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Groundwater Based Irrigation and Food Security in Raya-Kobo Valley, Northern Ethiopia

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Abstract

The Raya-Kobo valley is characterized by good groundwater resources potential (excess of 198 Mm3) located in northern Ethiopia. The total area of the valley is approximated to be 3510 Km2. Despite this potential of groundwater, the area has been suffering from droughts. Establishment and expansion of cooperative societies, small business enterprises and irrigation farming were given priority as interventions to address the food security problem in the valley. These interventions were designed and implemented in the last several years by the regional governments administrating the Raya-Kobo valley, and groundwater is used as a source of water for irrigation farming for more than nine to ten years. Nevertheless, food insecurity is still a major problem in the area. The present study has been conducted to investigate the extent of contribution of the groundwater based intervention in the elimination food insecurity. The study was conducted by collecting, analyzing and interpreting all the existing relevant data of the study area. Groundwater potential was compiled from the author's previous works and recently conducted research works. The impact of the groundwater based irrigation on food security issues was assessed using informal and formal interviews and focus group discussions. Limited area coverage of the irrigated land and the long time taken for the extension works in those drilled productive wells are the major limitations in the Kobo valley that makes the groundwater based irrigation unable to release the farmers of the area from the food insecurity. In Raya valley, besides to these problems, absence of responsible office, failure of pump, and the long time taken for pump maintenance are also the major factors. In Raya-Kobo valley food security is highly related to the availability of water. Irrigating the whole potential irrigable area, increasing and sustaining availability of groundwater and management of the irrigation scheme are vital to eradicate food insecurity from Raya-Kobo valley.

Keywords: Confined aquifer, Groundwater storage, Government investments, Northern Ethiopia, Unconfined aquifer.

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1. Introduction

1.1. General

Groundwater is that part of the hydrologic system that occurs in a geologic environment. It plays an important role in water supply, ecology and maintaining river flow. It comprises 97 percent of the world's readily accessible freshwater and provides the rural, urban, industrial and irrigation water supply needs of 2 billion people around the world [1]. As the more easily accessed surface water resources are already being used, pressure on groundwater is growing.

Compared to surface water, groundwater is likely to be much more compatible with a variable and changing climate. Relative to surface water, aquifers have the capacity to store large volumes of water and are naturally buffered against seasonal changes in temperature and rainfall. They provide a significant opportunity to store excess water during high rainfall periods, to reduce evaporative losses and to protect water quality [2].

According to the Ministry of Water Resources [3] Ethiopia is endowed with huge natural water resources, which include 122 billion m^3 annual surface runoff and 2.9 billion m^3 of groundwater. However, the county's water resource has not contributed enough to the country's socio-economic development, because major part of the surface runoff is not utilized and at the same utilization of groundwater for irrigation is still in infantile stage.

This study is conducted in both Raya and Kobo Valleys in northern Ethiopia, which are located in the Tigray Regional States and Amhara Regional State, respectively, having an area of about 3808 Km^2.The valleys are characterized by flat topography and experiences arid to semi-arid climatic conditions with highly erratic and unreliable rainfall. In both cases the main economic means is rain fed agriculture.

Among the northern parts of the country, the Raya-Kobo valley is one of the areas that are highly affected by frequent droughts. Major climatic limitations for agricultural production are erratic rainfall, unpredictable monsoons, which often combined with intermittent dry spells that regularly threaten the survival of the crops, resulting in reduced production and food insecurity [4]. The infamous drought caused by very low rainfall (Figure. 1) in 1984 had claimed thousand lives.

Raya-Kobo valley is administrated by two regional states: Tigray Regional State and Amhara Regional State. The northern part, commonly called Raya valley, is administrated by Tigray Regional State whereas the southern part, called Kobo valley, administrated by Amhara Regional State. To improve the problems of food insecurity in this valley groundwater based irrigation was introduced to the respective administrative area of the valley by the respective regional governments before five years at different time. Since then groundwater based irrigation become one of the activities in addition to rain fed agriculture.

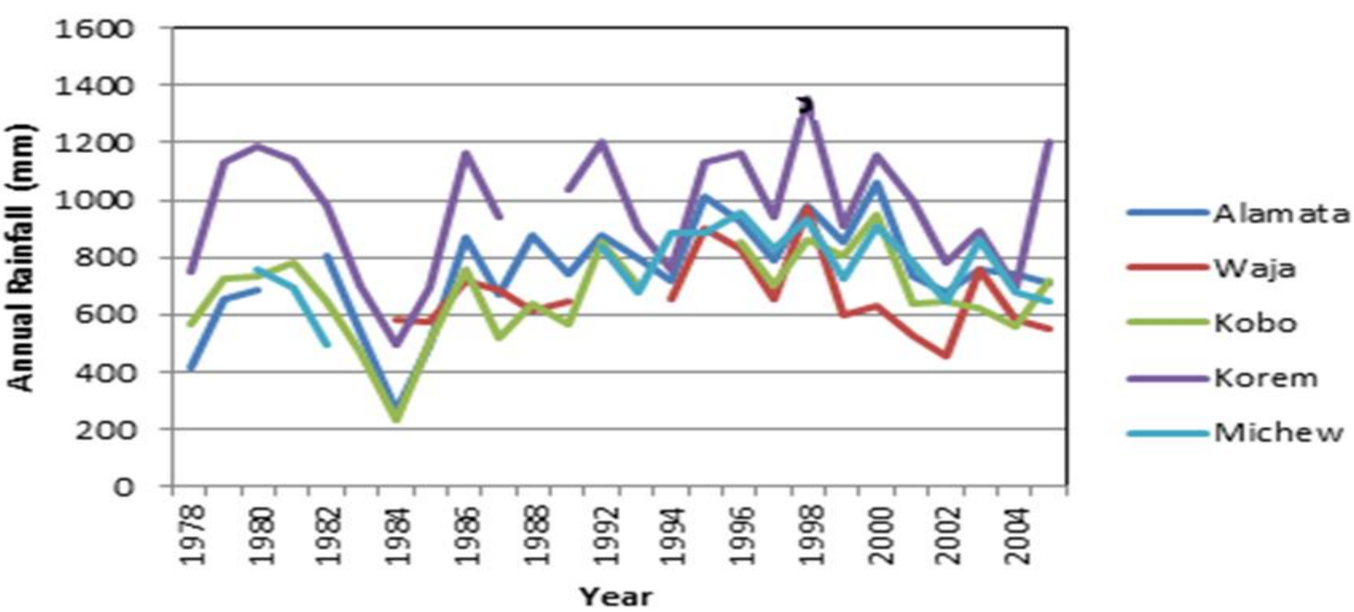

Figure-1. Annual rainfall distribution in selected meteorological stations in Raya-Kobo valley.

Groundwater based irrigation was commenced in Raya valley in 2008 by the Ministry of Water resources currently called Ministry of Water, Irrigation and Energy. In Kobo valley it was commenced by the regional government and run by Kobo-Girana Valley Development Project since 2005 [5]. In both areas of the valley, this irrigation scheme was implemented with the aspiration of increasing food security and by then reducing the dependency on rain fed agriculture.

At present, in both areas of the valley large numbers of groundwater structures, mainly deep wells, were drilled and still new groundwater developments are underway. Following the drilling of boreholes, constructions of irrigation infrastructures are in progress, and small areas are covered by irrigation using functional boreholes, which are very few in numbers. Those farmers who are involved in the irrigation schemes and their land covered by irrigation are cultivating different crops using complimentary and supplementary irrigation systems.

Even though groundwater based irrigation is there as intervention since five years ago, food insecurity is remain as a major issue in this valley without any significant improvements. Groundwater based irrigation has not yet been able to play the major role in the agricultural production. A study that reveals the reason behind to this has not yet been done, which is the main objective of this study. The present study has been conducted to investigate the extent of contribution of the intervention in the elimination food insecurity and the reason why it is unable to boost agricultural productivity to the extent that enable it to play a major role in the agricultural production in this valley.

1.2. Location

Raya-Kobo valley is located within UTM 37P, 541000-59600m E and 1319000-1428000m N, and covers an area of 3510 km² (Figure. 2). Raya valley has a total area of 2595 km² whereas the remaining 915 km² is constituted by Kobo valley.

1.3. Groundwater Resource

Nearly 268 deep boreholes are inventoried in the study area. Boreholes that are drilled mainly for irrigation purposes are 135 and 64 in Raya valley and Kobo valley, respectively. Semi confined aquifer, confined aquifer and unconfined aquifer are the major aquifer types in Raya-Kobo valley. The depth of the boreholes ranges from 51 to 311m with an average depth of 148 m. The static water level ranges from artesian condition to 90m below ground surface with a mean value of 27 meter. The drawdown ranges from less than a meter to 63 meter with an average value of 15 meter. The well yield also ranges from 1.13 to 121 l/s with a mean value of 41 l/s. The general flow direction of the groundwater coincides with the surface water flow direction. Generally the groundwater flow direction is from west to east (Figure 3). Basically the downstream upstream relationship is governed mainly by west to east flow. Hydrogeologicallly there could be a hydraulic connection from north to south as the main aquifer is unconsolidated deposits.

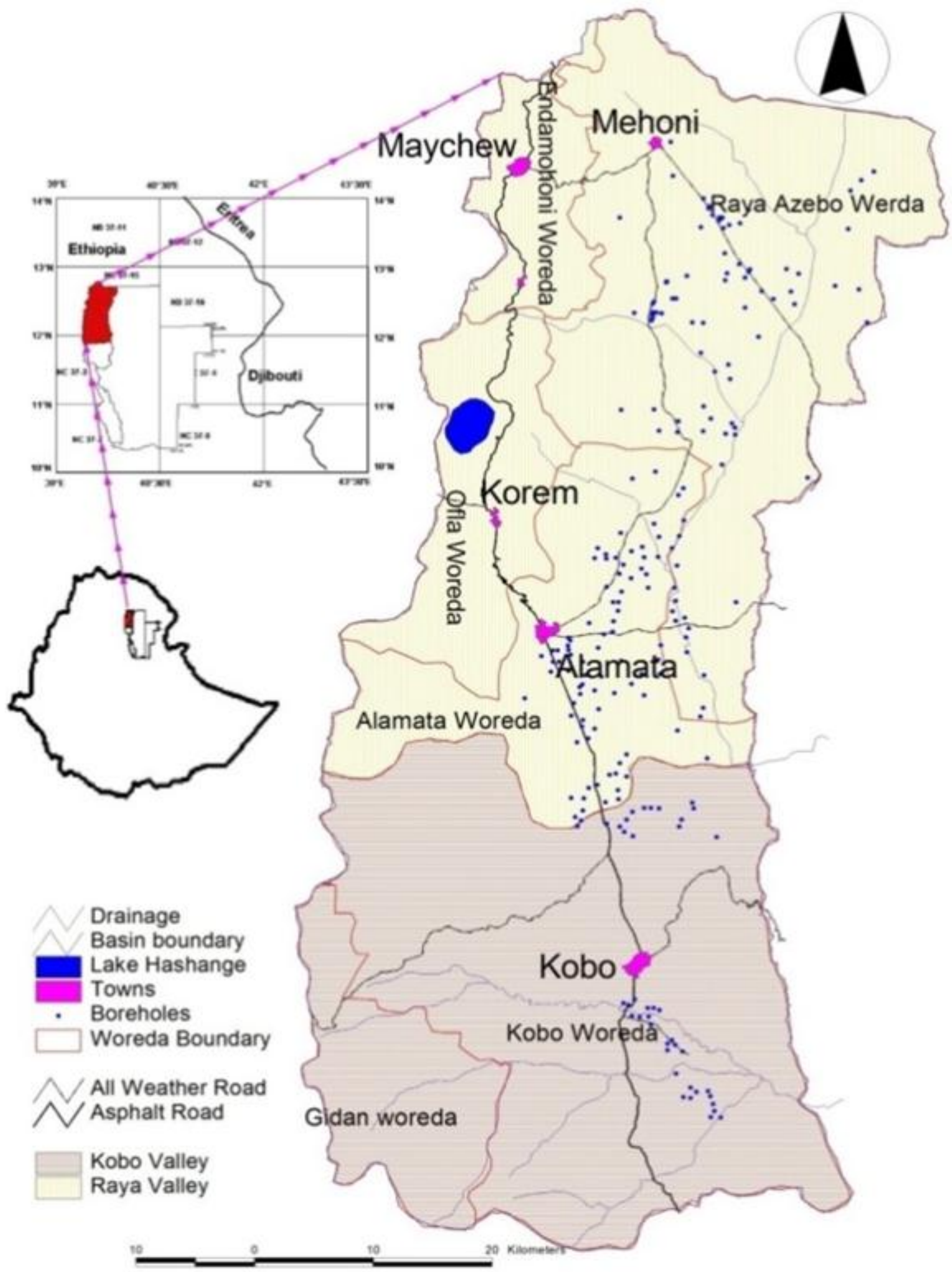

Figure-2. Location maps Raya-Kobo valley

Source: Nata, et al. [6].

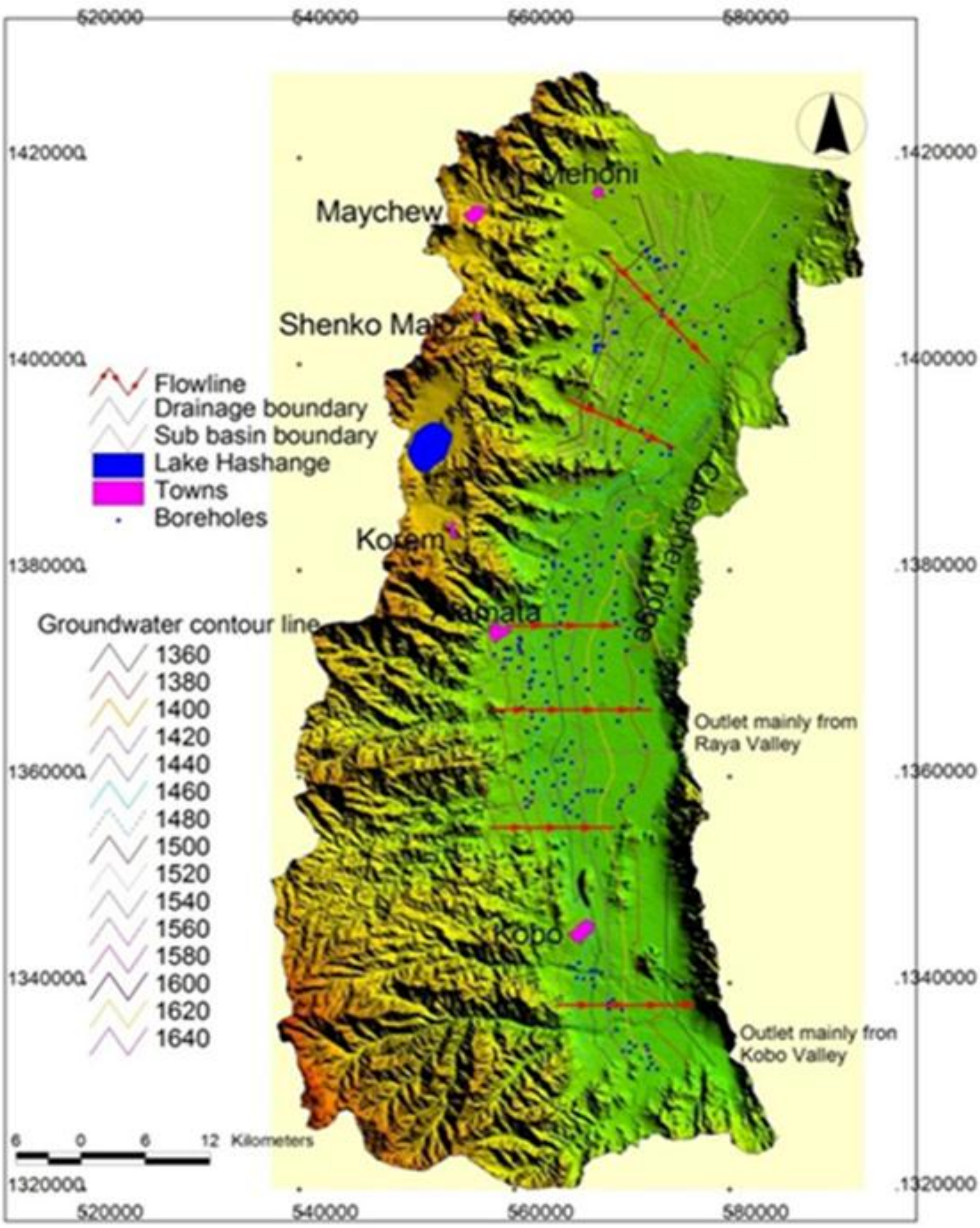

Fig-3. Digital elevation model, groundwater contours and flow line map of the study area.
Source: Dessie [7].

1.3.1. Groundwater Resource Potential of Raya Valley

The groundwater recharge, estimated by using water balance method, is 129.3 MCM (50 mm) per year [7]. The recharge occurs in all parts of the catchment based on availabilities of excess rainfall. The major portion of the recharge occurs on the plateau and the escarpments through direct (diffuse) infiltration. The escarpments due to their geomorphological setup, act as runoff zones rather than being water storage medium during rainy periods. Limited infiltration can take place in the fractures of the rocks. Fractures serve as an inlet for the rain fall in the escarpments. Both runoff and the limited infiltrated water in the escarpments act as a source of replenishment for the aquifers that occur down in the topographically lower areas. A significant portion also recharged along the foot of the escarpment through indirect rainfall recharge from local surface runoff. From field observation and the general flow direction of the groundwater system the whole basin recharge is concentrated towards the valley fill material. Reducing the amount used by the community on the plateau and escarpments which is estimated to be 5.731 MCM/year [8] the net groundwater recharge to the valley floor aquifer is found to be 123.6 MCM/year. This amount does not take into account the possible recharge that will occur because of irrigation as a return flow. The valley floor aquifers could yield theoretically about 123.6 MCM without adversely affecting the groundwater resource if all assumption for the calculation of the water balance is correct. The total yield of the wells (the sum of all the wells yield) which are already drilled and tested is 233.3 MCM. Only few wells are operational currently. If all the wells are made operational and worked for eight months of the year for 12 hours then the total yield from the Raya valley basin is estimated at 77 MCM. Generally sustainable yield may not be equal to the conventional safe yield [9]. The future development of the wells should take into consideration the sustainable yield, which is less than the safe yield.

The total groundwater storage was estimated by considering the total area of the valley floor, the saturated thickness and the storativity. Accordingly the average thickness of the valley fill sediments is found to be 149 m and the average depth to the static water level is around 25 meter resulting in an average saturated thickness of 124 meter. If we assume a storativity of 0.003 for confined and semi confined aquifer which accounts about 70 % in the study area and a specific yield of 0.19 for unconfined aquifer which accounts 30 % of the study area [10] then the total groundwater storage for an area of 1018 km^2 is about 7460 MCM.

1.3.2. Groundwater Resource Potential of Kobo Valley

The annual dynamic groundwater potential in Kobo valley as calculated using Chloride mass balance method is 68.9 MCM [8]. Similar to Raya valley, the groundwater recharge is mainly concentrating in the alluvial deposit in the valley floor. Recharge takes place in the same way with Raya valley. The total number of wells extracting groundwater is not well known. It is difficult to know the planned or current groundwater abstraction to compare its impact on the sustainability. Sixty four boreholes with a potential total yield of 74 MCM per year are inventoried but more were under construction during this research work. If we assume eight months operation for 12 hours a day the planned abstraction from the inventoried wells is equivalent to 24.6 MCM per year. The sustainable yield from this valley will be much higher as the major river is perennial and dependent on the groundwater discharge. The development of new irrigation well should take into account the possible negative impact on the surrounding surface water resources.

The groundwater reserve for the alluvial aquifer in the Kobo valley with areal coverage of 417 km^2 comprising 70% confined and semi confined aquifer and 30% unconfined aquifer can be estimated by considering the storativity for confined aquifers to be 0.003 and specific yield for unconfined aquifer to be 0.19. The saturated thickness is estimated to be 95 meter. The total storage is 2331 MCM.

2. Methods

To achieve the above mentioned objective all the existing relevant primary and secondary data of the valleys were collected, analysed and interpreted. Data that were generated in the previously done groundwater related activities were collected from different sources in Addis Ababa, Alamata, Mehoni and Kobo (Figure. 1) whereas first hand data were collected during the field investigation.

Field investigation and compilation of existing studies were used to estimate the groundwater resource of the area. The groundwater resource exploitation was assessed on field by direct communication with the farmers and the responsible district professionals. The impact of the groundwater based irrigation on food security issues was assessed using informal and formal interviews and focus group discussion with District Administrators, Woreda Agriculture Office, Woreda Food Security Office, Woreda Water Offices, WUAs (water user cooperative associations), individual farmers and by directly observing the living condition on the spot. Furthermore, discussions were held with agriculture extension agents in the district (Woreda is local name for district).

3. Results

3.1. Food Security versus Irrigation Development in Raya-Kobo Valley

The study area comprises three districts, locally called "Woreda": Alamata, Raya Azebo, and Kobo. Two of them, Alamata and Raya Azebo, are in Raya valley whereas the third one is in Kobo valley.

3.2. Kobo District (Woreda)

In this woreda, the potential irrigable area is about 20000 hectare. Up to June 2012 a total of 64 deep wells have been drilled by governmental organization and investors for this purpose. Out of these drilled wells 92.2 % was drilled by the governmental organization and the remaining 7.8 % was by investors. All the wells that were drilled by the investors are currently functional and used as a source of water for irrigation. In those wells that were drilled by governmental organization, however, only 28.8% of the drilled wells are functional and serving as a source of water for irrigation. For the remaining 71.2% the required works that make them to serve as a source of water are under construction. All the functional wells, both governmental and investors together, at present irrigating an area less than 1100 ha. Around ten thousand people are benefiting from this intervention.

The district has 41 smallest administrative units, locally called 'Kebeles', and all of them are found in the rural areas. Even though the use of groundwater as source of water for irrigation was started since 2005, all these rural Kebeles up to June 2012 are registered as food insecure.

The safety net program which is designed as a social welfare for rural community registers families which are in need of support. For someone to be considered in safety net his annual productivity should be less than six months consumption.

According to the statistical data collected from the food security office, out of the total population of 202262, 51550 peoples are supported by the Productive Safety Net Programme (PSNP). The Productive Safety Net Programme (PSNP) in Ethiopia is aimed at enabling the rural poor facing chronic food insecurity to resist shocks, create assets and become food self-sufficient [11].

In the Kobo valley, the Productive Safety Net Program (PSNP) has two components: the direct support and public work components. In the direct support program those community members who are not able to work because of age and health condition are registered. Accordingly, out of the total safety net beneficiaries, 5946 are in the direct support and the remaining 45604 are in the public work component. In the past years between 2008 and 2012, those farmers included in the irrigation schemes graduated from PSNP are being certified as food secured.

3.3. Raya Valley - Alamata Woreda

In this area government led groundwater irrigation is there since 2008, only 6.9 per cent of the total drilled wells were utilized for this purpose till the end of 2012, and the remaining 93.1 were nonfunctional due to different reasons. Even though the potential irrigable area in Alamata is 16575 ha [12] up to the end of 2012, only 180 ha was developed through irrigation using these functional deep wells, and 588 peoples were benefited from this scheme. Albeit an irrigable land of 1700ha is given to the investors, only 30 ha land is irrigated up to the end of 2012 using two deep wells. However, it is so slow, deep well groundwater irrigation has increased from less than 20.5 ha in the year 2008 to 210 ha in the year 2012.

Alamata has 14 rural Kebeles and one rural town. All of them have peoples who are enlisted in the safety net program. There were 49990 beneficiaries in the safety net program at the initial stage. In the past years between

2008 and 2012, 3794 households graduated from PSNP because of the intervention of the groundwater based irrigation.

3.4. Raya Valley - Raya Azebo Woreda

Like Alamata, government led groundwater based irrigation practice is there since 2008, only 5.4 % of the total drilled wells were served as a source of water for this purposes till the end of 2012, and the remaining 94.6% were nonfunctional due to different reasons. Using these functional deep wells 92 ha were covered by irrigation and 144 peoples were benefited from this scheme. Out of the 2128.35 ha given to the investors, 324.5 ha was utilized for irrigation using five deep wells till the end of 2012. The potential irrigable area in this part of the valley is about 19880 ha [11]. Although, it is so sluggish, deep well groundwater irrigation has increased from 76.8 ha in the year 2008 to 416.5 ha in the year 2012.

There are 20 Kebeles in the woreda, and all of them are food insecure. The total population of the woreda is about 127000. Out of these the total beneficiaries of the PSNP at the initial stage was 64213. Between 2008 and 2012, 4480 households graduated from PSNP because of the intervention of the groundwater based irrigation.

4. Discussions

The agency/department managed, farmer-managed or the community managed schemes and public-beneficiary managed are the different management styles associated with government-led irrigation schemes [13]. *With the exception of the very few areas that are owned by investors, i*n the study area the major groundwater irrigation schemes are government-led and are managed by the beneficiary farm households via their WUAs (water user cooperative associations). Each cooperative association is administered by irrigation committee which consists of five to seven executive members. In each cooperative 50 to 100 households are involved.

Even though utilization of groundwater for irrigation is implemented in Raya-Kobo valley before five years, the study area is still known as one of the food insecure area. This is mainly because the rain fed farming is still the one that plays the major role in the agricultural production. Dependence on rain-fed agriculture not only reduces productivity but also greatly increases growth volatility of the agriculture sector and the vulnerability of the poor [13]. Contrary to the huge land and groundwater resource potential, food insecurity is still the major problem in Raya-Kobo Valley.

In Raya valley government is highly engaged in the development of groundwater. However, drilling of boreholes was not accompanied or immediately followed by the essential extension works, which makes the drilled boreholes being an active water sources for the purpose that they were drilled. Because of these only 6.25% the total drilled boreholes were functional at the end of 2012 and the remaining 93.75% were found closed and idle. Management of utilization of the groundwater, management of the functional boreholes and of the irrigation schemes are left to the farmers. As it was mentioned above farmers are managing all these by themselves as cooperatives. One of the major problems for the administrative body of the cooperatives is a breakdown of pump that happened sporadically here and there. Lack of technical knowledge of the irrigation committee, lack or absence of immediate assistance from the concerned body, lack of immediate access to the technicians and lack of spare parts makes the repair services difficult and time consuming. As the maintenance duration takes more and more time the farmers will be forced to depend only on the rain fed agriculture and this exposed them to food insecurity since the rainfall is unreliable and erratic. Frequent breakdown of motor pumps (scheme machinery) is a common problem in any irrigation scheme that use groundwater as source, and if it is not get an immediate solution it becomes a major problem to the sustainability of irrigation systems. This is a case of Raya valley groundwater based irrigation scheme.

Absence of responsible governmental or government affiliated office in the management of utilization of the groundwater, management of the functional boreholes and of the irrigation schemes, the delay in the extension works on the drilled boreholes, failure of pump, and the long time taken for pump maintenance are the major factors that exert an obstacle to the proper implementation of groundwater based irrigation and its sustainability in Raya valley. Due to all these problems plus limited area coverage of the irrigation scheme, the groundwater based irrigation is not yet able to set the farmers free from food insecurity, which is highly related to the availability of water in the area.

In Kobo valley, unlike the Raya valley, the cooperatives get full support from the regional government through an office called"Kobo-Girana Valley Development Office".The office was established with the aim of enhancing food security through irrigation development in the Kobo-Girana valleys, and it has been operating in the area since 1999 [6]. Development of groundwater, management of functional boreholes, groundwater utilization and management of the irrigation scheme are all managed by this office.

Even though the office is there since 1999, the area covered by irrigation, excluding the area irrigated by investors (less than 520 ha), is less than 580 ha, which is less than 3% the potential irrigable area in the valley; indicating the sluggish rate of the implementation of the groundwater based irrigation in the area. Moreover, the drilled boreholes are not used immediately after construction for the purpose they were drilled. The extension work is found taking more time than what is allocated for it. Pump maintenance is not a problem to the cooperatives since it is handled by the office. Consequently, sustainability is not an issue.

In the Kobo valley, even though, the presence of responsible office maintains sustainability of the irrigation systems, still the valley has peoples that are food insecure. This mainly attributed to the limited area coverage of the project as compared to the total irrigable land in the valley and the long time taken for the extension works in those drilled productive wells.

5. Conclusions

The groundwater resource potential of Raya-Kobo area is in excess of 198 Mm^3 as confirmed by several studies and subsequent drilling operations carried out in the past. There have been more studies than the implementation of projects. The main challenge revealed in this study is the failure to utilize this huge water resource potential due to various reasons to alleviate poverty by reducing the number of population dependent on the safety net. As a result, food security and livelihood improvement still remains as a major problem.

Absence of responsible office, the very long duration taken for the extension works, failure of pump, and the long time taken for pump maintenance are the major factors that exert an obstacle to the proper implementation of groundwater based irrigation and its sustainability in Raya valley. Due to all these problems plus limited area coverage of the irrigation scheme, the groundwater based irrigation is not yet able to set the farmers free from food insecurity.

Limited area coverage of the project as compared to the total irrigable land in the valley and the long time taken for the extension works in those drilled productive wells are the major limitations in the Kobo valley that makes the groundwater based irrigation unable to release the farmers of the area from the food insecurity.

In Raya-Kobo valley food security is highly related to the availability of water. Therefore, increasing the availability of groundwater to the users and maintaining sustainability of the irrigation scheme are highly indispensable in successfully transferring the beneficiaries of Safety Net to become food self-sufficient.

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