.3. Water distribution

The main task or water use activity in which the canalero is most involved is the distribution of water along the canals. Most literature which talks about these personnel had indicated the duties which are performed by the canalero in water distribution. In manually operated irrigation systems with flexible water control structures, they physically move the weir and sluices and adjust the radial gates and intake structures (Van der Zaag, 1992). This has been evidenced in different countries which include Mexico, Zimbabwe, Nepal, Sudan, USA, Indonesia, Tanzania, and Malawi (Chidenga 2003, Clemmens et al 1994, Singh M, personal communication 08 July 2011, Van der Zaag 1992). Van der Zaag (1992) has mentioned that the canalero makes a flexible system work. They even work out the water distribution programme not on paper but using the knowledge they have gained through experience of working in these systems for quite some time (Chidenga 2003, Van der Zaag and Rap manuscript, Singh M, personal communication 08 July 2011). Schippers (2009) also echoes this when he mentions that the canalero internalises the infrastructure in accordance with the existing irrigation practices. This shows that the canalero goes an extra mile of making him a part of the system. Usually the water levels in the field aren't those which were designed so the canalero makes some adjustments on the gates along the canal to obtain a required level and ensure that water reaches to the tail enders (Rap,2004). Canaleros also drive up and down the canal several times and readjusts gates as necessary which can also be regarded as patrolling in some other irrigation systems (Clemmens et al 1994; Rap 2004; Van der Zaag 2002; Wade 1982). For example in Sudan the canaleros can work alongside each other, the other one opening and closing the off take gates, whist the other is responsible for follow ups along the minor length from the off take to the tail including the opening and closing of FOP(field outlet Pipe) (Woldegebriel,2011).

The canalero's role in water distribution is not only limited to open surface irrigation systems but also in closed pipe system which can either be pressurised or of low pressure. In Chakowa irrigation system in Zimbabwe a section or block had been converted into a pressurised sprinkler system. The canalero implements the distribution of water among farmers in that section. He ensures that all laterals have been changed before requesting the pump attendants to resume pumping (Chidenga, 2003). It has now become a tradition to check that the farmers have changed and aligned the pipes properly. The *water bailiff* seems to be experienced enough to determine the number of laterals and sprinklers to work under a certain level of system leakages (Chidenga, 2003).

The role of the canalero is of relevance in water distribution because his task in not only limited to opening and adjusting gates but to also make follow ups patrolling to check if the structure had not been tempered with. Wade shows that in STY FLIA the canalero patrols the main and branch canals twice daily using bicycles adjusting the gate settings (Wade, 1982, p39). It was mentioned earlier that the canaleros in the Gezira irrigation system work alongside each other and one of them will be making follow ups along the canal length (Woldegebriel, 2011). The *repartidor* in Chancay Lambeyeque checks the functioning of the gates and if they haven't been vandalised by the farmers (Vos, 2002). This shows that the canalero play an important role of making sure that the system is in good condition. Since most of these systems do not work according to the intended supply levels, they have to figure some ways of adjusting the system in order to supply the intended water levels.

What is common about the canalero in either farmer managed or government managed irrigation systems is that most of them did not acquired any technical expertise to perform this role. In farmer-managed irrigation systems they are voted to get into that position by the local water users. Most literature shows that in most cases the canaleros in government managed irrigation systems are the inhabitants of that area.

The tables below give a detailed description of the role of the two characters, one from a farmer constructed system and the other from a government constructed system. The characters are the *mirju* from Tajikistan and *ulu-ulu/pembantu ulu-ulu* from Indonesia. Information of the *mirju* was obtained from Bossenbroek whilst that of the *ulu-ulu* was obtained from Duewel 1984

Text box 1

Mirju in Water Use Activities

The mirju is an elderly person usually of an average age of +/-45 years. He is responsible for the day to day operation and maintenance in the main canal and independent systems in a farmer managed irrigation system. They exist in irrigation systems in Tajikistan (Spienz and Shorhirizm) which were constructed by the farmers. The mirju is elected by the water right holders in the village. Their term of office is two years. There is much debate about the position of the mirju because no one is keen to fulfil the job because of the demand the job entails. The Rais (village head) may go to the house of the chosen person and ask him personally to become Mirju if he is reluctant to become one. Young mirjus are usually not respected and that has a great influence on the implementation of the water graph. He is expected to be a fit, strong, flexible in order to gain respect from the other water users. The mirju has the highest authority and decides when the water graph in the main canal and independent systems in which he is responsible should be implemented. The water graph is a form of a booklet where the mirju records the name of the water right holder, followed by the quantity of land that is owned, the water share (in time), the amount of money or grains/fodder that should be paid and finally the last column if the water user actually paid. The water graph is implemented between the months of June and July when the water level in the secondary canal starts to drop. He walks to the water source each day and is responsible for solving disputes which might arise among farmers. The mirju attends meetings with the Rai (village head) to discuss the three main aspects which are the maintenance work, when the water graph in the main canal implemented, and lastly the conflicts that erupt between users. The meetings with the Rai are sometimes not planned in advance. Shorhirizm has a slightly different arrangement of water management to Spienz. Unlike Spienz the mirju has got assistants in the independent scheme that assists him to distribute water called the abshars.

The ulu-ulu in water use activities

In reference to the two irrigation systems in Bima and Tayuban of Indonesia the distributor ulu-ulu system was used to organise local irrigation in tertiary blocks of 50 to 200ha. These were government constructed irrigation systems. Prior to the formation of WUA in 1957 water allocation was supervised by the ulu-ulu based on cultivator requests and water needs. The primary duty of the ulu-ulu was centred on water distribution. In addition to his job of water distribution, he also supervised the maintenance and repair of block irrigation in close cooperation with the territorial sub chief. This system was modified when the Water users Association were formed and a dry season specialist called the pembantu ulu-ulu was added to assist the ulu-ulu in water delivery tasks. The added pembantu ulu-ulu conveyed and delivered water to individual farm plots under the guidance of the ulu-ulu. Tayuban irrgation system practiced all year round rotation thus the pembantu ulu-ulu worked throughout the year in this system. The pembantu ulu-ulu also collected seasonal payments at the end of each season. In Tayuban 3 pembantu ulu-ulus will guard the flow of water past upstream tertiary intakes while the seven delivered it to the individual farm plots. During the rainy season they worked individually or in pairs in irrigation units which ranged from 20 to 50 ha. When the water supplies declined during the dry season the size of the working group and areas was enlarged to 4 or 5 pembantu ulu-ulus and the frequency of delivery to individual plots reduced significantly. The WUA lined the canals thus the tertiary canals were no longer cleaned on a group basis in Bima, but instead it was done by the pembantu ulu-ulu under the supervision of the ulu-ulu. Within the block the ulu-ulu decided on which units would get water during specific turns. The actual task of channelling water to plots was handled by the pembantu ulu-ulu.it seems the coming in of WUA modified the distributor ulu-ulu system in such a way that the pembantu ulu-ulu displaced the position of the ulu-ulu. The ulu-ulu took a more supervisory position after the formation of WUA. The way in which the pembantu ulu-ulus from Bima and Tayuban were viewed by the people was different. Tayuban pembantu ulu-ulu had a higher social status than in Bima. This was because many of them held influential positions outside of their irrigation roles. Bima pembantu ulu-ulu was mostly viewed as labour specialist.

4.3 The role of canalero in the organisational activities

The organisational activities in water management include decision making, communication, resource mobilisation and conflict resolution (Uphoff, 2004). Decision making involves the decisions he takes in allocating, distributing, operation or maintenance of the physical structures and also regarding any organisational tasks. The canalero might be involved in the mobilization of resources such as funds, manpower, materials, information or any other input needed. This will be used to analyse how is involved in the mobilisation of resources in different irrigation systems. The canalero's role in communicating and conveying information about decisions, resources mobilisation and conflicts to be resolved will be presented. The canalero at times deals with differences of interests that arise from activities of acquisition, allocation, distribution to name a few and how he does this will also be presented.

4.3.1. Decision making

The level of participation in the decision making process depends on the level of the canalero in the water management organisation. In government managed irrigation systems, the canalero occupy low level positions and are not much involved in the decision making process. The canalero is usually an implementer of the decisions already made by his superiors. According to Vos the sectorista makes most of the decisions of distribution, he gives orders to the *tomero* to implement those decisions(Vos, 2002).a similar case is seen in Mutema irrigation scheme in Zimbabwe where the water controller makes decisions and gives orders to the water bailiff to implement them(Chidenga, 2003). This might show that the canalero in government managed systems are not much involved in decision making. Occupying low level positions doesn't imply that they are completely not involved in decision making. Van der Zaag (1992) has stated that canaleros are implementers who interpret guidelines from above, reshape and adapt them to varying needs and constraints found at field level. This shows that they are involved in decision making but at the field level. In the Left bank irrigation system of Mexico the farmers started using mobile sprinkler systems which include a diesel pump, a temporarily fixed main line and hand moved laterals(Rap, 2004). The canalero is not involved in the working of sprinkler systems but since they abstract water from the canal he manages, he makes the decision of requesting more water in order to cater for the pumping (Rap, 2004). This is another evidence of field level decision making. Although they have the right to deny water allocation to a farmer who doesn't request water on time, they do not have the final say in the matter (Rap 2004; Vos 2002). In Indonesia the tertiary block ulu-ulu lacks the authority to sanction irrigation offenders and enforce discipline, which can be an indication that his role in the decision making process is limited (Duewel, 1995).

The decision making process in the traditional irrigation systems or farmer managed irrigation systems is different from the government managed irrigation schemes. The mirju in an independent/farmer managed irrigation system in Tajikistan has the highest authority and decides when the water graph should be implemented (Bossenbroek, 2011). The village water master in Indonesia took all the important decisions regarding water management and he was involved in the organisation of water rotation between villages and water distribution over the fields (Schrevel and Rowbottom, 1988). Uphoff et al (1990) also stated that in ancient times the government was not much involved in the management of the community systems, the village council was. The communal authority were the overseers of most water related matters such as cleaning out reservoirs, channels and coordinating water issues. The vidane was part of these local leaders and enforced water rotation and planning schedules (Uphoff et al, 1990).

4.3.2. Communication

Communication is another area where the canalero is most active. The major role of the canalero in communication is taking the intermediary role mostly between the farmers and the office. This task can be ranked as the second influential task the canalero performs from that one of water distribution. They are involved in information exchange and get water requests from farmers and take them to the managers (Schippers 2009; Singh M, personal communication 08 July 2011; Uphoff et al 1990; Woldegebriel 2011). Van der Zaag (1992) see them as interfaces who link farmers to districts, districts with sugar refineries and also creating linkages among farmers. The other side of their intermediary nature is that they attend meetings at the office quite often and then give the information which needs to be conveyed to the farmers (Wade, 1982). Whilst they act as intermediaries they can also be important sources of information. In Mexico they farmers rely on them on information on issues like irrigation fees/ crop subsidies, available land to rent, interpretation of the bill, new crop varieties and names of buyers to mention but a few (Rap 2004; Schippers 2009; Van der Zaag 1992). In other systems they can take the role of informing farmers about the latest developments (Wade, 1982). In a sprinkler system in Zimbabwe it is the task of the canalero to inform the farmers when the pump stops working unexpectedly (Manzungu, 1999). In addition to that the pump operator is so much depended on the canalero because he is the one who tells him to run or stop the pump (Manzungu, 1999). One can wonder what will happen if the canalero is absent from work for a day. In another irrigation system in Indonesia the canalero had to communicate with the irrigation authorities or upstream villages to organise distribution and rotation of water within his area (Schrevel and Rowbottom, 1988). This assists in showing that the communication role of the canalero started decades ago thus validating its importance in irrigation water management.

4.3.3 Conflict management

Conflict management entails dealing with differences of interests that arise from activities of acquisition, allocation, distribution, drainage, design, construction, operation, maintenance, or from any organisational activities (Uphoff, 2004). Conflict management also differs with irrigation systems. In other irrigation systems the canalero solves the conflicts which will arise in the field. Places like Malawi, Thailand, Tanzania, Zimbabwe, Tajikistan, Indonesia and South Korea the canalero is very active in solving water conflicts at the field level. Some farmers see the canalero as a real help, especially the weaker farmers (Manzungu, 1999).

In Malawi the canalero is responsible for settling disputes which can arise but this is rather difficult for him because the farmers will steal water at night when he is no longer at work (Garsight, 2010). Even though they steal water at night, his existence would be an assurance to downstream farmers that they would have access to their water share at least in the daytime which would have been highly unlikely if he wasn’t present (Garsight, 2010). So the conflict is eased off with that guarantee of his presence in the daytime.

There are also places were the higher authority is responsible for conflict management for example in Central Arizona, Peru and Nepal. In this case if a dispute arises in the field it is taken to a higher authority to solve it (Duewel 1995; Singh 2011; Vos 2002). There are also places where the canalero can deal with the conflicts in his area but if it involves two areas/head tail end problems he refers them to a higher authority (Schrevel and Rowbottom, 1988; Thi Phoung Lihn 2010).

In other events the conflict will involve the canalero himself who will be blamed for insufficient supplies (Schippers, 2009). A good example is a case in Mexico where the canalero was being blamed for insufficient supplies of water. In this event the canalero would try as much as possible to convince the farmers that he is not the one depriving them of water, but it is the pipe which restricts the amount of water needed to serve the whole area (Van der Zaag, 1992). In a way he will be solving the matter through convincing them by showing them where the problem is which is the infrastructure and not him.

4.3.4. Resource Mobilisation

Apart from his main duties of distributing and allocating water, the canalero has to perform other tasks. This makes him a multi tasked personnel. These other tasks can fall under resource mobilisation since he will be mobilising funds, manpower, materials, information or any other inputs needed. In other irrigation systems the canalero is expected to record the area irrigated area daily, water levels at the cut throat flume, take electricity readings, check the alignment of crops rows, check for subletting, check that weeding is done, enforces cropping programmes and receive visitors (Manzungu, 1999). Whilst in other areas with the WUA formation their additional task is fee administration (Duewel 1995; Rap 2004).

They are also involved in organising public meetings for the association and also attend them (Manzungu 1999; Rap 2004). The canalero also has the responsibility of checking the participation of the water users (Chidenga, 2003). They can be engaged in agricultural extension work of helping in the promotion of optimum levels of inputs (Wade, 1982). Assisting in spotting pests and diseases attacks and giving advice to farmers about what to do by way of countermeasures are some of the additional task they do (Wade, 1982). In South Korea the canaleros who executed the tasks were generally small/marginal farmers, who were not amongst the more respected farmers, so their extension efforts were highly likely not to be taken seriously by others (Wade, 1982). This was rather stressful to the canalero because he was doing an extra job which the intended beneficiaries did not appreciate.

4.4. The role of canalero in Control Structure Activities

4.4.1. Design and Construction

The canalero is not involved in the design of the irrigation system. Usually it is the responsibility of the organisation which constructed it. In other places the canaleros had obtained their jobs after they had participated in the construction of the canals for example in Zimbabwe and Mexico (Manzungu 1999; Rap 2004). Although participating in the construction of the irrigation system wasn't a guarantee of obtaining the job some of them were present at that time.

4.4.2. Operation and Maintenance

From the literature studied it shows that the canalero is not much physically involved in the maintenance of the control structures of the irrigation systems. Instead they can be involved through organising and monitoring the maintenance work (Chidenga 2003; Manzungu 1999; Schrevel and Rowbottom 1988; Thi Phoung Lihn 2010). An exemption is in South Korea where the canalero was also physically involved in the maintenance work, but the small maintenance he does by himself (Wade, 1982).

They are usually physically involved if the maintenance can hamper or delay their tasks. For instance in Chibuwe irrigation scheme the canalero has to work together with the pump operator to remove the sand around the intake which comes about due to decreasing levels in the river (Manzungu, 1999). In another block the canalero would remove the debris which causes the clogging of the pipe because there is no sand trap to avoid this incident (Manzungu, 1999). He had to do it because the blame would be placed on him if insufficient amounts of water reached the fields and moreover, the farmers are not allowed to remove the debris leaving the task to him (Manzungu, 1999). In Autlan El Grullo they liaise with the engineers to speed up the maintenance in order to ease their job and reduce tension with the water users and also initiate for the maintenance of the canals (Van der Zaag, 1992). In Bima Panita scheme the canalero is also involved in the tertiary canal maintenance and incidental upkeep of quaternaries (Duewel, 1995).In Domasi irrigation scheme they can be involved in the small maintenance work of the main canal (Garsight, 2010).

The canalero can also do some minor maintenance work which includes small fixings of certain intakes which will not shut by throwing in a few buckets of sand and gravel from the road. The modernisation of part of the open canal system into a closed pipe system in Aultlan El Grullo saw the canalero having an extra task of checking and cleaning the tomas (intakes) of the three tubes before returning back to the office. This according to him is a filthy job which he performs everyday (Schippers, 2009).In South India the canalero used to patrol the distributary and check for blockages which would have been put by upstream farmers (Chambers, 1988). They also remove debris blocking the gates (Vos, 2002).They can even join in the maintenance if there is no irrigation taking place and also do some minor repair works to valves(Chidenga, 2003).

4.5. Conclusion

The canalero plays an important role in the management of irrigation water. The canalero can be involved in water acquisition and allocation depending on the type of management present in the system. There are places in farmer managed irrigation systems where the canalero has a role to play. The guard in the Maira furrow of Mozambique ensures that the weir is not tampered with by the downstream farmers. The mirju of Tajikistan walks to the source to do checkups. These are some of the ways in which the canalero is involved in water acquisition. The canalero in farmer managed irrigation systems plays a major role in water allocation. In Spienz and the former Lower Moshi irrigation systems the canaleros take requests from farmers and make rotational schedules. In government managed irrigation systems they might take water requests from farmers but they are not involved in the real allocation. They pass on the requests to the superiors like the sectoristas in Peru and water controller in Zimbabwe. There is quite a lot of evidence which confirms that the canalero plays an important role in water distribution. what's striking about this is that in some of the systems they do a checking task to ensure that the distribution is not disrupted. Most canaleros in farmer managed irrigation systems are fully involved in the decision making process. The canalero in the government managed irrigation system usually implements the decisions and not make them for example the situations mentioned in the section of decision making from Peru and Zimbabwe. However they can be involved in making field level decisions which have to do with the operation of the infrastructure. There are several cases which have shown that the canalero is involved in mobilisation of resources of the organisation. These include taking records of areas irrigated daily, taking electricity readings, fees administration to mention a few. This shows that they can be multi tasked personnel performing different duties in one irrigation system. Places like South Korea and Zimbabwe have confirmed this.

5. Infrastructural, Agro- ecological and Institutional conditions

5.1. Introduction

In this chapter I will try to answer two of my sub research questions. One of the questions is looking at the different types of infrastructure where the canalero exists and why. The other one wants to find out the agro-ecological and institutional conditions which influence the roles of the canalero in irrigation water management. The first section will describe the existence of the canalero in surface irrigation systems. This will be followed by their existence in the closed systems which can be either surface systems or pressurised systems. Lastly a description of their existence in automated systems will be presented. Under surface irrigation systems three distinctions will be analysed which include the Government managed systems, Farmer managed systems and lastly Agency managed systems. Within these systems I will look at their makeup and the forms of water distribution which they were designed for. The operational rules will also be highlighted including the part of the system which the canalero operates. Several cases will be presented which shows the existence of this type of personnel in different parts of the world. Examples or cases which illustrate the existence of the canalero in government managed systems are from countries which include South Korea, Sri Lanka, Peru, Turkey, Indonesia, Mexico and Zimbabwe. Cases which assist in showing the existence of this type of personnel in traditional or farmer managed irrigation systems will come from countries like Tanzania, Mozambique and Tajikistan. A few places will show the canalero's existence in other type of infrastructure like closed pipe systems (Mexico and Zimbabwe) including automated systems (USA).

In the other section of this chapter I will describe how the roles of the canalero in irrigation water management are influenced by agro-ecological and institutional conditions. The agro-ecological conditions which will be considered are issues of water scarcity/ abundance and cropping patterns in different irrigation systems. These will be described with the help of illustrations from countries which include Malawi, Tanzania, South Korea, Mexico and Peru. These will show how the roles of the canalero are influenced by these factors. Water scarcity issues might lead to head-tail end problems in an irrigation system so these examples will show how these problems emerge in this kind of a situation. Institutional conditions or arrangements are also influential on the role of the canalero and even including his existence. Some few illustrations from countries which include Sudan, Turkey and Malawi to mention a few will also be used to show this.

5.2 The existence of the canalero in different infrastructural settings

Differed aspects are considered when looking at the infrastructural conditions of an irrigation system. One aspect is to look at whether they are open canal or closed systems. The other aspect involves the mode of operation which is carried out in that system which may be automated or non automated system.

There are several places around the world which have proven that the canalero is most prevalent in surface irrigation systems which are manually operated. These systems are characterised with division structures and sliding gates. This is also based on the literature research and expert responses pertaining to these personnel. According to Van Vuren they are present in medium surface irrigation systems which are around 500ha in Tanzania and Malawi and are also present in Morocco and India (G.Van Vuren, e-mail interview, 05/2010). Although Plusquellec, shares the same sentiments with Van Vuren, he goes on to argue that these types of personnel exist at least on paper. They are hardly visible in the field according to him (H.Plusquellec, e-mail interview, 10/05/2010). The reason he has given to support his argument is that in some systems the control structures have reached such a level of deterioration and are no longer functional such that the field staff cannot play any role for example in the Philippines with the exception of the head works. The field staff might also have no means of transport or will operate structures within their vicinity (H.Plusquellec, e-mail interview, 10/05/2010).

5.2.1. Surface Irrigation Systems (Government constructed and managed systems)

Classical literature by Wade shows that this type of personnel existed some thirty to forty years ago. He showed this when he described the functioning of an irrigation system in South Korea which he named SY FLIA. This was an irrigation system which was managed by Farmland Improvement Associations (FLIA) in the northern part of South Korea. The rule of water delivery was continuous flow and no rotation (Wade, 1982). FLIAs were parastatal bodies set up by the Ministry of Agriculture to operate and maintain the systems above 50ha.Although it was supposed to be continuous flow, in practice it was demand delivery, for how much flow went to a command area was depended on the farmer's needs. Canal patrollers who were attached to the field office commanded an area of an average of 100ha.Their job in these systems was to patrol the main and branch canals in their area twice a day. They adjusted the level of the gates and checked that the structures were in good repair. In water abundant situations the whole canal system was normally open all the time except when heavy rains made the water unwanted. Water flowed continuously from lateral to each plot in the land development area, and continuously from plot to plot in the other areas There was no attempt to save water by opening and shutting some gates in rotation, or by having each plot take water from the lateral in rotation. Only in the drought years was the rotational schedule implemented which was rare in this system. The canals were unlined except in weak places and there are 11 cross gates which regulate main canal flow. There were also twenty pump stations for lifting surface water from rivers, canals and drains and they were situated near the tail end areas. Fourteen out of twenty pumps supplemented canal flow and the remainder lifted water to where it could not physically flow by gravity alone (Wade,1982). Distribution below the outlets in this system was in the hands of the farmers but in rare cases of disputes over water might the patroller be involved.

In Gal Oya which is also a government constructed irrigation scheme in Sri Lanka, there was a trifurcation immediately below the dam which distributed water among Right bank, Right division and Left bank areas. In the Right division and Left bank, rice monoculture was practiced in two distinct seasons. Until 1974, the system was run on a continuous flow at or near Full supply level (FSL) but canal deterioration necessitated the implementation of a rotational schedule (Amarasinghe et al, 1998). The irrigation department staff were responsible for operating the distributary channel gates but they had no control of them especially before the rehabilitation started in 1979(Uphoff in Chambers, 1989). The control of distributary channel gates was effectively in the farmers hands for a soon as the irrigation department staff member (*jala Palaka*) had bicycled off after closing a gate, farmers would go out with their home made keys and change the settings at will (Uphoff in chambers,1989). Rust also went on to say that in Gal Oya farmers had established informal control over water at significantly higher levels in the system than formally designated. It was highly improbable that the irrigation department could ever regain control over water down to the level of individual field channels (Rust in Chambers 1988). In the same system in ancient times the irrigation headman (*vidanes*) who were under the village council will enforce water rotation and planting schedules at the field level (Uphoff et al, 1990). This is another system whereby an irrigation department or agency controlled distribution at higher levels which is the mains and secondary canals, and the farmer organisation in the form of village councils would oversee the distribution or water at field level.

In Jaquetepeque irrigation scheme in Peru, the main canal is lined and doesn't have the check structure to regulate water levels, but there are weirs to increase it. In this system the water flow in the canals is fixed throughout the season (Vos, 2002). No individual water turns have to be scheduled everyday and water distribution does not follow a complicated and precise schedule based on request turns, but continuous flow normally requiring changes in gate settings once a week. In normal years water inside the tertiary block is not scheduled in turns to individual plots but rather runs continuously to all plots except in the beginning of the rice irrigation season where water is scheduled in fixed rotations. During this period irrigation turns are requested to the canalero. The canalero also schedules water in times of fertiliser application (Vos, 2002).

Chancay-Lambayeque irrigation system which is also in Peru is a gravity driven open canal surface irrigation system with no pumping. The main canal is lined, while off takes are regulated with radial or sliding gates. The operation and maintenance of the system is paid out of the volumetric water fee. No subsidies for operation and maintenance come from the government (Vos, 2005). On-request water scheduling is practiced in this system whereby each water user with a water right is allocated a maximum volume of water each year. The volume depends on the crop allowed to be grown according to the cropping zones. Sugarcane is cultivated in the head end, rice in the middle, maize and beans at the tail end. Farmers have to buy water turns which are requested at the irrigation office (*Comisiones de Regantes*). The unit of water delivery is the *riego* (one hour of water delivery with a flow of 160ls^{-1} at field level costing about US$2,00 (Vos, 2005).The *sectoristas* of Chancay-Lambayeque gets water orders from users and decides how many *mitas* are to be delivered to each tertiary unit block. They also estimates how many farmers are willing to buy how many hours of water in order to have a frequency of about one complete rotation each(Vos, 2005). Along the secondary canal the *sectoristas* determine the gate settings and gives instructions to the *tomeros* for gate operation. Water flows are only measured at the entrance of the secondary canals by the *sectorista.* At the tertiary level the division structures are either manually operated adjustable underflow sliding gates or wooden overflow stop logs. The tertiary block is managed by more or less informal organisations who might hire personnel called the *repartidor* who works under an NGO which also operates in that system. He does almost the same job as the *sectorista* especially in the tertiary block (Vos, 2002).

Cumra irrigation scheme which was constructed around 1912 has its three main diversion structures built along the Carsamba River. Inflows to the secondary canals were generally regulated by means of head gates which were operated by ditch riders (FAO Report, 1975). Water allocation in the tertiary block was in the hands of the farmers. The absence of cooperation among farmers resulted in no distinct pattern of water allocation in the tertiary canals thus irrigation practices in this block were of a random nature. In area 1 and area 2 of the Cumra irrigation system, the take out structures which supplied water to tertiaries still existed but were no longer working as planned because the spindles had been removed by the farmers. They would raise or lower the gates on their own through the use of make-shifts such as crowbars, chains and rocks. In 1963 rehabilitation of one area of the scheme started. The secondary and tertiary canals were lined and control structures and division boxes were put in place. During the irrigation season, the flow in the main and secondary canal was of a continuous nature. The department of the Turkish Ministry of Public Works constructed and managed the system (FAO Report, 1975).

Duewel also showed the existence of these personnel in Bima and Tayuban irrigation systems in Central Java of Indonesia The systems received water from multiple weirs and river systems which were operated primarily by the Government. Bima had three concrete structured weirs with metal gates. Two weirs had two primary /main canals each and the third one had one primary canal . The three weirs were operated by dam guards which were paid by the irrigation service. Each of the main canals was managed independent of the others. During the rainy season, water flows continuously into Bima's tertiary canals (Duewel, 1995). During the four to six months dry season, the pre determined inter *desa* (village complexes) schedules were implemented. Tayuban's 415ha was irrigated by two weirs located at the transition point where two parallel rivers entered the lowland. Unlike Bima, this system had no dam guard so it was run by three *desa* in accordance to a year round weekly cycle. Below the weir diversion structures, the tertiary and quaternary canals were operated by the communities concerned (Duewel, 1984). These communities used to practice the *distributor ulu-ulu* system before the formation of the Dirma Tirta WUA of the 1971/72 era. In this system water allocation was supervised by *ulu-ulu* (water master) based on cultivator request and water needs (Duewel, 1995).

The canalero also existed in the surface irrigation systems of Mexico. The Left bank is one of the system in which Rap described his role in this system (Rap, 2004). The system was constructed by the Ministry of hydraulic resources. It started operating in the early 1950s with direct intakes form the river that let water into earthen canal systems. It was rehabilitated at the beginning of 1970s and the area under irrigation was expanded to 20 000ha (Rap, 2004). The main canal has a capacity of $25m^3/s$ and its total length is 49 km and It delivers water to secondary canals. From the secondary canals the water is diverted to the tertiary canals where it will reach the field through field canals. The upstream water level is controlled by gated cross regulators in order to achieve sufficient head of the intake structures and field inlets (Rap, 2004). The system consists of manually operated intake structures which are undershot devices with a vertical plate and hand wheels which are adjustable. These are operated by the canaleros in that system. They distribute water from the main canal, via the laterals and sub laterals canals up to the intakes of individual farm plots. They are also responsible for the weekly programming of water volumes that their sections require. They also schedule and supervise irrigation turns for the farmers who irrigate their crops at field level (Rap, 2004).

In Zimbabwe at Chakowa irrigation scheme which is a gravity fed system, rotation is done in the main distributary canal. The *water bailiff* has to adjust all gates in the canal in order to get a proper flow in the off take canals (Chidenga, 2003).

In most parts of Pakistan and North West India places like Punjab, Haryana, Rajasthan and Uttar Pradesh the canal systems were constructed by the British solely for the protective purposes (against famine and promoting cash crops cultivation)(Wester and Jurriens, 2005).In these systems a *warabandi* system of water distribution was implemented. This is a system of rotational water supply both in the main system level and tertiary level with the primary objective to ensure equity in water distribution (Jurriens et al, 1996). The operating principle of the *warabandi* is that the irrigation water entering the *chak* (tertiary unit) is allocated to every landowner for a fixed time period in proportion to size of landholding (Jurriens et al, 1996). At the main system level all the canals are run at full supply level (FSL), however in periods of water scarcity (water levels below 75%) rotational schedules are implemented in the main system. The *warabandi* is a two tiered operation with each operation managed by a separate agency, the upper managed by the state whilst the water flowing out of the outlets is managed by the cultivators. The outlets are specially designed, fixed, ungated structures (Wester and Jurriens, 2005). However, according to Wester the government staffs does some occasional gate turnings at the head end of the fixed and proportional systems where only gates exist to ensure that the Full Supply Level (FSL) is not compromised. But he is doubtful if the staff operating these gates will be under the heading water guard (F.Wester, e-mail interview, 10/05/2010). However, different forms of warabandi exist. There is the strict or formal system called *pucca warabandi* which means that the rotation is solid or regulated. The *kacha warabandi* contradicts the former one because it has no legal basis and farmers arrange rotation rosters for themselves (Wester and Jurriens, 2005). In Rajasthan the cultivators practice a form of *kacha warabandi* whereby the cultivators of one *chak* form an irrigation collective (*panchayat*). They manage water distribution amongst themselves with the help of a time keeper known as the *Mirab*. In the *pucca warabandi* there is the *Zilladar* who schedules the roster assisted by his *patwaris.* The roster and its changes have to be approved by the irrigation authorities. In both forms of *warabandi* there Is a personnel who is responsible for water distribution in the *chaks*. In the *pucca warabandi* there is the *Zilladar* who schedules rosters for rotation whilst in the *kacha warabandi* there is the *Mirab* who acts as a time-keeper in managing water distribution. Even though the outlets are fixed ungated structures there is still someone at the field level who oversees or is responsible for water distribution. This can also be an indication that the canalero type of personnel exists in this type of system though not much has been written about them.

5.2.2. Surface irrigation systems (Agency managed system)

The canalero were also present in the Agency managed irrigation system called Arnapurna in Nepal. In this system water flows by gravity from a captured dam and is distributed on a continuous flow basis in periods of water abundance (Maskey and Weber, 1996). The gate operators (*dhalpas*) operate the main and branch gates. The gate operators together with the supervisors assess the volume at the intake and determine the number of gates to be opened during the drought period or water scarce situations. The number of gates to be opened depends on the volume available at the intake and not at the farmer's requirements (Maskey and Weber, 1996). In water abundance the *dhalpa* regulates the main gate to provide water to all the branch canals and in water scarce situations due to long drought spells he distributes it in a rotational basis (Maskey and Weber, 1996).

In government and agency managed irrigation systems a certain pattern seems to emerge from the examples listed above. One of the common things in these irrigation systems is that they are manually operated systems. Most of these systems operate on a continuous flow in periods of water abundance. Places like SY FLIA in South Korea, jacuetepecue in Peru, Bima in Indonesia, Arnapurna in Nepal, to mention a few confirms this. The other common characteristic is that the whole system is not managed by one organisation in this case the government but is usually two tiered. The government will be responsible for the upper part of the system up to the off take structures and water distribution from that point is the responsibility of the farmers. Although this is the most common mode of water management in these systems there are exceptions like Chancay Lambayecue in Peru and the Left bank of Mexico. This difference might be caused by the forms of water scheduling which need more accountability. In these two systems a volumetric based water scheduling is implemented which is a form of an on- request water scheduling.

5.2.3.Surface irrigation systems (Farmer managed/traditional irrigation systems)

The canalero type of personnel also existed in farmer managed or traditional irrigation systems in countries like Tanzania, Mozambique and Tajikistan. The type of infrastructure and their operation in these systems are described below.

In Tanzania, the furrow irrigation system was a traditional irrigation system which was brought about by the people who migrated from the crowded highlands to the lowlands of Lower Moshi. The Lower Moshi was a farmer built irrigation system and its operation was a run of river gravity type with temporary diversion structures and conveyance from the source to the irrigation fields (Kissawike, 2008). The original technology of diversion and conveyance was rudimentary without gates or water control structures. Local materials like tree branches, stones and bags full of sand were used to divert water into a system or canal (Kissawike, 2008). There was a local Village Government Committee within each village which appointed members of the furrow committee. This committee was used to arrange for the election of a furrow man (*mzee wa mfongo*) from among the local farmers. The furrow man was elected by the other farmers using the water resource canals (Kissawike, 2008). Mzee wa mfongo was a water manager and an elderly and respected man who organised daily water distribution. The election for the furrow man was held in every three years. This exercise was done in each village within the Lower Moshi since each village had its own government. Each system had a common water committee which comprised of fifteen people headed by the *mzee wa mfongo* (Kissawike, 2008). They worked with a representative from the Village Council which was the overseer of all the other sub villages. The furrow man guided the committee to prepare water schedules and organise canal maintenance. The furrow man was assisted by the water man who was selected by the board of elders to allocate water. Farmers had to request for water to the *mzee wa mfongo*. Water was rotated between irrigated areas within the village and it was allocated and distributed according to a four 6 hour schedule (6am, 12am, 6pm, and 12pm). These were the times that different farmers had to get their water (Kissawike, 2008).

In Mozambique the canalero type of personnel was also found in the Maira furrow which is one of the unlined furrows in the Revue catchment. It has a semi permanent weir at intake and a lined head end. The furrow was constructed by the Chitofu family in the 1950s to supply its water driven grinding mill and to irrigate their fields (Bolding et al, 2009). The water is diverted by a semi permanent weir and runs for about a kilometre providing water to around 20 families on a 12 ha land area. The furrow discharges into river Nhamatamba where water is diverted into a pond. From there a pipe draws water to the grinding mill which runs on hydro power (Bolding et al, 2009). Also a small furrow diverts water to recently terraced lands of the family. A full time *guarda* (guard) is hired by the Chitofu family to maintain the furrow and to secure water for the grinding mill. The other farmers upstream will have a guaranteed water share when the Chitofu's had gone to church. The family has a strong religious obligation of not running the grinding mill on Saturdays when they are gone to church (Bolding et al, 2009). During periods of water scarcity, the Saturdays are the only days the *guarda* allows others to use water from the furrow. Downstream of the mill, the Chitofu family use water to irrigate their beans, green maize and vegetables. The location of the grinding mill upstream virtually guarantees all year round water supply to these fields. During the hot season of October, November and December all the water from the Revue River is diverted to the Maira furrow and this is usually accompanied with conflicts. In this kind of situation the *guarda* is not always able to prevent the destruction of the semi permanent inlet by downstream farmers (Bolding et al, 2009). This shows that the *guarda* is responsible for the whole furrow including the distribution of water along its length up to the downstream end. Even though sometimes he is not always able to prevent the destruction of the semi permanent weir his presence guarantees the Chitofu family their full share or all of the water.

In Spienz and Shohririzm, irrigation schemes which are farmer managed irrigation systems in Tajikistan, the flow of water in the main canal is continuous in periods of water abundance. In water scarce periods which usually begin around June or July rotational schedules are implemented (Bossenbroek, 2011). These rotations are worked out in the form of a water graph. A water graph is a graph in which the *Mirju* records the information about the name of the water right holder, the amount of land that is held by an individual holder, the water share (in time), the amount of money of grain that should be paid and lastly a column which shows if the water user has actually paid. In Spienz irrigation system the village head together with the *Mirju* decide on when the water graph in the main canal should be implemented. Each main canal is comprised of one or two *Mirjus* (Bossenbroek, 2011). The number of *Mirjus* in each canal is depended on the length of the canal, its steepness and the location of the water source. Apart from operating in the main canal they are also responsible for implementing the water graph in the independent systems in which they are responsible. Independent systems in this context are like tertiary blocks or field level block where water will be distributed to individual farmers (Bossenbroek, 2011). The operation of the *Mirju* in Shohririzm irrigation system is slightly different to that one of Spienz irrigation system. In the former irrigation system there is one *Mirju* who is responsible for the day to day operation of the two main canals. In the independent smaller systems additional types of personnel known as the *Abshars* are responsible for implementing the water graph (Bossenbroek, 2011).

Farmer managed irrigation systems also have common characteristics. The most common one is that the systems were built by the farmers themselves. The farmers would organise themselves into an institution to have rules that govern the water distribution in their systems. Within those institutions they would elect personnel who would be responsible for allocation and distribution of water. Characters like *mzee wa mfongo* of Lower Moshi and the Mirju of Spienz are some of the examples of this type of personnel. The situation of the Maira irrigation system slightly differs with the other two because the *guarda* was hired by a family not a group of farmers. His main task was to secure water for the grinding mill and not to distribute water among the farmers. The guarda in this situation is taking a security role making sure that the Chitofu family gets most or all of the water at the expense of other farmers. He has to abide by the requirements of the Chitofu family because they claim that they are the ones who constructed the furrow so they have a right to water. Moreover he is highered by them to perform this task.

5.2.3. Their existence in modified/Closed pipe irrigation systems

The canalero does not only exist in open canal systems, but there are cases where they seem to be found in closed irrigation systems or modified surface systems. Examples of places where the canalero is operating in such systems include Mexico and Zimbabwe (Rap, 2004, Schippers 2009,, Manzungu 1999, Chidenga 2003).The way in which the canalero operates in these systems is different from one system to another. In one system they can continue with the roles they were performing before the up scaling whilst in another they have to formulate strategies on how to distribute water and deal with the problems accompanied with this type of infrastructure.

An example of a sprinkler system where the canalero had to more or less continue with their roles is Mutema irrigation scheme in Zimbabwe. It was constructed in the mid 1930s and water was diverted by gravity from Tanganda River to irrigate 150 ha through surface irrigation (Chidenga, 2003). The scheme was later extended to 262 ha in 1962 and a borehole was put in place to supplement water to the surface irrigated fields. In 1972 a decision was made to convert 182 ha of the total of 262 ha to a conventional lateral move sprinkler irrigation system. The remaining area was still served with surface irrigation water from the Tanganda River (Chidenga, 2003). The *water bailiff* controlled lateral changing by farmers. The reason for changing parts of the scheme to a sprinkler was because of the realisation that the amount of water in the river would not sustain the total area of 262 ha and it was also considered too sandy to be under surface irrigation. The system comprised of asbestos cement main field pipelines supplying water to hand moved laterals through hydrant control valves (Chidenga, 2003). The *water bailiff* took water requests from farmers in the sprinkler setting which was his task even before the conversion of the other part of the system took place. Although they were not literally involved in the movement of laterals, they still had to ensure that the pipes were aligned properly. They also monitored the rotation of pipes among the farmers which is almost similar to monitoring the irrigation turns among the farmers in a surface irrigation system. As was the case before, they reported to the water controller who was locally referred to as the *senior water bailiff*. After receiving a report from the *water bailiffs,* the water controller would work out the number, length and the positioning of the laterals that should be operating at any one time.

Autlan El Grullo an irrigation system in Mexico had modernised some parts of its infrastructure since 2000 (Rap and Van der Zaag, manuscript). This was a particular form of irrigation modernisation whereby the open canal infrastructure at the secondary and tertiary level was replaced by an underground pipe network. The network had intake boxes at the primary canal from where the water is diverted into intake pipes of gradually diminishing diameters as the network extends into the lower lying areas (Rap and Van der Zaag, manuscript). There is a hydrant after every 4 hectare which services a series of field level pipes which distribute water over the furrows. The canaleros continued with their task of water distribution and conflict resolution. The new infrastructure of invisible water flows is rather a complication to the canalero's job because they have to figure a way out to solve the problems which arise like the low pressure at the hydrants (Schippers, 2009). However they were able to continue with the job of water allocation and distribution because they were able to internalise the infrastructure whose design was in accordance with the existing irrigation practices (Schippers, 2009).

The left bank of Mexico has a different case altogether. In section five of this irrigation scheme the most common irrigation practised is sprinkler. It was initially introduced by the tobacco companies comprising of pumps and mobile sprinklers to irrigate the lighter tobacco varieties they had started producing (Rap, 2004). The components of the sprinkler system consisted of a diesel pump, a temporary fixed main line and hand moved laterals. The uses of the sprinkler systems increased when the tobacco market was nationalised at the beginning of 1970(Rap, 2004). Tabamex a parastatal company started promoting the growing of tobacco through among other things arranging the irrigation of tobacco plots for thousand of tobacco producers. In addition to that Tabamex staff together with private owners who rented out their installations determined the timing of irrigation turns (Rap, 2004). After Tabamex dismantled in 1991 the tobacco companies who became active decided to decentralise the costly labour intensive tasks to the tobacco producers. They started giving out loans to the farmers but unfortunately most small scale tobacco producers could not qualify for such loans. So they started hiring the sprinklers form more well up farmers and the companies pre financed this and the farmers had to pay at the end of the season. The companies also started to advance the irrigation fees of their tobacco producers to the WUA (Rap, 2004). This type of arrangement resulted in producers not finding the need to interact with the canalero or WUA for permission to irrigate and learn their operational rules. Moreover the owners of the sprinklers normally employed a *bombero* (pump operator) and additional *regardores* (irrigators*)* as labourers. The capacity for the canalero to monitor the pumps which are operated in these systems is very low due to the private ownership by the farmers (Rap, 2004). In this case the operation of the sprinkler systems doesn't comply with the existing operational rules. Although the canalero's role is not much significant in this type of system, he has a part to play because the *(bomberos*) take water from the canal he manages. If he doesn't take action to cater for the pumps operating in this canal, the downstream farmers will run short of water and the blame will be put on him. This shows how complicated the role of canalero can be in this kind of system where the system of water distribution is not well defined. The canalero at times has to request for more water to flow in this canal in order to cater for these individual arrangements of water abstraction by framers. At times he does not know the number of framers who will irrigate and sometimes the water goes to waste because he would have requested more water than needed (Rap, 2004).

The canalero type of personnel also existed in a surface irrigation system which is served by an underground/buried low pressure pipes. An example is Fuve Panganai which is a small holder irrigation scheme in Zimbabwe. The construction of this system was financed by a German organisation (Manzungu, 1999). The feasibility study done on this closed pipe system gave autonomy to farmers to irrigate anytime within limits. Manzungu goes on to argue that the 'limits' were not clearly defined in the reports and were left to be discovered by the operators on the ground which are particularly the *water bailiffs* (Manzungu, 1999). Operational guidelines in the form of a manual were lacking in this section and thus the extension worker was not able to assist the *water bailiff* in advising him how the system was supposed to operate. A situation occurred during the first days of irrigation in which if the farmers in block B irrigated at the same time farmers in the upper section of that block ran short of water. To redress the situation, the extension worker and the *water bailiff* reverted to their previous experience of using rotational schedules in open canal systems (Manzungu, 1999).

This shows that the feasibility study undermined the operation of the system which complicated the role of the *water bailiff*. The limits within which the farmers were to irrigate were not clearly defined and in addition to that the farmers were given autonomy to use water at anytime. The initial arrangement of the tasks of the *water bailiff* were limited to operating the off take gate at the main canal and the reservoir including measuring the quantities of flow using a Par shall flume (Manzungu, 1999). The role of the *water bailiff* in water distribution in the field seemed to have been undermined but when a situation occurred that some farmers ran short of water they would come back to the *water bailiff*. In this situation the *water bailiff* made it his responsibility to make sure that 50 farmers in this block would irrigate when they wanted without running short of water. This meant that he had to allow some water to remain in the reservoir so that farmers did not have to wait for the reservoir to fill up every time they wanted to irrigate. The design of this system did not correspond with the reality of how the system was operating in the actual field and the task was left to the *water bailiff* to deal with the unforeseen situations which might occur. This shows the importance of this kind of personnel in this kind of irrigation infrastructure.

The existence of the canal operator in modified irrigation systems like Autlan El Grullo and Mutema irrigation system heavily depended on their existence prior to the development. Before parts of these systems were modified, they were manually operated open canal systems. What's striking about their existence in these modified systems is that they can easily adapt to the new infrastructure. Schippers also observed that they were able to continue with the job of water allocation and distribution because they internalised the infrastructure in accordance with the existing irrigation practices. This is true for both cases. They look for ways to solve problems which might arise in this part of the system though they might not have the full knowledge of its operation. In Autlan El Grullo the canalero has to clean the *tomas* of the three tubes in the system to ensure that water reaches to the fields. There are also times when the water reaching the fields will have low pressure in that case the canalero has to find the cause of that problem (Schippers, 2009). Chidenga also noticed that the water bailiff in Mutema system seemed to be experienced enough to determine the number of laterals and sprinklers to work under a certain level of system leakages (Chidenga, 2003). This confirms how they formulate ways to solve the problems in these modernised systems. In the low pressure pipe system of Fuve Panganai the services of the water bailiff were thought to be unnecessary since the farmers were to irrigate at any time when they wanted. This theoretical basis proved not to be true because all the farmers would not irrigate at the same time and thus they had to consult the water bailiff to solve the problem. Even though the water bailiff didn't have enough knowledge of this type of system he would come with solutions to prevent the water shortage crisis.

According to Plusquellec there is virtually no field staff in pressurised irrigation systems or under remote automatic control systems for example Mula in Spain, Canal de Provence ((H.Plusquellec, e-mail interview, 10/05/2010). He goes on to say that in USA and Australia, farmers usually place their orders on the phone or through e-mail. There is a limited number of field staff due to financial considerations (H.Plusquellec, e-mail interview, 10/05/2010)).An example of an irrigation system which wanted to implement the automatic control system is Maricopa Stanfield Irrigation and Drainage District of Central Arizona. It is an arranged delivery system and volumetric water payment is practiced by farmers (Clemmens et al, 1994). The system was designed so that all canal check structures (cross regulators), including laterals and sub laterals could be controlled by motorised gates remotely through radio communication. The engineers who designed the system designed it in such a way that the entire system was to be operated by supervisory control (remote-manual control). The supervisory control system was finally installed in 1989 but it wasn't performing as was expected by the district (Clemmens et al, 1994). They also attempted to use automatic downstream level control but it did not succeed partially due to inaccurate gate positioning. The district operational staff had developed some scepticism about the remote control and feared that it would degrade delivery service relative to their manual approach (Clemmens ea al, 1994). Results of researches done on this system showed that manual control performed better than the automatic downstream level control. However, the subsequent efforts of implementing the control system in the summer of 1991 proved that it is likely that a properly operating supervisory control system could provide better control with less effort. Therefore in this regard, the input /effort of the field level personnel will not be required.

5.3 Agro-ecological and Institutional conditions

The canalero works under different agro-ecological and institutional conditions in different irrigation systems and their roles are usually influenced by them. Agro-ecological conditions may include the head-tail end issues. The canalero is mostly involved in these issues because he distributes water between these two the two extremities. They also include the situations of water abundance and scarcity. These conditions influence the way the canalero does operates in the irrigation systems. They can also include the cropping patterns or programmes within the systems. The way the canalero operates in a system can also be influenced by the institutional conditions under which he performs his tasks. As described earlier in the chapter an institution can be regarded as social arrangements that shape and regulate human behaviour (Merrey, 2007). These arrangements can be in the form of among other things rotational schedules, membership rules of water users associations(WUA) or property rights in water and infrastructure (Merrey,2007). These institutional conditions can either be used to benefit the people concerned or they can be manipulated by the beneficiaries at the expense of others. Different examples will be presented below which illustrate or help explain how the role of canalero is influenced by the issues mentioned above.

5.3.1 .Water scarcity

Cases from Tanzania, South Korea, Malawi, and Mexico will be described below to show how water scarcity can in influence the role of the canalero.

In 1987 to 1993 the government of Tanzania decided to modernise the lower Moshi irrigation scheme. The major intakes were lined and had floating types of weirs. The main, secondary and tertiary canals were lined and division boxes, diversion structures and cross regulators were put in place (Kissawike, 2008). Not all farmers in the area benefited from this exercise, hence there were farmers who lived outside of the newly established Lower Moshi Irrigation Scheme (LMIS). These farmers were not included in the farming programmes of the scheme and after realising that the farmers who were in the scheme would profit from growing irrigated rice they started to copy their farming practices (Kissawike, 2008). The farmers outside of the scheme decided to construct a main canal which took water from the main intake of the LMIS. This exercise created water scarcity situation within the scheme because the design didn't take into consideration the farmers outside the scheme. So insufficient amounts of water were now flowing into the LMIS. The farmers within the scheme decided to take the dispute to court since they had water rights. This was all in vain because the farmers outside the scheme also claimed the right of using the water because they started farming in that area for a long time before this modernisation process occurred (Kissawike, 2008). Due to this water scarcity some tail end farmers in this scheme started to develop strategies to obtain water. For example some members of the Water Users group made use of their status and political and social connections to obtain water through bribes. Some farmers were also able to get more water to their plots because they had a personal relationship with the water man (Kissawike, 2008). This situation of water scarcity led to some informal arrangements of water distribution in which the canalero was involved. At one time he had to give water to the farmers because of their social and political positions and at another time he would give it to his close associates. This is an example of where the farmers manipulated their positions in the social system in order to get water share.

In South Korea in the SY FLIA irrigation system, head-tail end problems were minimal because of the abundance of water. In 1978 they experienced a drought where lower rainfall totals were recorded in May which is the time when more water is needed for transplanting (Wade, 1982). The president, manager and head of agricultural affairs decided to introduce a rudimentary rotation between sections of the main canal. For instance they decided to use the cross gates halfway down the canal to close the bottom half for four to five days at a time and then close the other half for roughly the same period(Wade, 1982). A that time the staff were concentrating their whole attention on providing farmers with alternative means of getting water. The farmers and the staff had to work long hours in order to keep the paddies irrigated (Wade, 1982). Which shows the dedication of the canal operates who didn't want to compromise their reputation due to low water availability.

The canalero played an important role during the periods of water scarcity in the Domasi irrigation scheme in Malawi. After the formation of WUA in 2002 the block leaders who were democratically elected did the water distribution job at the field level. Since these local leaders didn't get a compensation for their job, they started to misuse their position by becoming biased and favouring farmers within their blocks and accepting bribes for doing so(Garsight, 2010). In other places within that system the distribution was based more or less on needs basis. Farmers who grew maize and water melons would partially open the gates of the main canal on their own and divert it to their fields. This was problematic especially during the time of water scarcity for the tail end farmers. To redress these problems the WUA decided to hire water guards who would carry out an irrigation schedule (Kissawike, 2008). The water guards performed their duties during the day. After the guards had ceased their duties farmers would emerge and contest for water in the late afternoon. This resulted in less water reaching to the downstream end. The WUA doesn't do anything to sanctions those farmers who steal water at night even if they know the culprits (Garsight, 2010). This further complicated the role of the canalero, whilst he is performing his work of allocating water there is nothing he can do to stop farmers from stealing water at night. The water guard is an easy target for the farmers to blame for the water shortage. But looking on the brighter side even though farmers would steal water at night, the existence of the water guard will make an assurance that the downstream farmers would have access to their water share at least in the day time, which would have been highly unlikely if they were absent (Garsight, 2010).

Van der Zaag referring to the case study of Autlan el Grullo of Mexico mentioned that there is a situation of sudden rains in the dry season which disrupts the established irrigation schedule (Van der Zaag, 2002). In this system it is the canalero who works out a water distribution schedule in any one canal on the basis of differences in water demand, field by field, depending on crop and soil and farmer's request. In the situation of sudden rains irrigation will stop but the consequences will be that all farmers will request for water at the same time which complicates the work of canalero. Water users are also free to choose the crop they wanted to grow and the planting dates they want which further burdens the scheduling (van der Zaag, 2002).

5.3.2. Cropping patterns

Cropping patterns also have an influence on the way the canalero performs his duties. Schippers found out in his research he did in Autlan El Grullo that the job of the canalero is difficult in the beginning of a new suspension period of sugar cane production (Schippers, 2009). During this period almost all farmers would want to suspend their last irrigation turn till this last period in order to harvest the cane whilst it is still heavier. At this period most farmers do not show up for meetings and some will not stop irrigating in time (Schippers, 2009). The canalero proves to have less power in distributing water during this period. This illustration shows how a cropping pattern can make their job a strenuous one.

In Chancay-Lambayeque almost all areas are allowed to grow rice in water abundant years. Vos in his thesis gave an illustration of an incident which occurred in this irrigation system during the rice cultivation period. The *repartido* an NGO employee who is responsible for water distribution at the tertiary level was caught in a dilemma of how to distribute the water among the farmers during a rice production season (Vos, 2002). In this incident some farmers need water to irrigate their seedbeds but yet it was not their turn to have the allocation. The other farmers needed water to wet their dry land for transplanting at the same time with those who wanted to irrigate their seed beds. Some of them were claiming to have the allocation first because of soil conditions (Vos, 2002). Thus the task of the canalero in this situation was to decide on how to allocate water in situations where the users have different priorities which needed immediate attention. In another situation almost all the farmers applied nitrogen fertiliser and they did not request for water with the fear that all of it will be swept to one side if irrigated. Again all of them will come at once and demand water having the fear that the fertiliser will burn their crop if they do not immediately irrigate (Vos, 2002). These incidents show how the role of the canalero in water allocation and distribution is undermined or overlooked yet it can be so complicated in reality.

5.3.3 .Institutional influences

Before the irrigation management transfer (IMT) the management of Gezira irrigation scheme in Sudan was two tiered. The upper part of the system was managed by Ministry of Irrigation and Water Resources (MOIWR) whilst the lower part i.e. from the field off takes was managed by the Sudan Gezira Board (SGB) (Woldegebriel, 2011). The *ghaffir* was employed under the (SGB) and he was responsible for operating the field outlet pipes. After the formation of WUA at around 2007 to 2008 the operation and maintenance at the farm level became the responsibility of the farmers (Woldegebriel, 2011). WUA was not effective enough in implementing its operation and maintenance duties. Woldegebriel also mentioned that they concentrated more on collecting water fees and maintenance charges whilst neglecting the operation aspect of the system (Woldegebriel, 2011). It is not surprising that the role of *ghaffir* disappeared in this kind of situation. Since the formation of the WUA there had been no planned rotational schedule among the field outlet pipes. Farmers would open and close the field outlet pipes at any time they want and during the irrigation peak period they would leave them open for 24 hours (Woldegebriel, 2011). Moreover farmers along the Tuweir minor canal started pumping water from that canal. Since this is their individual arrangement there is not much that the operator (Government employee) would do to stop them. This affected the downstream farmers because this led to less water reaching to their area (Woldegebriel, 2011). Lack of working rules which govern the distribution of water makes it difficult for downstream farmers to request for water thus sometimes they will go to the head end and close the gates on their own. Lack of institutional arrangements that governed water distribution at field level led to improper abstraction and distribution of water. This lack of institutional arrangements consequently led to the field operation figure (*ghaffir*) to disappear hence no personnel to implement a proper rotational programme.

A similar situation was found in the Cumra irrigation system of Turkey. The distribution of water in the tertiary units was in the hands of the farmers. Again there was no cooperation among them and as a result there was no distinct pattern of water allocation in tertiaries. The rules of water delivery were not clearly defined at the tertiary level (FAO Report, 1975). The random irrigation practices are an indication that there weren't field level personnel who would regulate water distribution among the farmers. This can be an indication of the importance of that type of personnel. This also shows that the canalero's existence is depended on the institution with well-defined rules which govern water distribution.

In the Left bank the large and powerful producers who have strong connections with the WUA president are generally given water and do not have to wait for their turn to have it. The association undermines the job of the canalero by listening and doing the wishes of farmers through allocating more water to them even when their turn has not yet arrived. The canalero does not have the actual control of water distribution because they do not have a support from the management. In this case it is the powerful producers that determine the amount of water they want in their fields and not the canalero. The canalero is there to ensure that they get the water they are not supposed to. This situation is almost similar t that one of the LMIS in Tanzania where the farmers use their influential political and social positions to get water even if it's not their turn (Kissawike, 2008). The only difference is that in LMIS this usually occurs in periods of water scarcity but in the Left Bank the powerful producers have greedy intentions of getting more water than they need. In the Maira furrow the *guarda* follows the orders he gets from the Chitofu family because he was hired by them to do so. This can be regarded as another institutionalised arrangement where a family can determine how the *guarda* should operate.

5.4. Conclusion

The role of the canalero is most prevalent in manually operated open canal systems irrespective of the type of management in that system. These systems usually operate on a continuous flow in periods of water abundance and rotational schedules are implemented in water scarce situations. In government and agency managed irrigation systems the main section of the system is usually managed by the government whilst the tertiaries are the responsibility of farmers. In farmer-managed irrigation systems it seems the canalero is the overseer of water distribution that is from the main canal down to the tertiaries unlike in the Government or Agency managed systems where they operate specific sections of the system.

The canalero's exist in modernised irrigation systems mostly because they already worked in the systems prior to the development. In two cases described earlier from Mexico and Zimbabwe, it seems they were already working in these systems before parts of the systems were upgraded or modified. However despite their little or limited knowledge or the system they proved to be competent enough in dealing with water distribution issues in these types of systems. Fuve Panganai closed pipe low pressure system was designed in such a way that the services of the water bailiff would not be necessary. However this proved not to be true on the actual ground which confirms the importance of the canalero in such situations.

The services of the canalero are not needed in an automated system. This had been verified in the Maricopa Stanfield irrigation system that a properly operating supervisory control system could provide better control with less effort, hence no need of field level personnel.

Agro-ecological and institutional conditions have an influence on how the canalero operates in a system. Issues of water scarcity can lead to some of the farmers using political and social power to acquire water. This disrupts the work of the canalero and at times he might accept bribes. In most irrigation systems the water scarce period is the time when the canalero is most active. His presence in water scarce periods is seen by other farmers as a guarantee for them to get their water share referring to the case of Domasi irrigation scheme and the case of the Chitofu family in Mozambique. Sudden changes in agro-ecological conditions like unexpected heavy rains in the dry season can complicate the work of the canalero.

Cropping patterns can also have an influence on how the canalero executes his duties. Like the suspension period in Autlan El Grullo where farmers would suspend their last period so that they harvest the cane whilst it is still heavier (Schippers, 2009). Farmers would deliberately not attend meetings so that they are not allocated a water share before this period. Some will not stop irrigating in time. This makes the job of the canalero to be difficult in this time of the season. In other situations the canalero is caught in a dilemma of deciding how to allocate water in situations where water users have different priorities which need immediate attention for example the case of rice production period in Chancay Lambayeque in Peru.

Institutional settings can determine how the canalero functions in an irrigation system. They also show how relevant this role is important in everyday water distribution especially at field level. His absence may lead to no distinct pattern of water distribution, hence the creation of head-tail end problems. How the canalero executes his duties is sometimes if not most of the times determined by the institutions he works under. In the Left bank of Mexico the powerful producers who have strong connections with the WUA determine how water should be distributed. The case is the same for Tanzania where the Water Users group members use their positions to have more water in water scarce periods. In Mozambique a family sets out its rules which the *guarda* has to follow. All these examples show how institutions influence the working of the canalero.

6. Conclusion

The mode of operation of the canalero in farmer managed irrigation systems seem to differ with that one from a government managed irrigation system. Canaleros in farmer managed irrigation systems seem to occupy respected and influential positions compared to the canalero employed by the government. The reason for this is that the canalero in farmer managed irrigation systems are elected to get those positions in the local water committee. Examples are the *mzee wa mfongo* of Tanzania and the *mirju* Tajikistan. The government canalero are usually low level personnel who are inhabitants of the irrigation area. The common aspect about both of them is that most of the time they do not possess technical qualifications to perform their duties in irrigation water management.

They play an important role in the irrigation water management. The canalero in farmers managed irrigation system seem to be more involved in the irrigation water management activities compared to the canalero in government mange irrigation system. This can be attributed to the fact that the canalero in government managed irrigation systems work in an organisation which is hierarchical where decisions are made from the top. So their involvement in different irrigation water management activities depends on the infrastructure they work on and the rules that govern the management of water which are formulated by the government. Unlike the canalero in the government the canalero in farmer managed irrigation systems manage smaller irrigation systems and the rules of governing water management are made locally thus they can easily be involved in irrigation water management activities.

The canalero seem to be most prevalent in manually operated open canal systems which operate on a continuous flow in periods of water abundance and rotational schedules in period of water scarcity. They are also present in open canal systems which use a *warabandi* system of water distribution. These types of systems have slightly different infrastructure with the other surface systems in that they do not have gates at the farm off takes to regulate water flow. In these systems their main task is to make rotational schedules and time-keeping. They may also exist in systems which have modernised or upgraded infrastructure. The reason why they are present in such systems is because they were already working in these systems prior to modernisation. These are open canal systems were parts had been converted into closed pipe systems or pressurised sprinkler systems. The canalero figure is absent in fully functioning automated irrigation systems.

Their role in irrigation water management can be influenced by different factors. Situations of water scarcity and cropping patterns have much influence on the performance of their tasks. His power or authority to distribute water seems to get lost in times of water scarcity. In most cases the influential people in the social and political arena will determine the distribution of water. Some farmers will revert to stealing water at night when the canalero has ceased his work of the day leading to head -tail end problems. There are cases where the canalero will start to accept bribes or start to favour some other farmers at the expense of others in this kind of situation. Cropping patterns can complicate the job of the canalero especially rice and sugarcane production in places like Mexico and Peru. There is a time when all the farmers will want a share of water at the same time and this complicates the work of the canalero. His presence at local level is determined by well established institutional arrangements at the local level. His absence can lead to no distinct pattern of water distribution hence the emergence of a lot of problems. So to conclude one can say that the canalero plays an important role in irrigation water management.

7. References

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Annex I. Datasheet of names where the canalero exists

Country	Canalero name	Irrigation size	Infrastructure	Constructed by	Past management	Current management	Name of irrigation system	Author/reference
Asia								
South Korea	Patroller	11000ha	Manually operated open canal system	State	Parastatal		SY FLIA	Wade,1982,p39
Sri Lanka	Vidanese	125000ha	Manually operated open canal system	State	Government and village councils	WUA	Gal Oya	Uphoff et al, 1990,p28
Nepal	Dhalpa	300ha	Manually operated open canal system, gravity fed	State	State	WUA	Arnapurna	Maskey and Weber,1996
Pakistan	Zilladar & patwaris		Manually operated main canal, ungated structures at outlets	British colony	State	WUA		Jurriens and wester,1995
Indonesia	Village water master	4,800ha	Manually operated open canal system	State	State &village council	WUA	Sedeku	Schrevel& Rowbottom,1988
India	Neerganti		Tank system, gravity flow	Community	Community/State	WUA	Andhra Pradesh	Meinzen dick, e-mail intrerview
India	Neerkati &Neerani		Tank system, gravity fed	Community	Community /State	WUA	Tamil Nadu	Meinzen dick, e-mail intreview
North West India	Mirab		Manually operated main canal, ungated structures at outlets	British colony	State	WUA	Rajasthan	Jurriens and Wester, 1995
Nepal	dhalpa		Manually operated open canal system	State	State and village council	State and WUA	Pacahkanya	Singn,2011,personal communication
Indonesia	Ulu-ulu		Manually operated open canal system	State	State and Village council	WUA	Bima and Tayuban	Duewel, 1995
Tajikistan	mirju		Manually operated open canal system	community	Community	community	Spienz and shohrirism	Bossenbroek, 2011
Africa								
Zimbabwe	Water bailiff	80ha	Pump driven open canal system, manual operation	State	State	WUA	Chibuwe	Manzungu, 1999
Zimbabwe	Water bailiff	262ha	Open canal and pressurised system	State	State	WUA	Mutema	Chidenga,2003
Tanzania	Mzee wam fongo/water man	2300ha	Manually operated Open canal	Community/state	Community	WUA	Lower Moshi	Kissawike, 2008
Malawi	Water guard	500ha	Manually operated open canal system	State	State	WUA	Domasi	Garside
Mozambique	guarda	12ha	Manually operated gravity fed	Family	Chitofu family	Chitofu family	Maira furrow	Bolding et al, 2009
Sudan	Ghaffir	880,000ha	Manually operated Open canal	State	State Sudan &Gezira board	State& WUA	Gezira	Woldegebriel,2011

South America								
Peru	tomero	111000ha	Manually operated Open canal	State	State	WUA	Chancay lambayecue	Vos,2002
North America								
Mexico	canalero	11500ha	Manually operated open canal system and closed pipe system	State	State	WUA	Autlan El Grullo	Schippers, 2009
Mexico	canalero	20000ha	Manually operated Open canal	State	State	WUA	Left Bank	Rap, 2004
Central Arizona	Ditch rider	35000ha	Manual upstream control &automatic downstream	State	State	State	Maricopa Stanfield	Clemmens et al, 2000
Europe								
Turkey	Ditch rider	32500ha	Manually operated open canal	State	State	WUA	Cumra	FAO Report,1975
Spain	No field personnel		Remote automatic control	Farmers	Farmers	State	Mula	Pluscuellec,interview response

Annex II. Locations where the canalero exists around the world