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Groundwater Management for Irrigation in the Raya and Kobo Valleys, Northern Ethiopia

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Abstract: The study area, Raya and Kobo valleys, are located in the northern parts of Ethiopia. From the hydrological point of view, the sites are located within the Afar drainage basin. The areal coverage of the valleys is 2369 km^2 for Raya and 1439 km^2 for Kobo. The amount of groundwater that is currently discharged for irrigation purpose in Raya and Kobo valley is 10755.9 m^3/day and 30600 m^3/day, respectively. This is estimated to be about 0.06% and 6.91% of the total safe groundwater discharge of each valley, respectively. The annual average groundwater recharge in the Raya valley is estimated to be 84 million cubic meters and that of the Kobo valley is 122.9 million cubic meters. At present, the amount of natural recharge in both valleys is more than the abstraction. With regard to the irrigation development in the valleys, the problem is not lack of water; it is rather absence of or poor management. This is mainly due to absence of responsible and efficient institutions that are equipped with adequate capacity. Sustainable management of groundwater resource is indispensable for better development, allocation and optimum utilization of the groundwater resource of the valleys and to avoid any adverse effects. It is therefore necessary to establish responsible and efficient groundwater management system that can undertake not only detailed groundwater management studies of the basins but also effectively implement the on-going irrigation development in the valleys, following the objectives of the national water resources management policy of the country.

Keywords: *Groundwater Management, Irrigation, Raya and Kobo Valley, Northern Ethiopia.*

1. Introduction

1.1. General

With the high spatial and temporal variability of rainfall in Ethiopia, agricultural development can succeed on sustainable basis with a complete integration and application of effective/ efficient technologies, appropriate institutional arrangements and monitoring systems in order to properly utilize the available water resources in a certain area. Pressurized irrigation, which is defined as the application of water through point or line sources (emitters) on or below and at required discharge rate resulting in partial/full wetting of the soil and plant root, is applied in Raya and Kobo valleys in northern Ethiopia.

The Ministry of Water Resources has initiated irrigation development study in Raya valley of south Tigray region in 2008 with an aim to efficiently and optimality utilizes the water potential of the area, mainly groundwater using pressurized irrigation system. Water Works Design and Supervision Enterprise together with Concert Engineering and Consulting Enterprise were assigned to undertake the study eight years ago.

Kobo pressurized irrigation project was initiated sixteen years ago by the Commission for Sustainable Agriculture and Environmental Rehabilitation in Amhara Region (Co-SAERAR) to tackle the food insecurity in the valley. Then after, Kobo Girana Valley Development Program Office (KGVDPO) was established in 1999 by the Amhara National Regional State with the aim of enhancing food security through irrigation development in the Kobo-Girana valleys.

As it was mentioned in Water Works Design and Supervision Enterprise (2008) Raya valley pressurized irrigation project report, previous studies and drilling was conducted (mostly at the western part of the valley) by German Consult, Kobo-Alamata Agricultural Development Program (1977), Relief Society of Tigray (1998), Water Well Drilling Enterprise (1998), Ethiopian Institute of Geological Survey (1998), Water Works Design and Supervision Enterprise (2005), and Tekeze Deep Water Wells Drilling Plc (2006). These studies showed that the western part of the valley has high groundwater potential. Intensive and integrated study of the Raya valley was carried out in the year 1996 by Relief Society of Tigray (REST) and the Tigray Regional Government. In the year 1997, feasibility report was produced by the Raya Valley Agricultural Development Project (RVADP). The Raya and Kobo valleys have also been investigated previously by different governmental and nongovernmental organizations and scholars such as Dessie (2003), Sileshi (2007), Abrham (2009), Mohammedsultan (2010), Abdella (2011), Abduwassie (2011) and Merhawi (2012). Even though they came up with different values of groundwater recharge estimation of the valleys, all these previous studies indicated the availability of huge groundwater resource on the valleys.

In both Raya and Kobo valleys, currently the projects are in the first phase of development. A number of boreholes were drilled and irrigation structures constructed. Farmers are cultivating both cereal and vegetable crops using complimentary irrigation system. Those farmers participating in the irrigation activities are found to have better income and improved life styles.

Even though the farmers are getting benefit from this intervention, the sustainability of the project and also the resource itself has to be examined from current development and utilization trend point of view. This step has not been initiated, leading to present study. The present study has been carried out: (a) to study the development and trend of utilization of groundwater and its management in both Raya and Kobo irrigation schemes, and (b) to recommend options for sustainable utilization of the groundwater resources in the Raya and Kobo valleys.

1.2. Description of the Study Area

1.2.1. Location and Accessibility

The Raya pressurized irrigation project is located between 12°16' and 12°55' N latitudes and 39°22' and 39°53'E longitudes. It is found at about 600 kms north of Addis Ababa and at 180 kms south of Mekelle, the capital of the National Regional State of Tigray. It is bordered by the Afar National Regional State to the east, the Amhara National Regional State to the south, part of Ofla and Enda Mehoni Woeredas to the west and Alaje and Hintalo Woredas of Tigray National Regional State. The surface watershed of the valley approximately covers a total land area of 2369 km^2.

The Kobo Sub-basin where pressurized irrigation project is located between 12° 18' to 11° 56' N latitude and 39° 23' to 39° 47' E longitudes. Administratively, it is located in the northern Wollo Zone of the Amhara National Regional State, Kobo Woreda. It is found at a distance of 50 kms from the zone town Woldia and 410 km from the regional town, Bahir Dar. The total area of the sub-basin is estimated to be 1439 km^2 of which 29 percent is flat plain and the remaining is either mountainous or hilly. The project area is bounded by Tigray National Regional State from north, Alwha sub basin from South, Lasta mountain from west and Zobel mountain in the east. The location map of both valleys is shown in the Figure 1.

1.2.2. Geology

Raya Valley

According to the 1998 study of the site by the Relief Society of Tigray (REST) and the 1996 second edition Geological Map of Ethiopia, the project area is a flat plain dominated by deep to very deep undifferentiated alluvial, lacustrine, and beach sediments. These sediments are bounded on the east and west by Ashangi formation, which is a series of volcanic rocks characterized by deeply weathered alkaline (olivine) and transitional basalt flows with tuff intercalations, rare rhyolites from fissures and dissected by dikes and sills.

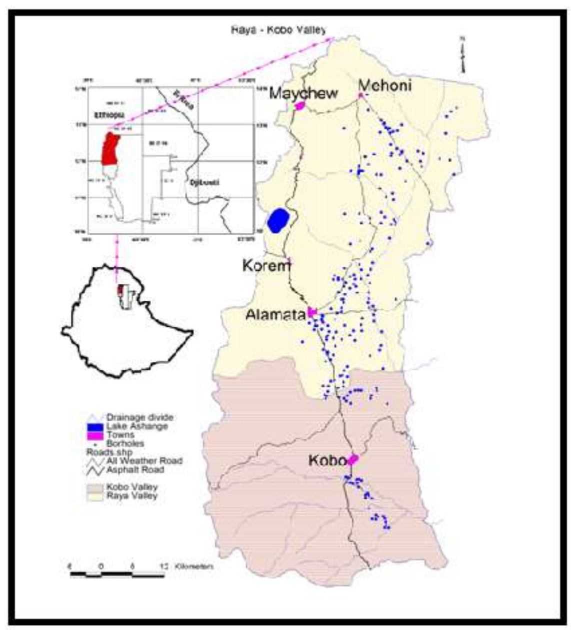

Fig. 1 *Location maps Raya and Kobo Valleys.*

Kobo Valley

The valley lies in a region occupied by marginal grabens formed in the escarpment zone of the Afar-Ethiopian Plateau boundary. The northern portion of the area is occupied by the southernmost part of Corbetta graben, which has a total length of about 90 kilometers. It is known that the depressions in the rest of the area are also formed by smaller grabens.

The geology of the area is made up predominantly of basaltic rocks occurring in the graben shoulders and beyond and superficial deposits on the graben floors. Other rocks such as rhyolite, small granitic intrusions and sandstone do also occur.

1.2.3. Hydrogeology

Raya Valley

The valley floor is bounded on both west and the east directions by highly fractured and weathered basaltic rocks, mainly Ashangi basalt. A groundwater resource is believed to be the huge water resource in the area.

The dominant groundwater flow directions are north-south and west-east. The depth of groundwater varies from about 20 m in Waja and Adis-Kigni (south) areas to over 60 m in the northern part of the project area (Water Works Design and Supervision Enterprise, 2008).

According to the study of Water Works Design and Supervision Enterprise (2008), the average groundwater recharge in the area is estimated to be 84 million cubic meters per year and the static groundwater reserve is estimated at 7150 million cubic meters. However, the total exploitable quantity of groundwater per year, at this stage, in the valley is about 130 million cubic meters.

According to Mohammedsultan (2010), the annual average groundwater recharges of the Raya valley, estimated by chloride mass balance (CMB) method and by the inverse modeling are, about 116 mm and 114 mm, respectively.

Based on the hydrogeology studies and current aquifer tests conducted on the area by Water Works Design and Supervision Enterprise (2008), a safe yield for 35 production wells existing in the area had been determined. Accordingly, the yield ranges from 30 l/s up to 50 l/s with an average potential yield of 32.3 l/s, which can be exploited from the drilling of a single borehole.

Waja Springs

The Waja spring development area is located upstream of Waja town, which is approximately 15 km downstream of Alamata town. The main source of springs is located to the left side of the main highway S-N, which is the elevated part of the site.

The total discharge of the Waja spring is estimated to be 400 liters per second. This would mean that, if the spring water is collected by a proper engineering structure, the estimated water quantity becomes equal to the capacity of 12 boreholes, which can irrigate an area of 360 ha (Water Works Design and Supervision Enterprise, 2008).

Kobo Valley

The most important aquifer in the valley is the plain unconfined sediments. The eastern and western acidic volcanic rocks and the inselberg hills within the plain are almost impermeable.

The Kobo plain is a flat plain with decreasing slope from west toward east and it is filled with Quaternary alluvial deposits derived from the surrounding basaltic mountain range. The alluvial deposits are composed of intercalating layers of gravel, sand, silt and clay. Both geophysical investigation and drilled well logs indicate thickness of the sediment aquifer ranges from few meters to 170 meters. The thickness is minimal on both western and eastern flanks whereas the maximum of 250 m, occurs towards the central part. Depth of groundwater table in the valley varies according to local hydrogeological and morphological conditions. In the western and central part it varies from 20 to 5 m and it gets shallower towards southeast. It is greater than 50 meters along volcanic ridge of Mendefera, western flank and near to the inselberg hills. Shallower groundwater depth condition is expected along the proximity of dry rivers.

The groundwater of the basin unconsolidated deposit aquifers have a groundwater divide along the Mendefera volcanic ridge and is divided into two parts: Hormat-Golina and Waja-Golesha groundwater systems.

Hormat-Golina Well field:-The well field is located south west of Kobo town. It includes Horamt, Golina and Aramo areas. It has an approximate area of above 50 sq. km. and the sediments comprise sand and gravel.

Waja-Golesha Well Field:-occupies the plain located between Waja and Golesha within Kobo sub-basin. The well fields starts from the alluvial fan at the bottom of the Lasta Mountain to the edge of Zobel ridge. In the south it is bordered with Mendfra Insberg hill. It has an approximate area of about 45 sq. km. The geology is mainly composed of coarser materials, sand and gravel.

According to the report of Kobo Girana Development Project Office report (2011), the Kobo sub-basin groundwater resource safe yield was estimated using analytical method. It is found to be around 309,942.00 m^3/day (186,514.00 m^3/day for Hormat Golina well field and 123,428.00 m^3/day for Waja Golesha Well field).

The major sources of groundwater recharge for the plain unconsolidated sediment aquifer are draining water from the fracture openings of the volcanic rocks of the western Lasta mountainous area. The second recharge is from rainfall induced and other perennial surface runoffs that flow over the alluvial deposit and infiltrate and recharge the groundwater source. The third minor recharge comes from irrigation return.

According to the feasibility study report for the Kobo-Girana valley development program (1999), annual groundwater recharge capacity of the Kobo-Robit sub-basin where Hormat-Golina well field is located is 59.3 million cubic meters and Kobo-Waja sub-basin where Waja-Golesha well field is located is 63.6 million cubic meters.

1.3. Overall Nature of the Project

Raya Valley

The Raya pressurized irrigation project is located in two woredas: Alamata and Raya Azebo. It is intended to be developed by pressurized irrigation system using wells pumped from the aquifer of the valley.

A total area of 46,444 ha of land is considered for the analysis in the project at both woredas of which 33,905 ha (73%) land is used for pressurized irrigation development unless limited by the availability and development of groundwater resources. The number of boreholes and amount of water required to develop this area through pressurized irrigation system is estimated to 1,034 and 18.31 million cubic meters per day, respectively (Water Works Design and Supervision Enterprise, 2008).

The number of proposed boreholes to be drilled and the estimated irrigable area for a detailed design to be implemented in the first stage of development of the project is 31 wells and 1020 ha, respectively. The relative amount of groundwater, which is used for irrigation is estimated to be 55, 000 m^3/day (Water Works Design and Supervision Enterprise, 2008).

Kobo Valley

The Kobo valley pressurized irrigation project is run by Kobo-Girana Valley Development Project. The project plans to conduct this pressurized irrigation project in four sub-basins where irrigation well fields were identified: Waja-Golesha in Kobo-Waja sub-basin, Hormat-Golina in Kobo-Robit sub-basin, Alawuha in Alawuha sub-basin, and Mersa in the Gelana sub-basin.

The maximum number of boreholes in the respective well fields was designed by dividing the safe yield of the sub-basins to the annual production of one borehole during the feasibility study of the project. The annual production of a well is calculated assuming pumping of 20 hours/day for 250 days of the year at a rate of 30 l/sec. Accordingly, a total of 246 high capacity irrigation wells can be developed in Kobo-Waja, Kobo-Robit, Alawuha and Gelana sub-basins (Feasibility Study Report for the Kobo-Girana Valley Development Program, 1999).

The number of proposed boreholes to be drilled in the first stage of development of the project is 160 which is about 65% of the total boreholes planned to be drilled by the project. According to the Feasibility Study Report for the Kobo-Girana Valley Development Program (1999), the first phase breakdown is 70 wells in Waja-Golesha, 76 wells between Hormat and Golina, 10 wells in Alawuha and 4 wells east of Mersa town.

2. Methods

The research involved collection of all the available pertinent primary and secondary data for both Raya and Kobo valleys. Secondary data related to geological, hydrological and hydrogeological data were obtained from different sources in Addis Ababa, Mekelle, Alamata, Mehoni and Kobo.

During the fieldwork, much time was dedicated to observation of groundwater irrigation schemes, and to visiting governmental and non-governmental organizations which are dealing with water resources development and management in Alamata, Mehoni and Kobo towns. It turned out that Kobo Girana Valley Development Project Office, the Office of Woreda Water Bureau in Alamata and the Office of Woreda Water Bureau in Mehoni have abundant data on drilled wells, hand dug wells and developed springs.

During the field investigation, groundwater development methods used by different governmental and non-governmental organizations involved in this activity were examined. Informal and formal interviews and discussions regarding groundwater discharge, allocation, utilization and management were also conducted with the farmers that are involved in the irrigation scheme and irrigation committee chair persons on those currently functional irrigation schemes. Moreover, discussions were held with agriculture extension agents in the woredas.

3. Results and Discussions

3.1. Current Groundwater Development Status

Raya Valley - Alamata Woreda

Until July 2012, seventy-two deep wells were drilled in different parts of the woreda for irrigation purpose. Among these, 54 were drilled by Water Works Design and Supervision Enterprise and the remaining by Tekeze Drilling PLC. Out of the seventy-two boreholes only five are functional at the time of field visit (19/07/2012) and the remaining sixty-seven are nonfunctional. The number of beneficiaries and the size of the irrigated land are given in the Table 1.

Table 1 *Functional boreholes in Alamata Woreda*

No.	Tabia	Number of boreholes	Number of Beneficiaries	Irrigated Area (ha)	Status	Remark
1	Limat	1	73	22	Functional	
2	Selam Bekalsi No.1	1	150	35	Functional	
3	Selam Bekalsi No.3	1	165	36	Functional	
4	Temuga	1	130	53	Functional	
5	Temuga	1	70	34	Functional	

Raya Valley - Raya Azebo Woreda

Until July 2012 fifty-six deep wells were drilled in different parts of the woreda for irrigation purpose. Out of these, only three are functional at the time of field visit (20/07/2012) and the remaining are nonfunctional. The number of beneficiaries and the size of the irrigated land are given in the Table 2.

Table 2 *Functional boreholes in Raya Azebo Woreda*

No	Tabia	Number of boreholes	Number of Beneficiaries	Irrigated Area (ha)	Status	Remark
1	Wargba	2	144	72	Functional	
2	Kara	1		20	Functional	
3	Wer abaye	1		-	Nonfunctional	Due to pump problem

The current irrigated land developed for pressurized irrigation system in the Raya valley is 272 ha which is 0.8 % of the proposed land for pressurized irrigation development in the valley, and 26.67 % of the proposed estimated irrigable area for a detailed design to be implemented in the first stage development of the project. Up to now the total number of productive wells is 128 which is 12.38% of the total proposed number of boreholes required to develop 33,905 ha through pressurized irrigation system and 4.13 times the proposed number of boreholes to be drilled in the first stage development of the project.

Besides, 7 deep wells are currently developed and utilized for irrigation purposes by investors in Raya valley: 2 in Alamata Woreda and 5 in Raya Azebo Woreda. Currently, an irrigable land of 3828.35 ha is given to the investors in the two woredas: 1700ha at Alamata and 2128.35ha at Raya-Azebo woredas. Out of this, currently the total irrigated area by the investors is 354.5 ha: 30 ha in Alamata and 324.5 ha in Raya Azebo.

The study revealed that the number of drilled productive wells is greater than that of the number of proposed boreholes to be drilled in the first stage of the development. However, irrigated area is much less than that of the planned irrigable area for a detailed design to be implemented in the first stage development of the project. Drilling is not accompanied or immediately followed by extension work that are supposed to be done immediately after drilling of the boreholes to achieve the objectives of the project. Because of this a number of productive wells are found closed in different parts of the valley (Figure 2). Moreover, those that were once functional have become non-functional due to pump failure (Figure 3).

Fig. 2 *Unfunctional borehole at Wer abaye Tabia*

Fig. 3 *A borehole Selam Bekalsi No.1. Tabia*

Kobo Valley

In the valley, a total of 59 wells have been drilled so far for the pressurized irrigation system. Out of these, 17 wells are functional and for the remaining forty-two wells extension works are under construction. The current development is 23.98 % of the total boreholes planned to be drilled by the project and 36.88 % of proposed boreholes to be drilled in the first stage of development of the project. The area covered by irrigation using these numbers of boreholes range from 561 to 578 ha. Besides, 5 deep wells are currently developed and utilized for irrigation purposes by investors. Currently, an irrigable area of 517 ha is given to these investors.

Since here the project is fully managed by the Kobo-Girana Valley Development Program Office, the drilling is immediately followed by extension works and the drilled productive wells are utilized for irrigation. The farmers would start their irrigation without any delays. In case of failures of pumps, the problem is solved by the Kobo-Girana Valley Development Program Office. As a result in the Kobo valley all the wells are functional.

3.2. Groundwater Utilization

In all the areas, Alamata, Raya Azebo and Kobo, in each functional borehole the utilization of groundwater by the farmers is set by the irrigation committee. Each irrigation committee consists of five persons elected by the farmers among themselves. The committee consists of chair person, secretary, cashier, store keeper and two members. This committee is the one that decides on the duration of the discharge and recharge of the borehole. The time of irrigation and duration of irrigation is also set by this committee. The members of the committee are not professionals. Both the committee and the farmers are assisted by agriculture extension workers which are assigned by the woreda agriculture office. All the members of the committee do not get any incentives for being members of the committee.

The communication link of the irrigation committee with different organs of the government follows a hierarchy of: Chair Person of the irrigation committee → Chair person of the Tabia → Rural Development (Agriculture) Office Tabia Chair Person → Woreda Agriculture Office.

In the year 2012, the total numbers of productive wells in the Raya valley are 128. Out of these 72 wells are found in the Alamata sub-basin and the remaining 56 are in Raya-Azebo. In the case of Kobo valley the total numbers of productive wells are 59. As it is shown in Figure 4, the total numbers of productive wells have increased in numbers in both valleys: 22 deep wells are added in Raya valley and 5 wells in Kobo valleys as compared to the wells in the year 2011. However, the numbers of functional wells have not increased in numbers parallel with the availability of the deep wells (Figure 5). The total number of functional wells that irrigate currently in Raya-Azebo and Alamata area are 3 and 5, respectively, whereas in Kobo valley are 17. The number of functional wells in Raya valley decreased in 2012 whereas in Kobo valleys it increased. Failure of pump is the main reason for this reduction. Correspondingly the size of irrigated land also increased in 2012 in Kobo valley by 195.93 % and decreased in Raya valley by 42.63% (Figure 6).

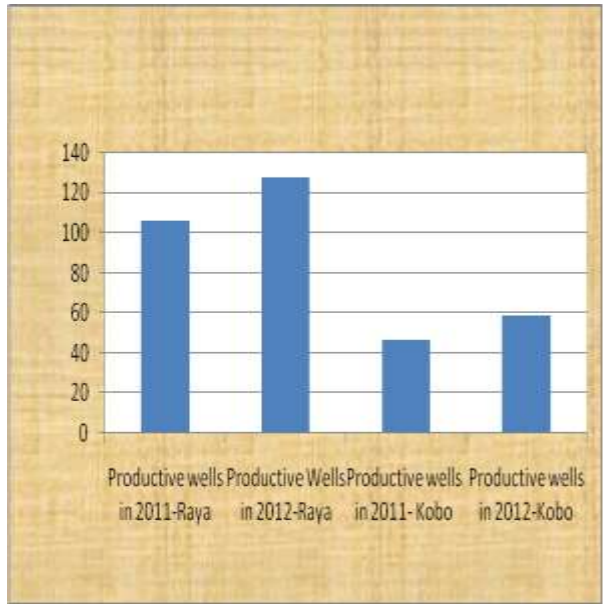

***Fig. 4** Productive wells in 2011 and 2012 in Raya and Kobo valleys.*

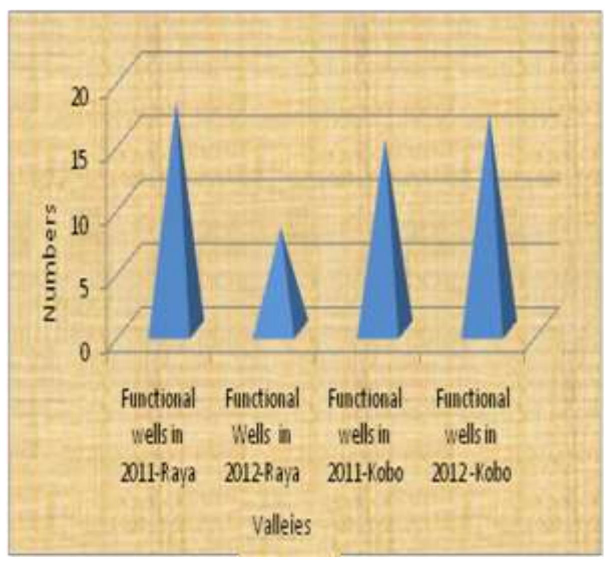

***Fig. 5** Functional wells in 2011 and 2012 in Raya and Kobo valley.*

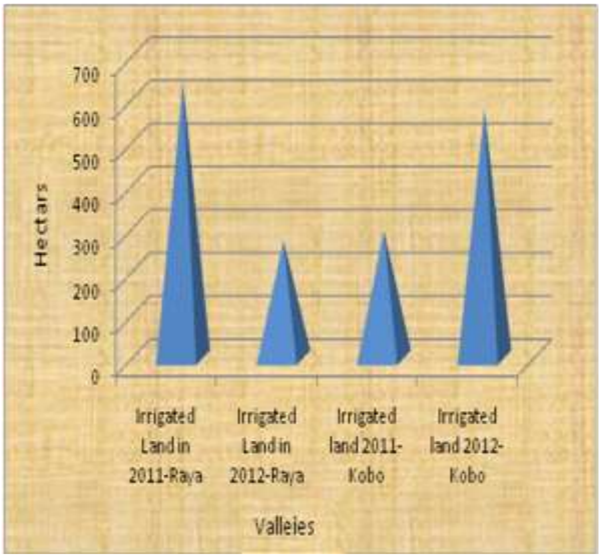

Fig. 6 *Irrigated land in 2011 and 2012 in Raya and Kobo valley*

The total abstraction of water for irrigation purpose depends on the capacity of a well to irrigate farm land. In 2012, according to the agriculture bureaus of Raya and Kobo areas, one well irrigates a maximum of 36ha. The average discharge of the wells of the Raya valley is 32.3l/s and that of the Kobo valley is 50l/s (Abdella Abdu, 2011).

The irrigation season is from January to June where the farmers utilize the groundwater for complimentary irrigation only. There is no clear irrigation scheduling in both valleys. The discharging time in Raya valley is ranging from 4:30 to 16:00 whereas in Kobo valley dominantly the discharge time is ranging from 2:00 to 6: 00 plus from 18:00 to 24.00. The frequency of irrigation for each farmer is once in four to seven days. Onion, Tomato, Cabbage, Pepper, Potato, Sorghum, Green bean and Sesame are the common crops irrigated in both valleys. In Kobo valley Banana, Mango and Papaya are also irrigated by private investors. The time of irrigation allocated for each farmer is 8 hours. The wells are pumped in an average for 11.6 hours per day of the irrigation months in Raya valley. In Kobo valley the wells are pumped in the average for 10 hours per day of the irrigation months. The total discharge per day is 5639.58 m^3, 5116.32 m^3 and 30, 600 m^3 in Alamata, Raya Azebo and Kobo, respectively. The current discharge is 19.56 % of the proposed groundwater discharge to be implemented in the first stage development of the project and 0.06% of the amount of water required to develop this area fully through pressurized irrigation system in Raya valley. In Kobo valley, this amount is 10.63% of the proposed groundwater discharge to be implemented in the first stage development of the project.

3.3. Different scenarios in groundwater development, utilization, and management of the irrigation schemes in the valleys

The groundwater development, utilization, and management of the irrigation schemes in Raya and Kobo valleys are different:

- **Model I** (Raya valley): Groundwater development, utilization, and management of the irrigation schemes are uncontrolled.
- **Model II** (Kobo valley): Groundwater development, utilization, and management of the irrigation schemes are controlled.
- **Model III** (private investment in both Raya and Kobo valleys): Groundwater development, utilization, and management of the irrigation schemes are managed privately by individual

Model I: Raya-Valley (Uncontrolled)

No project office exists that is mainly dedicated for supporting and controlling groundwater development, utilization, and management of the irrigation schemes. Consequently, in most drilled productive wells drilling was not followed by the necessary extension works that are required to utilize the groundwater for the proposed purpose. This has created frustration of the community. Due to this situation many of the closed productive wells are found damaged (Figure 7) by the communities. The so far operating groundwater wells have been managed by the user's themselves as cooperatives. In those productive wells pump failure is the major problem in groundwater utilization.

Fig. 7 *Broken uninstalled well indicating community frustration*

Major problem with management of the irrigation scheme are:

- Supply problems of fertilizers, pesticides, etc.

- No coordinated support is given to the communities/farmers in terms seed supply, type of crop per soil type, etc; mostly it is farmer’s efforts.

However, farmers/users of the irrigation have the freedom to:

- Select the type of crop they wanted: no restrictions on the type of crop.
- Lease/rent their land to any one that the farmers want.
- Manage their own land the way they wanted to.

Model II: Kobo-Valley (controlled)

An independent project called “Kobo-Girana Valley Development” project has been operating in the area since 1999. It is mandated to study, design and implementation of irrigation projects in the area.

The project office has been fully controlling the development and utilization of groundwater, and also management of the irrigation schemes by:

- Providing seeds/seedlings, and pesticides.
- Developing irrigation infrastructures.
- Controlling the type of crop for irrigation: farmers do not have the mandate to select their own crops.

The main advantages with the controlled scenario (as noted in the Kobo-valley) are:

- The farmers had only to cultivate, weed and harvest the produce.
- All supply used have been provided by the project office.
- Pump maintenance is taken care of by the project office.

The major disadvantages with the controlled system are:

- The support provided by the project office may not be sustainable.
- Framers have not been developing independent thinking in an entrepreneurial manner.

Model III: Private investment

There are 12 deep wells developed by private investments in both Raya and Kobo valleys. Groundwater development and utilization as well as management of the irrigation schemes are controlled by the individual investors themselves. There is no responsible office that controls how they develop and how much they are extracting and utilizing the water resources.

The only support such private firms are getting from the government is land (in the form of lease) and they are allowed to develop groundwater wells within their own farms. The investors do not pay for the groundwater that they are using.

3.4. Groundwater Management

3.4.1. Current Groundwater Management Practice

It is well understood that groundwater resources should be utilized in a planned manner to avoid any undesirable effects. In the case of Raya and Kobo valleys, currently, groundwater development is being carried out without any management plans. Groundwater management studies have not yet been conducted. Even though abstraction control through legislation is usually essential, there is no licensing control.

Farmers are irrigating their plot of land based on the time allocation given to them by the committee. The most influential factors such as crop type, plot size and soil type (for determining the frequency and amount of irrigation water used on the farm plot) are considered neither by the farmers nor by their assistant. None of the farmers in the study area record the amount of water that they apply during each irrigation period. The farmers put water on their farm land whenever their turn is reached and irrigate their crops until the furrow is flooded with water. In all cases farmers use water free of any payment or cost.

At present, in both Raya and Kobo valleys, the problem with groundwater irrigation is not lack of water; it is rather poor utilization and management of the water resources. In both cases, this is mainly due to lack of responsible efficient groundwater management organization that is well equipped with adequate legislation, funding and infrastructure. Current groundwater development and utilization for multi purposes and forecasts of future water demand suggest that mismanagement or lack of sustainable management of groundwater resources should be avoided if adequate ongoing water supplies are to be provided for domestic, irrigation and livestocks’s uses in these valleys.

3.4.2. Ethiopian Water Resources Management Policy

The major policy framework document with respect to water resources management of Ethiopia is the national water resources management policy of the Federal Democratic Republic of Ethiopia (FDRE) that was approved by the Council of Ministers in July 1999. The policy was formulated by the Ministry of Water Resources. The overall goal of Water Resources Policy is to enhance and promote all national efforts towards the efficient, equitable and optimum utilization of the available Water Resources of Ethiopia for significant socioeconomic development on sustainable basis (Federal Democratic Republic of Ethiopia Ministry of Water Resources, 1999).

Water resources management and administration in the country should be based on this policy and the water resources laws of the country. In the current development, utilization and management of groundwater resources of the Raya-Kobo valleys, the Ministry of water Recourses of FDRE is expected to fully implement the fundamental policy principles regarding specifically on groundwater resources of the national water resources management policy, which are not yet been implemented by the ministry.

The general policies, regarding specifically on groundwater resources (Federal Democratic Republic of Ethiopia Ministry of Water Resources, 1999) are to:

1. Identify the spatial and temporal occurrence and distribution of the country's groundwater resources and ensure its utilization for the different water uses. Provide special focus for those areas vulnerable to drought and water scarcity.
2. Ensure that the exploitation of groundwater shall be based on abstraction of the maximum amount equal to the sustainable yield as determined by competent authorities and establish regulatory norms.
3. Establish and develop norms, standards and general guidelines for sustainable and rechargeable management of groundwater.
4. Foster conjunctive use of surface and groundwater as appropriate.
5. Promote implementation of appropriate technologies suitable for water deficient areas in order to mitigate water scarcity problems.

Besides, the Ministry of Water resources of the FDRE has to work more on building and strengthening the necessary capacity in terms of institutions, legislation, facilities, human resources, finance, and information systems, regarding to the groundwater in the valleys, which have not yet been started.

3.5. What has to be done?

Groundwater constitutes a valuable resource that is being exploited at an ever-increasing rate. A variety of problems resulting from human activities alter the groundwater system. Alteration of the groundwater system can produce many unforeseen problems, as does alteration of any segment of the hydrologic system. Because groundwater is a flow resource, a scarce one, and also prone to negative externalities, proper management of groundwater-and of groundwater related activities- are crucial to the implementation of successful and sustainable processes of water development and conservation.

For better development, allocation, optimum utilization, and sustainable management of groundwater resource in both Raya and Kobo valleys, the establishment of responsible efficient groundwater management organization well equipped with adequate human, legislation, funding and infrastructure is highly imperative.

The main objective of the management organization is the implementation of the Federal Water Policy. The organization should also review the existing strategic plans in light of the new policy. In addition to these major duties, the organization is supposed to prepare alternative groundwater management plans in conformity with the Federal Water Policy and according to the social, economic and technical circumstances prevailing in the regions.

Since the Raya and Kobo valleys are located in low rainfall areas of the country, groundwater management will require very careful monitoring and long-term strategic planning. To facilitate the development and management of groundwater resource in these valleys, in addition to the above-mentioned duties, the following activities should be taken into consideration by the responsible groundwater management organization.

- Conducting a groundwater management investigation of the valleys.
- Issuing consent for investigating whether or not groundwater is present and worth abstracting. A variety of techniques or methods that are used for such activities usually involve drilling and test pumping boreholes, but may include excavation and pumping test of seepage lagoons or catchpits. The main concerns are that:
  - there is enough water available in the area;
  - Test pumping does not have an adverse effect on other water interests – wells, boreholes, streams, wetlands, etc.
  - water well contractors do not cause pollution, in nearby streams or in the groundwater;
  - drilling contractors work in a hygienic way;
  - Water well contractors dispose of any wastes, including drilling cuttings, properly.
- Licensing abstraction; Abstraction control through legislation is usually essential and should be enacted.
- Imposing a limitation on the extent of the cone of depression;
- Registration of new wells: To provide technical information for planning as well as for monitoring water use, registration of new wells is necessary.
- Registration of drillers: To ensure compliance with general requirements and to protect the public, registration of drillers should also be considered.
- Where groundwater users are in conflict or the environment is threatened, sensitive areas should be declared where notice of intention to drill will be required. In these areas, approval of drilling should include operating conditions to protect other users as well as the resource itself.
- Groundwater use must be carried out in the context of an adequate catchment management plan, based

on an understanding of the sustainable yield of the local groundwater sources.

4. Conclusion

At present, groundwater resource development in both Raya and Kobo valleys has not approached or exceeded the estimated groundwater yield. The current groundwater obstruction has not yet even reached 50 percent of the proposed yield which is required for the pressurized irrigation system to be implemented in the valleys. However, even for those amounts of groundwater that are currently abstracted the time of groundwater discharge, recharge, and allocation has exposed the groundwater of the valleys to risk and mismanagement.

Most of the irrigation scheduling and water utilization is set by the irrigation committee that is established by the farmers themselves who are involved in the irrigation schemes. In Kobo valley besides to the irrigation committee there is an established farmers Union which is handling the management responsibilities together with Kobo-Girana valley development program Office. Since from the beginning they were not established for this purpose, the existence of a number of irrigation committees in both valleys and in addition to these the existence of a Union and Kobo-Girana valley development program Office in Kobo valley do not help anything to the groundwater management of the valleys that is exposed currently to risk and mismanagement.

Pump problem is a major bottleneck in Raya valley that makes most of the functional boreholes ceased their operation for one or more than two irrigation season, which is not seen as a major problem in Kobo valleys. Extension works that have to be done immediately after the well has been drilled has not been done for long period of time in most drilled boreholes in Raya valley. This has created frustration among the farmers. Because of this in many parts of the Raya valley closed boreholes were found damaged on the top part and filled with stones. Since the extension work is done following the drilling activities in Kobo valley (by the Kobo-Girana valley development program Office), it is not a problem in this particular valley.

The following major points are recommended for sustainable development, allocation and utilization of the groundwater resource of the valleys for long period of time.

1. Establishment of responsible efficient groundwater management organization well equipped with adequate legislation, funding and infrastructure is highly recommended.
2. The legal framework concerning groundwater resources management has to be done more in conformity with the Constitution of the country and with the Federal water resources management policy.

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