Traditional Rainwater Harvesting Systems for Food Production: The Case of Kobo Wereda, Northern Ethiopia

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1. Introduction

1.1 Background

Agriculture is the major economic activity in Ethiopia, which provides about 46% of the GDP, 80-90% of the export revenues and employment for over 80% of the population (Asmare, 1998). Consequently, many a number of scholars and policy makers strongly underscored the fact that Ethiopia is and will remain for a long time to come as a predominantly agricultural nation and maintained that agriculture is the one area from which the country can reasonably expect significant economic development in the foreseeable future (e.g. Levine, 1965; FAO, 1986; FDRE, 1997, 2000, 2002). However, the Ethiopian economy has exhibited either stagnation or a very slow growth rate during the last three decades and this is most pronounced in agriculture. The yearly growth of food production in the country couldn't exceed 1% for several years while the average annual population growth rate is 3%. As a result, there has been chronic food shortages and drought induced famines have been common phenomena in the country during the past few decades (Asmare, 1998).

In the last two decades in particular, Ethiopia has been a regular recipient of food aid from international aid sources. One of the latest estimates shows that about 52% of the country's population is food insecure, facing chronic and recurring disaster-induced food shortages (Dagnew, 2000). According to the estimation made in 1995/96, on the whole, 45.5% of the Ethiopian population is living in absolute poverty, with a relative coverage of 47 and 33 percent of the rural and urban populations respectively (FDRE, 2000). Since the rural areas account for about 85% of the country's population, poverty is primarily a rural phenomenon. In Ethiopia, an average of only 25% of the population is supplied with potable water which is only 19% in rural areas; while the sanitation is in much worse condition where 92% of the population do not have access to adequate sanitation facilities (Anonymous, 2002).

The country's chronic food insecurity problem is the result of cumulative effects of various factors that have been increasing in magnitude over many years. According to Dagnew (2000), some of the major factors contributing to the current food insecurity include widening gap between the level of food production and the rapid population growth, degradation of natural resource

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base, dominance of crop farming which is exclusively dependent on rain-fed cultivation together with erratic and unreliable nature of the rainfall pattern that led to poor performance of the agricultural production.

The natural resource bases of Ethiopia seem to have a potential of supporting a far greater number of population (MoWRD, 2000, Ephraim, 2001). Nevertheless, use of these water resources to meet the socio-economic needs of the country and its people are very limited due to various constraints. The major limitation lies in the uneven distributions and mismatch of the available water resources with respect to the agro ecological and settlement patterns in the country. Moreover, despite Ethiopia's plenty annual rainfall on the aggregate, it falls either too early or too late with a characteristic high intra- and inter-annual variation in quantity as well as in terms of the spatial and temporal distributions of the seasonal rainfall.

Annual rainfall in the country ranges between 2700 mm in the South-Western highlands and less than 200 mm in some parts of the Northern and South-Eastern lowlands with a further decrease to 100mm in the North-Eastern lowlands. The Southern, Central, Eastern and Northern highlands of the country have a bi-modal rainfall pattern while the South-western and Western areas are characterised by a mono-modal rainfall. Ethiopia has five major agro-climatic zones, which are broadly defined on the basis of altitude ranges (Hurni, 1986). These are *Bereha* (< 500 meter above sea level [m.a.s.l]), *Kolla* (500-1500 m.a.s.l), *Weyna-Dega* (1500-2300 m.a.s.l), *Dega* (2300-3200 m.a.s.l) and *Wurch* (>3200 m.a.s.l). Because of the favourable climate and absence of many tropical diseases, the highlands of Ethiopia are favoured for settlement. The Ethiopian highlands (areas above 1500 m.a.s.l) harbour about 88% of the human and 65% of the livestock population (Hurni, 1986).

As the population density in the highland areas continued to increase more and more marginal lands were put under cultivation which eventually resulted in the severe degradation of the agro ecological resource bases and declining agricultural production. Consequently, population expansion increased towards the extensive lowland (Arid and Semi-arid) areas. Unfortunately, these areas are usually constrained by, among other things, shortage of rainfall for optimum agricultural production. This calls for the use of suitable technologies for improved and sustainable agricultural production (MoA, 2001). Available information indicates that nearly 70% of the total arable land in Ethiopia receives annual rainfall of less than 750mm. The areas with annual rainfall of 500-750mm are believed to support optimum level of agricultural activities, if the annual rainfall distribution is undisturbed and proper land management is applied. As of late, however, the annual rainfall distribution of most parts of Ethiopia, including the highlands, is not only lacking in uniformity but also highly unpredictable in its inter annual variations (MoA, 2001). Therefore, overcoming the limitations of these Arid and Semi-arid areas and making good use of the vast agricultural potential under the Ethiopian context, is a necessity rather than choice, which needs for appropriate intervention to address the prevailing constraints.

Research findings in many countries and traditional farming practices suggest possibilities for making use of areas with annual rainfalls as low as 200mm. This is achieved through applications of different technologies that can improve efficiency of moisture utilisation, which, if used at the right setting, can improve situations. These include, among other things, improved water control and rainwater harvesting. For the risk-prone areas such as those affected by recurrent drought, the main opportunities for improving water use include small-scale irrigation, rainwater harvesting and, above all, the better use of available moisture in the rain-fed farming systems on which the bulk of farmers continue to depend (MoA, 2001).

Rainwater harvesting, in a broad sense, is the collection of the raindrops/runoff for domestic consumption and/or food production purposes, which will otherwise cause soil erosion. It could also be described as an act of maximising utilisation of the available rainfall by making use of different techniques. Given the good potential of Ethiopia's agro climatic resources, the prevailing limitations in terms of rainfall distribution and amount could be effectively addressed if rainwater harvesting is seriously taken. Applications of rainwater harvesting techniques, however, are constrained by the limited availability of information on the technologies and relevant traditional practices, lack of resources to conduct local specific researches on performances of available techniques and inadequate attention to avail and promote suitable extension packages to the end users. In Ethiopia, only little has emerged from research that is suitable for marginal and drought-prone areas, as few resources have been devoted to this topic, perhaps reflecting the low perceived profitability of such investment (Ephraim, 2001).

1.2 Overview of RWH in Ethiopia

Over centuries, generations of farming communities in Ethiopia have evolved different farming technologies that can provide a basis on which to build improved land husbandry. Having been descendants of one of the earliest communities who began settled agriculture, Ethiopian farmers have been known for developing amazing varieties of agricultural technologies to suit different situations. A number of examples exist to indicate the immensely rich experience behind the traditional Ethiopian agriculture. For a long time, development and research institutions have failed to give enough attention towards addressing the rigorous demands of risk minimisation in these semi-arid areas. Nevertheless, farming communities in those areas have managed to deal with their environmental constraints through different locally innovated technologies and adoptive socio-cultural set-ups. These include the traditional soil fertility management practices, flood harvesting and in-situ moisture conservation. Such traditional farming practices and local innovations deserve adequate attention in order to use them as the bases for the research and development endeavours aimed at addressing the constraints of agricultural production, and thus, make use of the enormous agricultural potentials of the arid and semi-arid areas.

In Ethiopia, there are evidences that ancie00nt churches[4], monasteries and castles used to collect rainwater from rooftops (Habtamu 1999). According to the same source, history of rainwater harvesting in Ethiopia dates back as early as 560 BC by the Axumite Kingdom. During this period rainwater was harvested and stored in ponds for agriculture and water supply purposes. This is evidenced with documented literatures and visual observations on the remains of ponds that were once used for irrigation during that period. Furthermore, a roof water harvesting set up still exists in the remains of one of the oldest palaces in *Axum*. Other evidences include the remains of one of the old castles in *Gondar*, constructed in the 15 -16 century which has a pond built for rainwater harvesting for drinking and religious rituals by the kings. Also by king *Lalibela* (over 800 years ago), ponds and underground water storage tanks were used both for drinking and religious rituals within the system of rock-hewn churches that have existed up to now. The excess water management (drainage) of the rock-hewn churches is also impressive.

Even to this day, there are several traditional rainwater harvesting technologies in Ethiopia, which have been used by communities in areas of water shortage since long ago. For many traditional communities in rural areas where natural sources of water are lacking, collection of rainwater from pits on rock outcrops and excavated ponds are common practices. With the introduction of corrugated iron sheet roofing as of the turning of the last century, houses are fitted with gutters to collect rainwater that is stored in makeshift collection facilities like oil drums. In Ogaden area of Eastern Ethiopia, *Birkas* are used for storage of rainwater (Ibid.).

In Semi-arid lowland areas where rainfall is not adequate for crop growth, farmers use runoff irrigation as a source of a few lifesaving irrigation supplies. Runoff irrigation is widely practices in the Chercher plains around Mahoni and Waja near Alamata in Tigray, the Gato valley in North Omo, parts of Eastern and Western Hararghe, and many other places. The practice in the Gato valley also includes use of ridge ties to retain the moisture around the plants. Similarly, the people in Konso, Gidole and many other parts of the former Gamo-Gofa region have been exercising the art of conserving soil and water. This traditional rainwater harvesting techniques use the soils as a media, particularly using bench terraces and trash lines on their cultivated lands (Kruger et al., 1995; Habtamu, 1999).

In Gidole trash lines are constructed as grid system. The main lines (bigger trash lines) are constructed along the contour using maize and sorghum straw. However, the spacing and the material (straw) applied vary with in an individual plot. The technique is usually combined with ridges and commonly

[4] **Christianity was introduced to Ethiopia around 300 AD - i.e. during the** Axumite **Kingdom, which explains the existence of churches and monasteries since the ancient times.**

applied on maize and sorghum fields. The technique many purposes but the main emphasis is rainwater harvesting. According to the work of Kiruger et al. (1995), conservation based arable farming at farm level in Konso is coined to the strategy of production oriented water harvesting techniques. The technique is applied from the lower to the upper slope positions and it forms a belt (crops are grown along the belts) in the catchment. The technique accommodates different kinds of physical and biological/agronomic conservation measures. The conservation strategy applied is targeting on rainwater harvesting and maintenance of soil fertility. Examples of measures that have been used for rainwater harvesting are level bund, micro basins and trash lines.

In eastern Ethiopia (Hararghe), farmers construct stone bunds for different purposes. In areas where fields are stony, farmers clear the fields of stones and lay them along the contour so that they can plough. In other cases, bunds are deliberately constructed for soil and water conservation purposes. Stone bunds are also used to retain or slow down run-off and to prevent erosion. Their impact on crop yields owing to the increased moisture infiltration and the decrease in nutrient loss is particularly pronounced in the relatively drier areas (Asrat et al, 1996).

In Ethiopia, promotion and application of rainwater harvesting techniques as alternative interventions to address water scarcity were started through government-initiated soil and water conservation programmes. It was started as a response to the 1971-74 drought with the introduction of food-for-work (FFW) programmes which were intended to generate employment opportunities to the people affected by the drought. The earlier rainwater harvesting activities included, among others, construction of ponds, micro dams, bunds, and terraces in most parts of the drought affected areas in Tigray, Wello and Hararghe regions (Kebede Tato, 1995). Since then, however, the interventions have been extended to the other parts of the country with varying levels of coverage. Most of these undertakings were conducted through FFW and mass mobilisation. Although the level of attention had been gradually declined until recently, the relevant government agencies seem to resume their interest on rainwater harvesting as of late.

Recently, the Ministry of Agriculture of the FDRE has launched the national agricultural extension programme some years back. Water management, in particular rainwater harvesting, was mentioned in the programme document as one of its packages contained in the extension system (PADETES) that has been designed to enable attainment of food self-sufficiency (Belay, 1999). Relevant interventions in this regard have been included in the Soil and Water Conservation Action Plan (2001- 2006) of the Ministry. The action plan objectives are focused according to the rainfall regimes of the target areas such that specific technologies are designated with respect to the interventions for moist and moisture-stressed areas. The rainwater harvesting interventions intended for moisture-stressed and pasturalist areas include both on-farm rainwater conservation and off-farm rainwater harvesting (MoA, 2001).

Non-Governmental Organisations involved in IRDPs and the Water Sector in many parts of the country also undertake rainwater-harvesting interventions. These interventions include conservation of rainwater by making use of physical structures (e.g. soil bunds, terraces, …etc) and rainwater harvesting for domestic and irrigation purposes through pond and micro-dam construction and roof catchment schemes.

2. The Case Study

2.1 Location and Characteristics

The case study was conducted in *Ayub* and *Jarota Kebele* Administrations (KAs), located in *Kobo Woreda* along the Northern boundary of the *Amhara* National Regional State in Northern Ethiopia. In terms of geographic co-ordinates, the study area is located within the Gobu watershed described by 12°10′ and 12° 13′ North Latitude and 39° 22′ and 39° 33′East Longitude. The highway from Addis Ababa to *Mekele* crosses *Ayub* and *Jarota*. They are bordered by the *Gobu* River to the North, *Bereha-mariam* and *Shewoch* KAs to the west, *Gedeba, Bewa* and *Mendefera* KAs to the South and *Mesno Kelewa* to the east. The administrative centre of the *Woreda, Kobo* town, is situated 9 and 18 kms south of *Ayub* and *Jarota* respectively and its distance from Addis Ababa is 570 kms (See Figure 1).

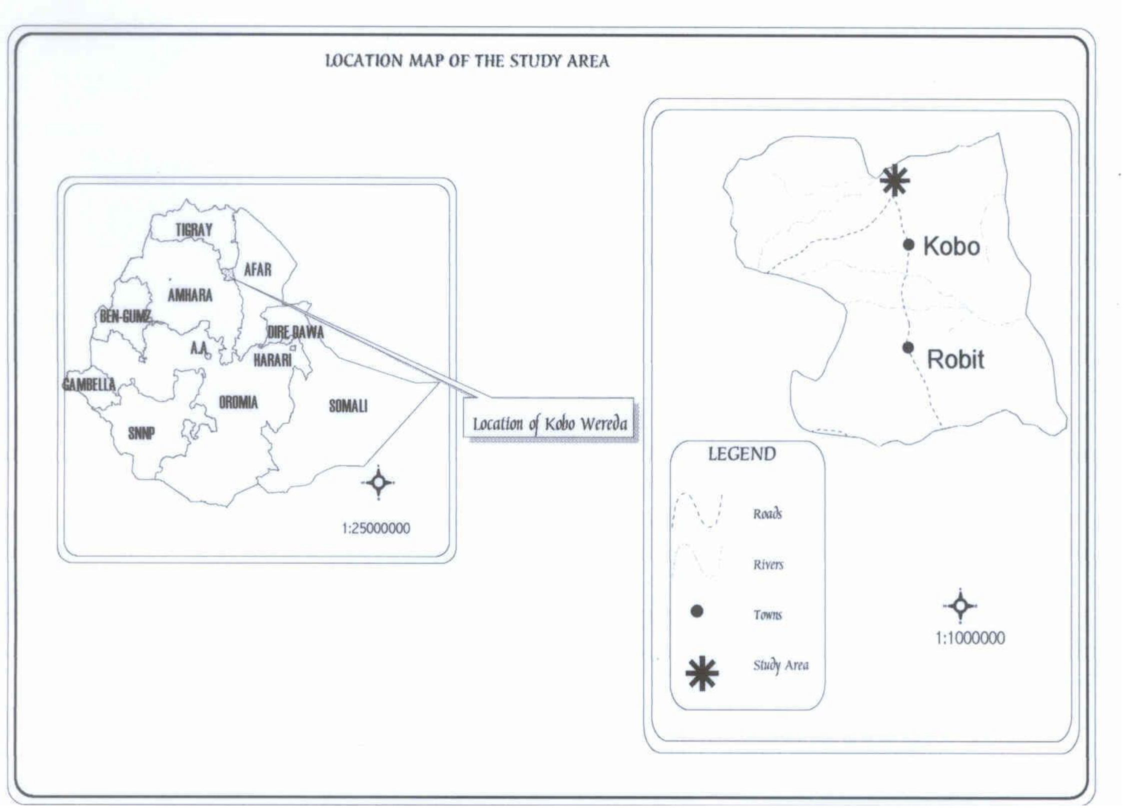


Figure 1: Location map of the study area [*Source: Soil Conservation Research Project Database (MoA, 1995)]*

Figure 2 shows the pattern of temperature, rainfall and evapotranspiration based on based on the data from the nearest meteorological station at *Kobo*. The highest long-term mean monthly rainfall is 197 mm in August while the lowest mean monthly rainfall is 10 mm in December. Mean maximum temperature of 34^0c and mean minimum of 12°c for June and December respectively. based on records of the nearby meteorological stations at *Kobo* Station for June and December respectively. The rainfall pattern is bimodal, i.e. the short rains (*Belg*-April and May) and long rains (*Kiremt*-July and August). The hottest and coldest months of the study area are May-June and November-December respectively. Regarding the rainfall distribution within and surrounding of the study area, the highest usually occurs during mid July to mid August. During the rest part of the year, the area experiences a varying degree of moisture stress with deficiencies reaching a highest level of over 155 mm (June) during which crops require a good level water/soil moisture availability for optimum production. In light of the monthly potential evapotranspiration (PET), sustainable agricultural production is only possible under supplementary floodwater irrigation.

The description of the soils of the *Ayub* and *Jarota* area is based on the information extracted from 1:500,000 scale soils map of Environmental Assessment and Sustainable Landuse Plan for North *Wollo* (DHV, 2001) and the transect walk during PRA study. According to the 1:500,000 scale soils map of Northern *Wollo* (DHV*, 2001*) the soils of the study area are mostly the result of the processes recent alluvial deposits and mainly occupied by Eutric vertisol/Eutric fluvisol soil association type. The types of soil observed in the *Ayub* area during PRA study are mainly clay and sandy loam by texture, and black and grey by colour. The type of soil observed in *Jarota* area during PRA study is sandy loam by texture and grey by colour.

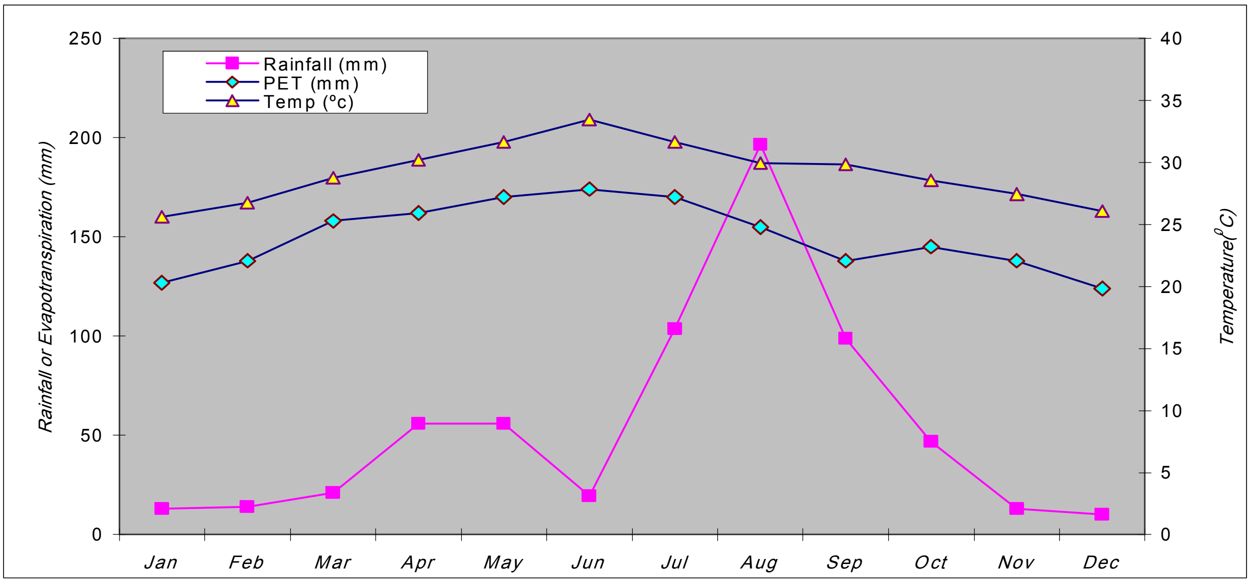


Figure 2: *Patterns of temperature, rainfall and evapotranspiration in Kobo area*

Source: Kobo-Girana Valley Development Programme, ANRS, 1999.

According to the PRA participant farmers, soil degradation in the study area commonly manifests itself as soil fertility decline. The major indicator of soil fertility decline, as cited by participant farmers during the study, was a decreasing trend of crop yields from time to time. However, there are no significant surface erosion features on farmlands at present. On the other hand, riverbank erosion is becoming a serious problem as cultivated fields are getting closer to the edge of the river, slumping of soil mass and thus eating towards the farm lands from the river bank side has been observed as a serious threat at present. Therefore, unless appropriate and timely measures are taken to reverse the trend, the riverbank erosion could possibly cause significant loss of the cultivated land adjacent to the river course.

The major sources of water for livestock and household consumptions are: rivers, streams, ponds and hand pumps (bore holes). In most cases, these sources dry up during dry season. The only dependable and permanent source for *Jarota* KA is *Waja* river, located at about 2-4 kms distance, and it serves as a major source of drinking water as well, whenever failure of hand pumps at improved water supply schemes occurs. In the study area there are a number of ponds and dug wells although most of the latter are not functioning. Many people get water from ponds (*Haroye`e*) and river for both home and livestock consumption. The seasonal runoff water from *Gobu* river is diverted into the cultivated lands and constitutes the major source of water for agricultural activities in *Ayub* and *Jarota* KAs. The periods during which sufficient runoff is flowing in *Gobu river* are *Belg* (March - April) and *Kiremt* (July - August) seasons as shown in Figure 3.

The high population density in the study area and the consequent necessity for expanding cultivated land, together with the increased need for firewood and construction poles, have led to an almost complete cutting down of trees and bushes in the low lying parts and on the adjacent mountain slopes. As a direct consequence, considerable erosion damage occurs on the up slopes during rainy seasons. After heavy rainfall, the water in the rivers flow off within a short period, the cultivated lands adjacent to the river courses get flooded and large quantities of stones, gravel and silt are deposited on the flooded fields. With the riverbeds becoming shallower and frequently changing their courses as a result of sedimentation, still more arable land is destroyed every year. In some instances, sediment deposits may be beneficial to farmlands, as these will also bring fertile soils from upland areas. However, more frequently deposits of sands, gravels and boulders brought along with the flood have a rather damaging effect on farmlands. As observed during the study, agricultural land losses are much greater at the upper slope areas than downstream. Every year, there are repeated incidences that the nearby town of *Waja* gets flooded and some of the bridges on the Addis Ababa - *Mekele* highway are overtopped or destroyed with frequent occurrences of temporary traffic blockades.

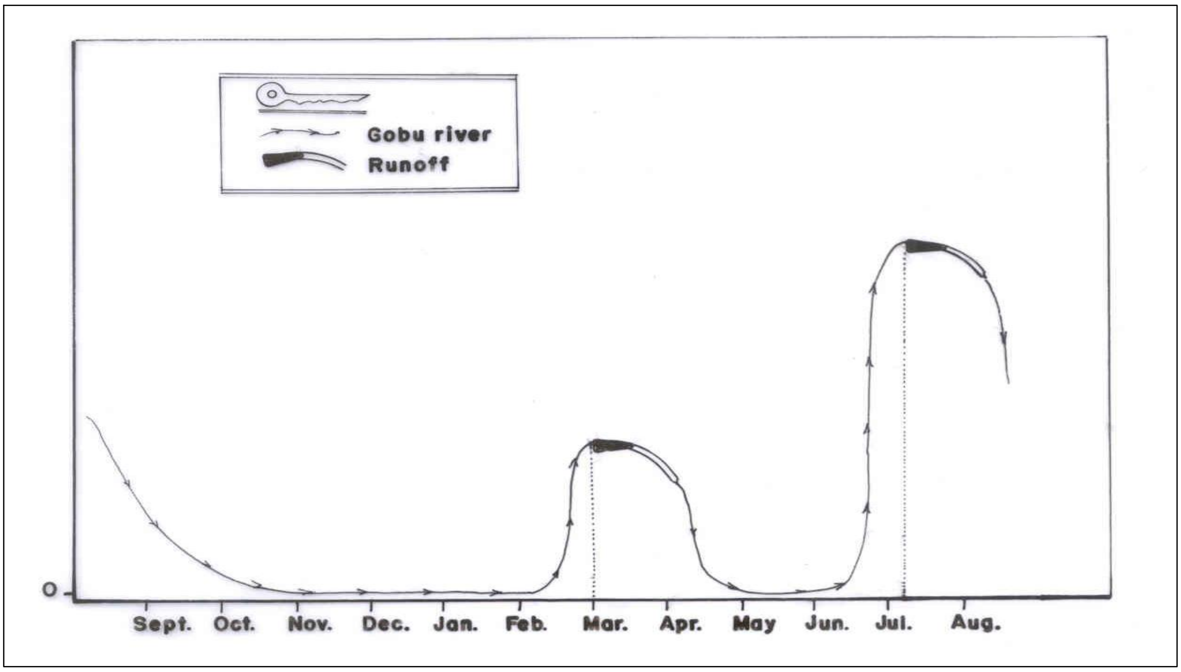


Figure 3 Runoff Water flow pattern in *Gobu* river [*Source: PRA* Report, *December 2001]*

1.2 Land use and land productivity

The land use and the vegetation pattern of the study area are greatly influenced by its semi-arid to arid or dry *Kolla* agro-climatic conditions. The dominant land use patterns in *Ayub* KA are cultivation (75 %) and bush/woodland (16 %), while in *Jarota* KA over 95 % of the land is under cultivation (Figure 4). In general, the current land use system of the area and its surrounding can be described as intensive cultivation. The types of crops grown in the KAs are sorghum, t*eff,* maize, chickpea and pepper. Sorghum is the dominant crop type in both the KAs. According to the information extracted from a 1:500,000-scale land use/cover map of Northern *Wollo* (DHV*, 2001*), the study area is characterized by intensively cultivated land use. The PRA exercise also confirmed that about 95% of the study areas are under intensive crop cultivation. The farmers practice the cultivation of sorghum, maize and pepper using rain and simple runoff diversion techniques from *Gobu* River. There is no any significant forest or bush cover in the area. However, a few trees of *Ziziphus spina-christi*, *Balanites aegyptica*, *Ephorbia tirucalli* and *Acacia* species were observed scattered in the field.

As per the comprehensive land reform proclamation, declared in 1975, "*land is a collective property of the Ethiopian people*" or rather a state property. Land thus acquired by the community was distributed to any person who is willing to cultivate land for his personal maintenance and that of his family. Consequently, all farm households in the study area, as in the rest of the country, had been entitled to use their holdings but not allowed hiring (let for renting), mortgaging or selling it. Each family is allocated land from different land use types (e.g. hillsides, plains, irrigable … etc) and most community members generally acknowledge the equity of land allotment in their respective KAs. The average land holding size, however, varies from one KA to another due to the difference in the available land resource and the population size among the different KAs. For example, the study indicated that the average land holding size in *Ayub* KA is about 7 *'Timad'* (equivalent of 1.75 ha), while it is only about 4 '*Timads'* (1 ha) in *Jarota* KA. In connection with this, however, there is an obvious trend of shrinking land holding from time to time which has already been below the optimum holding size to provide a living with the available technology being used by the community.

Besides the available land resource which forms the basis of the livelihoods of the farm households, other resources that influence their well being include labour, power source, cash, organisations access to credit, markets and other infrastructures. Most farm activities are done by family labour. The study indicated that average family sizes in the two KAs are 4.5 persons. Farm operations are usually seasonal with peak periods of labour demand during such activities as weeding and harvesting which lie between July and December. Although most farm households are dependent on family labour, hiring of labour and traditional labour raising practices are also common coping strategies during peak periods of critical labour needs. *Debo*[5] and *Jige*[6], for example, are the common traditional labour raising practices, which involve different reciprocal arrangements among farm households. The only power source for ploughing is oxen power. However, not all households are endowed with oxen. Subsequently, farm labour productivity in the study area shows wide variation. The study indicated that 46% and 51% of the households in *Ayub* and *Jarota* KAs respectively don't own any ox. Land preparation for crop production is carried out using oxen-drawn traditional plough, the '*Maresha*'. This method of ploughing needs a pair of oxen to pull the *Maresha*. Subsequently, a farmer that owns a single ox has to join with another farmer and take turns to use the pair. Those who couldn't find mutual partners or don't have any ox make some type of rental arrangements for which they may pay in terms of labour, grain or letting partial use of their plots.

The major sources of cash for farmers in the study area are sales of crops, animals, animal products, seasonal employment and sale of forest products (as fuel wood, construction poles and farming tools). However, animals are sold only in cases of crop failure or other equally important family problems. Farmers in the area organise themselves or let organised by the government for different purposes. They organise themselves for religious or social purposes and for pooling their resources together for productive activities. During the PRA, participant farmers identified different types of formal and informal organisations. Formal organisations established by the administration include *Kebele* Administrations (KAs) and Farmers' Service Co-operatives. Farmers' usually perceive these organisations as governmental institutions or establishments which continue to exist whether they like them or not. The informal community organisations, on the other hand, are formed to facilitate for socialising grounds and mutual co-operation among community members. Those for socialising and religious purposes include Idir (an association to assist each other during funerals and mourning) and *'Senbete'* for observing religious purposes. On the other hand, informal organisations for the purposes of mutual co-operation in productive activities include *Aba-Hagga, Debo* and *Jige*. The most influential informal institutional resource of the community is the *Aba-Hagga* which co-ordinates and manages the participation, utilisation and co-ordination of the flood-diversion system.

According to PRA findings, most farmers don't have access to formal credit services. However, some farmers targeted by the government's Participatory Demonstration and Training Extension System (PADETES) get certain

[5] '*Debo*', literally could mean "taking turns", is an institutionalised form of traditional co-operation among the fellow community members in the area whereby a group of neighbouring farmers take turns to work on each others' fields during certain seasonal farming activities when considerable amount of weeding or harvesting has to be done. '*Debo*' is a strictly reciprocating arrangement.

[6] '*Jige*' is sort of "an emergency call" made by a given family or household and involves all able persons in the neighbourhood community. It takes place when there is some type of an extra ordinary work such as constructing a new house, harvesting of crops for a family whose family head has been deceased ...etc. '*Jige*' is not readily reciprocated, but any one in the community participates from a '*Nege-beine*' (i.e. "Tomorrow could be my turn") feeling. In such cases, the family/farmer sends a word around so that, on a certain day, those who live around should come and assist at his place.

agricultural inputs, mainly chemical fertilisers and improved seeds on a partial credit basis from WADO. Nevertheless, most participants of the PADETES have been discouraged due to the strict requirement of settling their debts immediately after harvesting, which necessitates selling of their products at low prices. Local moneylenders or informal credit providers constitute the major credit sources in the area. The interest rates demanded by the local moneylenders, however, are too high to be considered as alternative means of raising productive resources. The interest rates vary depending on the season and range from 120% to 300% over the principal. The interest rates are usually higher during rainy seasons when many farmers are in need. As a result, farmers don't borrow money unless they are in serious problems. Small and big markets in the area serve as grounds of exchanging goods and information for the community.

PRA findings and other secondary data indicate that nearly 95% of the total land area in *Ayub* and *Jarota* KAs respectively is used for rainfed production of cereal crop. Consequently crop production constitutes about 60-90% of the household income (both consumption and sale) for the entire community in *Ayub* and *Jarota* KAs, as is also the case for most part of the people in Kobo *Wereda*. Sorghum, teff, maize and chickpea are the major cereal crops produced in the area, according to their order of importance. Sorghum and teff cover about 80% of the cropped area in both KAs and are used as staple food and cash source. Most farmers also produce chilli pepper for cash generation. The traditional favourite food, *injera* (circular shaped and thinly baked bread) is prepared from sorghum or *teff* and served with sauces made from either of chickpea, vetch or horse bean.

Improved farming practices such as use of fertilisers and improved seeds are generally lacking. A study report by KGVDP, covering the entire *Kobo-Girana* valley, indicates that only 3.4% of the total households use fertiliser and only 3% of the total land is fertilised. Similarly only 4% of the households use improved seeds with a total coverage of 3.8% of the cropped land. Consequently, average yields of the various crops in the area are very low. Except for sorghum, which attains about 13 qtls/ha, the average yields of most other cereal range from 7.7–9.8 qtls/ha. Farmers in *Ayub* and *Jarota* KAs have their reasons for not using fertilisers and improved seeds. Firstly, the land itself is fertile (*Muk-afer* or 'hot soil' as they call it) as it is supplied by fertile silt (alluvium) from the flood diversion every year and, if only the rainfall pattern is favourable, can give good production without applying expensive fertilisers. Secondly, they usually leave the crop residues purposefully and plough it in to maintain the soil fertility. Thirdly, given the unreliable rainfall pattern both in quantity and distribution together with the higher prices of fertilisers and improved seeds, farmers tend to avoid a likely risk of crop failure, which may leave them bankrupt. Moreover, farmers relate their discouraging experience of using improved seeds, which did not perform well under their moisture-stressed situation.

Prevalence of moisture stress and crop diseases are the main constraints of crop production in the area. The erratic and unreliable nature of the rainfall pattern in the area is the primary limitation of crop production. As a result, farmers usually experience poor grain yields or sometimes face a total crop failure. In some years, the rain comes early and in others very late, but commonly it ends too early. In order to cope with the moisture stress problem farmers have adopted different strategies including use of different RWH techniques and practices of appropriate land management methods (e.g. flood diversion, soil bunds, contour furrows and timing of tillage, … etc).

Most crops are attacked by pests and diseases including sorghum and maize (by stalk-borer, armyworm and other worms) and *teff* (armyworm and such insects locally called as *Fenta*, *Genbo* and *Burha*). Farmers apply traditional methods to control crop pests and diseases. For example, cutting affected plants controls stalk-borer and smoking leaves of a particular plant by a local name *'Merz'*. Excavating a ditch around affected (infested) plot checks armyworm from expansion to or attacking crops on adjacent plots. *Genbo* insects are controlled by hand picking and killing them. There are also other traditional methods such as adjusting sowing time depending on the crop type and the pests.

Livestock plays a significant role in the mixed farming system of the area. Their main contribution is in providing draft power, cash generation, food (e.g. milk for children) and as a status symbol. Livestock types kept by the farmers include cattle, sheep and goats, equines (donkeys and mules), camel and poultry. Oxen are kept to provide draft power, cows to provide farm households with milk and butter for consumption and sale, donkeys for transporting goods, whilst sheep, goats and poultry are mainly kept for sale. The feed resources commonly used by the farmers include natural grazing, crop residues and aftermath grazing. In the specific study area, the contribution of natural pasture as a source of feed is very limited due to the extensive coverage of the land by crops. Consequently, natural grazing for cattle in particular is limited to farm boundaries, and the lower slopes of the hillsides. Goats and sheep are, however, entirely fed from the natural grazing in the bushes and hillsides. Except for a couple of months, when natural grazing sources are available, cattle are usually stall-fed by using crop residues like wet/dry stalks of sorghum and maize and *teff* straw. The main sources of water for livestock during the rainy season are excavated ponds (locally called *Haroye'e*) and seasonal streams. These sources usually serve until some part of the dry season. During the latter part of the dry season, however, the livestock are trekked to perennial rivers located at distances up to 10 kms from villages. There are obvious signs that the livestock population in the area is much more than the optimum size, which the available feed resources can sustainably support. Besides shortage of feed, livestock production in the study area is very much constrained by animal diseases of various types.

1.3 Food security and coping mechanisms

As the livelihood of the entire community in the area is based on rainfed agriculture, the level of attaining food security primarily depends on the amount and distribution of the annual rainfall. The usual inconsistency in the amount and seasonal pattern of the rainfall as well as its inter annual variation constitute a major cause for the frequent failures of crops and scarcity of livestock feed. Consequently, the area has experienced repeated drought and famine which caused a great deal of human suffering and migration as well as considerable losses in human and livestock lives at its worst cases like the ones that occurred in the years 1974-75 and 1984. As a result, the area is among those affected by recurrent drought and famine of cyclic nature. Even during the 'normal' years, the food production is usually below the optimum level to ensure inclusive food security as it is constrained by different crop pests mostly associated with late on-set and early cessation of seasonal rainfalls. The complexity of the food insecurity in this area is particularly severe due to the limited resources of the exclusively subsistence production system of smallholder farmers to cope with the frequent disasters. Although there is an obvious disparity in terms of vulnerability, the capacity to withstand (accommodate) consequences of drought among the households of the different wealth category shows only little variation. This is mainly due to the fact that during an all out drought not only are the crops failing but also the livestock feed and water will be lacking. As a result, even the well-off households will not be able to use their livestock resources for copping purpose beyond a couple of months.

The communities in the area have their own coping mechanisms to deal with situations involving shocks/perturbations, which are incompatible to be accommodated within their available resources. Such situations of households could occur due to crop failure and/or livestock losses due to drought, pests and disease, or inability to meet the day-to-day living requirements by their available resources. Obviously, the extent of vulnerability to incompatible situations and their respective causes vary according to the well-being status of a given household. The corresponding coping mechanisms of households are also different accordingly. For those relatively better-off households, selling of livestock or other disposable assets could serve the purpose. On the other hand, poorer households usually lack such disposable assets and, therefore, employ different survival strategies (coping mechanisms) in order to balance their deficit in living requirements or to deal with other incompatible situations. The common coping mechanisms of poor households include renting one's plots for 1-2 years' period, employment as manual labourer, selling fuel/construction wood, producing wooden farm implements for sale and letting one's son (if able) to richer ones as a farm labourer or to tend livestock.

Other than intermittent relief food assistance provided by the GOs/NGOs in the events of major famines, there are no visible external interventions towards long term enhancement of the risk management capacity of poor farmers. As of late, however, there has been a government-initiated development programme, the *Kobo-Girana* Valley Development Programme (KGVDP), with a main objective of ensuring food security through development of the agriculture sector (both rain-fed and irrigated) as well as rehabilitation of the natural resources. Such interventions may contribute in augmenting the copping mechanisms of farm households in the area if designed to explicitly target the poor and follow all-rounded strategies to ensure sustainable livelihoods through reinforcing the traditional copping strategies of the poor people.

Traditional RWH practices including moisture conservation, flood diversion and spreading, as a substantial element of the farming system, constitutes a determinant factor of agricultural production. In short, availability and quantity of the floodwater makes a difference in annual production to the extent of whether a household harvests any crop or not. According to the PRA findings, sorghum yield in *Ayub* KA could be doubled with availability of floodwater, while in *Jarota* KA lack of floodwater may cause a total failure of sorghum crop. Similarly, pepper yields increase by up to 400% with application of floodwater. On the other hand, the availability and quantity of floodwater that may reach farm plots of households depends on the overall rainfall received in the upstream area and the soil moisture regime thus attained.

The agricultural production and productivity in the area are optimised as a result of the mutual complementarity between the flood diversion practice (flood yield) and the actual (in situ) precipitation on farmlands. By implication, absence or inadequate levels in either of them constrains/hinders optimum production levels. Despite its indispensable role in the food production of the area, the flood some times causes damage to the crops due, mainly, to the transported materials like boulders and gravel deposits on the low lying fields. Nevertheless, according to PRA participant farmers' views, such incidences are rare and do not cause water logging due to the nature of the soil. Moreover, the rare occurrence of flooding is not caused by the diversion structures (dikes), which are naturally controlled by being taken away with the river flow whenever larger flows occur.

3. Traditional RWH Systems

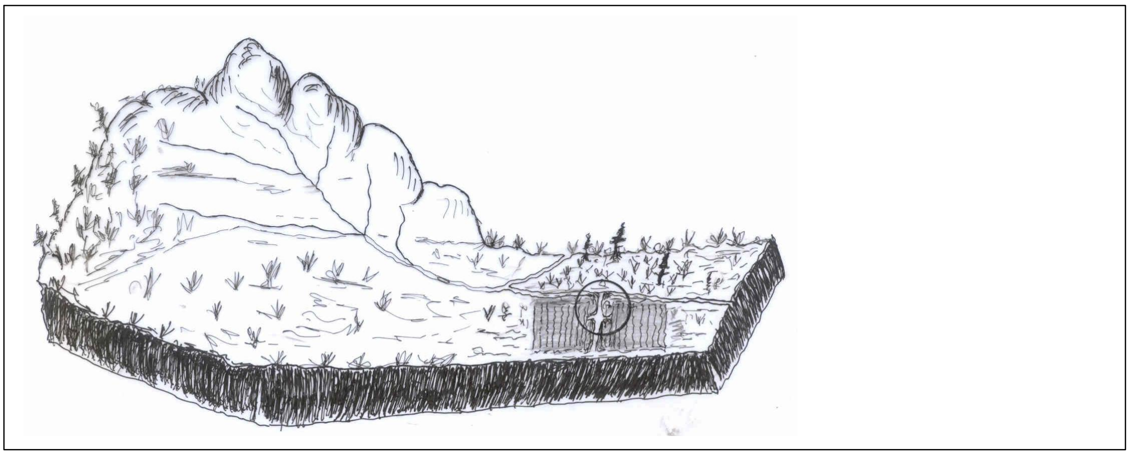
3.1 Types and purpose

The existing RWH technology has been practiced over many generations in order to cope with the inherent moisture stress on crop production. The technology is traditional in its origin, and was adopted and developed to its present level through experimentation and improvements made by generations of farmers. Being an essential element of the farming system in the study area, diverting runoff from the seasonal river (*Gobu)* to the cultivated lands is aimed at increasing the water available to the crops. The technology has been proven to be effective and sustainable for utilisation and management of rainwater for crop production in some parts *Kobo Wereda*. The traditional RWH system, which combine flood diverting, spreading and water conservation practices and processes at different levels in the farm include the *Mellée* - flood diversion from the seasonal *Gobu* river, ditches (i.e. contour, graded and netted) and *Harroye'e* (excavated ponds for livestock water supply). The *'Mellée',* which literally means 'Canal', refers to the flood diversion structure that leads the seasonal runoff in the *Gobu* river to the adjacent crop fields on either side of the river bank and constitutes an important element of the crop production. Rainwater harvesting technologies in general and runoff/flood diversions in particular are common practices by farmers in the area for various reasons. Primarily, the life-saving irrigation from the flood ensures optimum production of crops (e.g. sorghum) which otherwise can't survive under the prevailing moisture stress situation. Secondly, the technologies are 'home-made' which don't involve complications and high costs. Thirdly, the flood diversion and the other complimentary RWH techniques don't cause any threat or unwanted consequences to the land and the environment.

3.2 Flood diversion and spreading

Flood diversion is a technique that involves diversion of the floodwater from a seasonal river (*Gobu)* and directs it to the cultivated fields to supplement the rainfall received directly on the area. The main diversion canal is locally called '*Enat Mellée'* (i.e. Mother *Mellée).* The Mother *Mellée* starts as a small earthen embankment protruding into the flood course at an acute angle with a gradually curving and thickening build up that guides the flow to the cultivated fields. The Mother *Mellée* is further divided into '*Awraj Mellée* (Secondary Canal) and *'Tinishua Mellée' or* (tertiary/field canal) asshown in Figure 4. Once the water reaches *Tinishua Mellée* (field canals), it is spread on the cultivated land using different on-farm structures like bunds and *'shilshalo'* (contour/graded furrows). The excavated ponds, which serve for livestock watering are usually located in the downstream from cultivated land and supplied by the Mother *Melléé* and the excess drainage from the crop fields. There are also other in-situ techniques such as hillside and Fanya Juu terraces, which have been introduced lately.

Enat (Mother) ***Mellée***s (main diversion ditches) are constructed at a convenient angle across the riverbed slope in order to divert runoff/flood from seasonal watercourses and convey it safely to the *Awraj Mellée*s (secondary ditches). The longitudinal slope of the riverbed ranges from 1-3%, which is nearly uniform with minor irregularities all along the river course where the diversions take place.



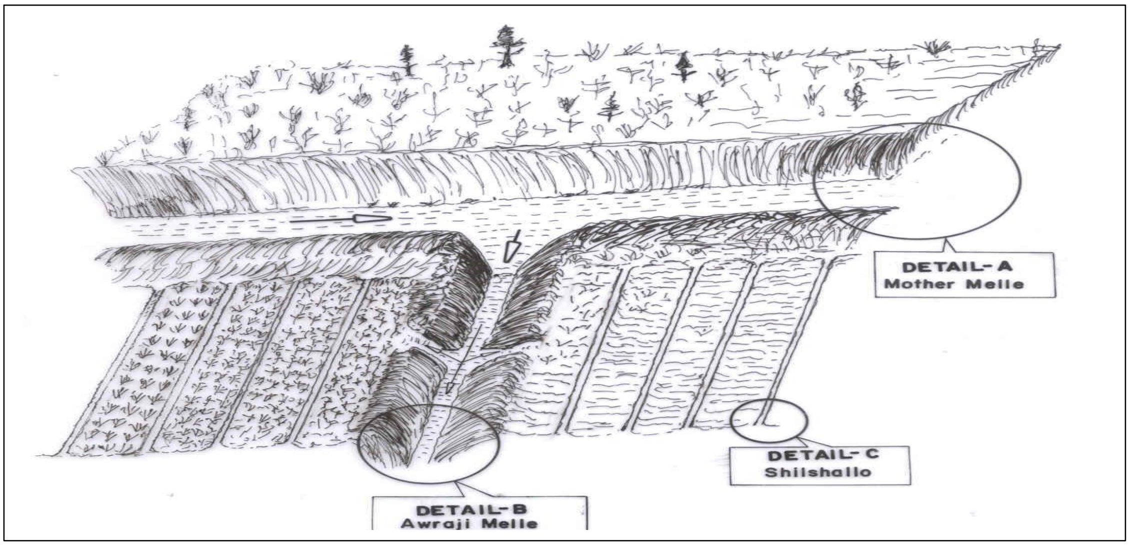


Figure 4: Schematic presentation of runoff/flood diversion system with the hierarchy of its elements

The usual height of the river bank (i.e. depth of the river bed in reference to the adjacent land at the points of diversion) are in the range of 0.5 - 1m, which is most likely due to farmers preference to avoid too much earth moving involved at sites with deeper river beds.It is noted that the river bed has a linear slope and the variation in the depth of the river bed is due to the undulating feature (topography) of the adjacent landscape, which has been taken as a reference to measure the depth of the of river bed. Moreover, farmers often locate the diversion points where the river course is relatively straight, which is purposefully done to avoid possibilities of changing/branching the river course if diversion takes place at a meandering location.

The headwork of a Mother *Mellée* is laid out at the periphery of the riverbed using a pile of different materials such as branches and logs of woods, stones and sand in order to form a dike. The dike directs a small portion of the runoff/flood and conveys it to the secondary ditches (*Awraj Mellées*). It is constructed without requiring formal engineering skills and the structure sufficiently serves its intended purpose. Obviously, the diversion structures constructed from such materials are so weak to withstand the impact of higher runoff rates. Consequently, the parts of the dikes that are protruded (extended) into the riverbed will be easily washed away whenever runoff with high velocity occurs and there are only little possibilities of causing alteration. Nevertheless, the 'weakness' of the diversion structures have their advantage in that they will not let too much flood into the field, and thus, avoiding the consequence of crop damage.

Renewal of Mother *Mellées,* under normal situation, takes place twice a year. The first one takes place just before the on set of the *Belg* (short) rainy season from January to February. The second one, which is usually a minor maintenance to the first one, is done from May to June, before the *Kiremt* (long) rainy season commences. At times, however, there happen occurrences of runoff with higher velocities in the middle of both rainy season and washing away the diversion structures. In such cases, farmers have to renew the *Mellées* repeatedly so that they will not miss the flood during the rest of the season.

The Mother *Mellée* is expected to carry more water at a relatively low velocity, and thus, requires a large ditch size (i.e. with wider cross-sectional area). During the study, participant community members indicated that they don't require any outsider support/skill to carry out the design and construction of the *Mellées.*

Experienced and knowledgeable people among themselves make the layout of the structure. The dimensions for the Mother *Mellée* are usually made larger in order to withstand damage from trampling by livestock. The dimensions of Mother *Mellée*s are varied slightly from one another depending on the number of group members and the length it travels. Accordingly, the top and bottom widths of Mother *Mellée*s range from 200-400 and 100-150 cm respectively and the usual depth is 100-200 cm. The top width of the earth embankment also ranges from 30-50 cm (Figure 5). The dominant shape of the ditch is trapezoidal, some rectangular and combinations of trapezoidal and rectangular shaped Mother Mellées are also used. The lengths of Mother *Mellée*s extends as far as 2-3 km from the riverbed before it begins to branch off into *Awraj Mellée*s.

Before constructing new Mother *Mellées,* repeated ploughing is done using oxen drawn ploughs to loosen the soil and then scooping the soil to form the structure. During maintenance, the silted soil accumulated along the ditch bottom and over growths of plants are cleared and scooped to allow easy flow of the diverted floodwater. The construction and maintenance works are done just before the on-sets of the short and long rainy seasons which takes place from January to February and May to June respectively.

The construction of Mother *Mellée*s involves laborious operation. Nevertheless, all the users equally contribute the entire labour requirement. Participants also estimated that labour requirement for construction and maintenance of Mother *Mellée* is about 286 to 333 person-days per km (Pds/km) and 7 to 10 Pds/km respectively. In other words, a person can construct an average sized *Mellée* of about 3 to 3.5 meters long over a day; or can do maintenance of a *Mellée* of about 10 to 15 meters length in one day.

Accordingly, the total number of days required to constructing a new Mother *Mellée,* which is shared by 30 - 40 farmers and has a length of 2.5 km is 20 - 26 days. Labour cost in *Ayub* and *Jarota* PAs ranges from 8 to 12 *Birr* per person-day, depending on the demand of labour for farm operations. Therefore, cost of construction for a single Mother *Mellée* (average length 2.5 km) is between *Birr* 6192 and 9288 (USD 720 to 1080). Similarly, for the same length Mother *Mellée* maintenance cost is about *Birr* 168 to 252 (USD 20 to 29) each year.

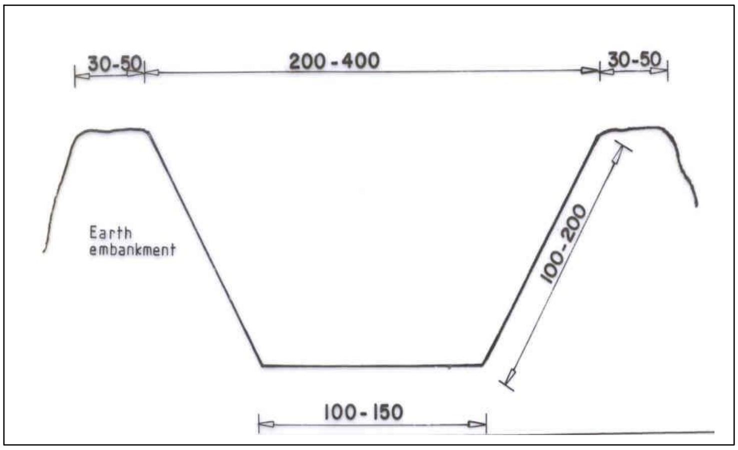


Figure 5: Cross-section of Mother *Melléé (detail-A)*

The floodwater from Mother *Mellée* is conveyed into cultivated land and/or tertiary canal via a branching canal called *Awraj Mellée* (secondary diversion ditches). The responsibility for construction and maintenance of *Awraj Mellées* rests on a group of farmers (usually 3 - 4 individual households) who are sharing supply of the same canal. No committee/*Abahaga* is required to manage the *Awraj Mellée* as it is operated by an *Awraj Mellée* group of farmers or individual land users who own farmland adjacent to each other and can easily divert runoff water from a common *Awraj Mellée*. For isolated fields, the owner is responsible for the construction and maintenance of *Awraj Mellée*.

The layout of *Awraj Mellée* along their respective farm boundaries either in-group or individually and they have no difficulties with this. Incidences of over-topping and problems caused due to improper layouts are rare as farmers have gained adequate experience over the years. The common shape of *Awraj Mellée* is rectangular although a few are trapezoidal (Figure 14 and Plate 2). Construction is made using oxen ploughing to loosen the soil and then scooping the soil to form the structure. A man can dig 3 - 4 m long ditches per day. The labour input required for maintenance of *Awraj Mellée* is insignificant.

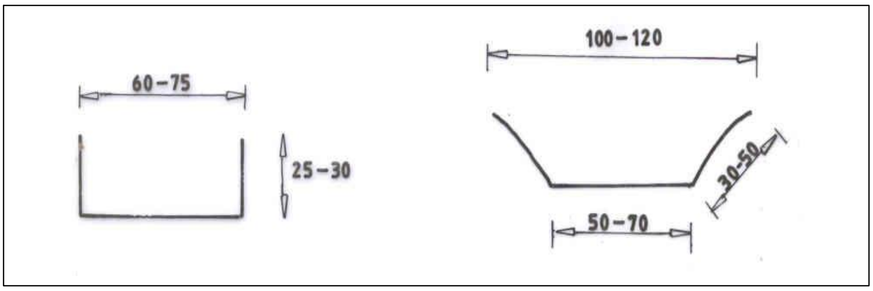


Figure 6: Cross-section of *Aweraj Mellée*, rectangular and trapezoidal respectively (detail-B)

Tinishua Mellée (tertiary canal) is the structure, which connects *Awraj Mellée* to the field/*Shilshallo*. This structure is usually made by individual farmers to intercept the floodwater from *Awraj Mellée* and convey it safely at a very low velocity to the field (*Shilshallo*). This structure also used as a means of getting rid of excess floodwater to the next field. The size, shape and position of the channel are dependent on the size (amount of water required) and relative position and aspects of the plot. At farm level, flood water is spread by a series of contour furrows or basins (*i.e Shilshallo).* The process for the formation of alternative contour furrows or basin in order to creating micro-catchment is called *Shilshallo*. *Shilshallo* is made in July, when the height of the crop (sorghum) is about 100-150 cm. These small, open trapezoidal shaped furrows achieve the water distribution system with in the field. This is done to increase the total time by prolonging the contact time of the soil and water.

Shilshallo is made along the contour by ox drawn equipment called *"Maresha*". Top and bottom width of *Shilshallo* (furrows) are 12-15 and 5-8 cm respectively and the depth is 15-20 cm. The spacing of cropped field i.e. the average space between furrows is 20-30 cm (See Figure 7). Bund construction is another method that has been used for a long time for floodwater management on cultivated fields. The purpose here is to retard the velocity of floodwater and help in retain the floodwater behind the bund. But the excess water is conveyed to the next farm via the tertiary field canal. Such terraces are often known as bench terraces.

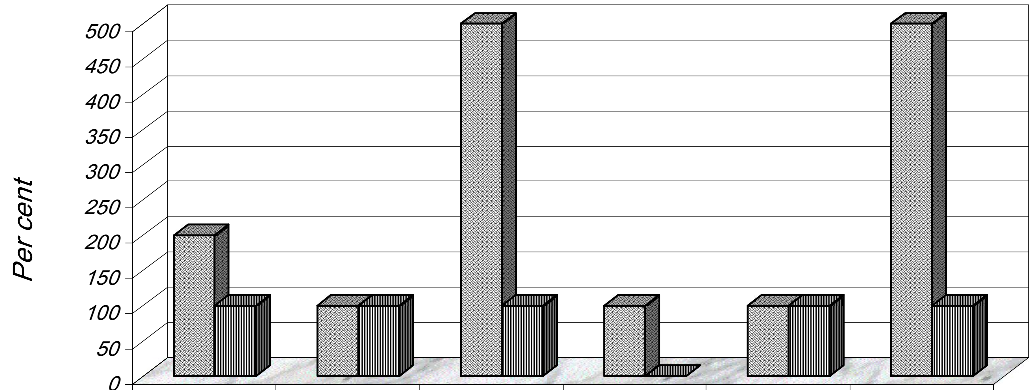
The *Belg*-runoff is used to inundate repeatedly ploughed seedbed between February and April, no structure (*Shilshallo*) is required during the first phase of inundation. The principle is to allow runoff water to retain behind the bund and leave the water standing to give time to infiltrate in order to suit for farm operations and make favourable environment for seed germination. The *Kiremt*-runoff is used to irrigate the crops (usually Sorghum) in July, August and September. During *Kiremt* runoff inundation structure (*Shilshallo*) is used to divert and spread the runoff water in the cultivated land. Runoff water fills the first furrow and spills at the top and end of the furrow into the next furrow.

The *Haroyée* is usually constructed along the lower reaches of the main flood diversion canal, or the *Enat- Mellée (Mother Mellée)* as locally called, and on the edge of the crop fields. Such positioning of the *Haroyée is* said to be purposeful as this will allow to keep the livestock off the crop fields and to utilise (collect) only the excess runoff after irrigating the farms and/or the natural drainage from the same. At times, however, the *Aba-hagga* may order farmers not to divert the floodwater into their farms in order to directly let it into the *Haroyée*. This is done when there occurs scarcity of water for the livestock due to inadequate rainfall.

3.3 Impact of floodwater diversion on crop yields

In the areas where the mean annual potential evapotranspiration exceeds the mean annual rainfall, rainfed crop production, is assumed to be uneconomical, unless supported by runoff diversion. It can be observed that using different RWH techniques like flood/runoff diversion had resulted in ensuring optimum crop yields. Conversely, without runoff diversion had the lowest yield. During the PRA study it is found that crop failure due to drought is common in *Kobo* area in general *Ayub* and *Jarota* in particular. During focus group discussions held in *Ayub* and *Jarota* KAs, farmers indicated their various benefits from overall changes obtained in the production and productivity of crops, which they mainly attributed to their use of flood/runoff diversion techniques. Farmers described the difference in productivity of certain crops by giving examples. Accordingly, sorghum production in *Ayub* KA shows a change of about 100% because of runoff diversion, while in *Jarota* absence of runoff may cause a total loss of sorghum yield.

Similar trends have also been observed in other crops (*Teff* and Chilli pepper) at both KAs. Chilli pepper production showed a tremendous increment under runoff irrigation i.e. under rain fed (dry) condition the yield is a mere 1000-1200 kg/ha but runoff diversion increases chilli pepper yield up to 5000 kg/ha (Figure 7). On the other hand, the production of *Teff* has no significant change in volume of production due to flood irrigation. However, availability (application) of the flood irrigation has an effect of improving the quality of *Teff* grains, which enhances the market prices due to the higher consumer preferences for the latter. Therefore, use of the flood irrigation for *Teff* still has a benefit to farmers as it ultimately increases the price of *Teff* at the market. Farmers also indicated the significant contribution made by flood diversion through increasing the total biomass production, which boosted availability of livestock feed. This, they said, is from the better volume of crop residues for stall-feeding and ease of browsing and grazing along the farm boundaries. The improved availability of livestock feed in turn improves household income generated from livestock products.



	Sorghum	Teff	Pepper	Sorghum	Teff	Pepper
		Ayub			Jarota	
Yield with flood (%)	200	100	500	100	100	500
Yield without flood (%)	100	100	100	0	100	100

Figure 2: Yield differences due to flood diversion [*Source: PRA report, December 2001.]*

3.4 Management of flood diversion

Management of flood diversion structures (*Mellées)* and ponds (*Haroyées*) is performed by a traditional community institution, locally called "*Aba-Hagga*". The *Aba-Hagga* is a committee consisting of 3 individuals elected by the general assembly of community members (30-40 households) sharing the same *Mellée* or *Haroyée*. Each *Mellée/Haroyée* has its own *Aba-Hagga.* All *Aba-Hagga* members are male and qualify for the task on the basis of their reputation of fair judgement, knowledgabilty, respect and recognition by fellow community members. After their election, individual members of the *Aba-Hagga* themselves are referred by the community members as "*Aba-Hagga*" or "Water-father". A number *Aba-Haggas* in a village(s) usually form a council or an apex *Aba-Hagga*. The council oversees the proper functioning of individual *Aba-Haggas* and observance of the traditional rules and regulations governing *Mellée/Haroyée* operation as well as handling/arbitrating disputes among different *Aba-Haggas* or in rare cases within *Aba-Hagga* constituents.

Each *Aba-Hagga* is vested by its constituents with full authority of controlling the *Mellée/Haroyée* operation in accordance with the long standing traditional laws and regulations of the community. *Aba-Hagga* tasks include scheduling *Mellée/Haroyée* construction or maintenance works, mobilizing and tasking users, assigning guards/attendants for *Haroyées,* determining durations of water diversions of individual users, and fining defaulters. In some cases, the *Aba-Haggas* are also given the task of managing other water utilizations like improved water supplies (hand dug wells, protected springs or piped systems) and river waters. In latter case, they ensure the proper utilization (e.g. collection/fetching hours, turns etc.), protection (e.g. assigning guards-hired or rotational bases), repair and maintenance (collection of small fees) on behalf of the users. In return for their service, individual *Aba-Hagga* members are privileged to divert floodwater to their plots on every Saturdays and Sundays. However, they are not given special treatment in using ponds and other water sources. The service duration/term of an *Aba-Hagga* is at least one year and at most two years. Every year or two, the electorate (general assembly of users) holds a meeting before the onset of the '*Belg*' (short rainy season) i.e. in February/March, to elect members of a new *Aba-Hagga*.

During the raining seasons, individual users are told their turn to use floodwater on predetermined date for specific duration (usually 8 hrs). If, by chance, there is no rainfall (runoff) on that date, the person's turn will be cancelled and waits for another round/turn. Since there is no adequate rainfall/flood during the '*Belg*' season, farmers are not concerned to get the floodwater. If there is enough floodwater, however, they usually inundate their plot, which helps for better tillage operation. During July and August, however, getting a turn to use the floodwater is more of a necessity than a preference by any user. Thus, users are busy during the two months to make the complementary irrigation, which determines whether a household harvests any/better crops at all.

3.5 Limitations

Despite the invaluable importance of the flood diversion technique, there are a few limitations that need concern in considering its future contribution to ensure sustainable food security. Some of the limitations that have been summarised from the perceptions of PRA participant farmers and analysis of the different information have been summarised as follows.

i) Remains rainfed: The contribution of flood diversion as a determinant factor of crop production in the study area, no doubt, has made life of farmers easier than otherwise. Availability and quantity of floodwater that may reach farm plots of households depends on the overall rainfall received in the upstream. However, the floodwater only compliments the actual rainfall directly received on the farm plots, which primarily influences the different aspects of the microclimate to favour plant growth. The contribution of the floodwater of whatever magnitude is, therefore, minimal in the absence of a direct rainfall on the area.

Therefore, despite the existence of the traditional RWH system that provides a life saving 'irrigation' water, the production system remains to be a rain-fed agriculture that makes the community's vulnerability to intermittent shocks unavoidable in the events of the failure/shortage of seasonal rainfall. Moreover, the use of the flood diversion practice to increase land productivity, in terms of realising two or three harvests of crop production during the year, is not in view. As a result, despite the high production potential of the land and suitability for a diversity of crops, there are still a number of other interventions needed to facilitate a long term sustainable production system as well as inclusive food security in the short term.

ii) Equity: There are certain aspects of the traditional RWH system that limit its equitability aspect. The fact those individual users told by *Abahaggaas* about their turn to use the floodwater on predetermined date might not get flood at all. The worst part is, if, by chance, there is no rainfall in the upstream on that date the person's turn will be cancelled. In such an environment, where the rainfall pattern is typically unreliable, waiting for another round or turn would mean missing the entire seasonal flood by individual households. Consequently, there is a higher possibility of reduced production and productivity those households due to both the untimeliness and adequacy of the floodwater.

iii) Research & Development Interventions: According to PRA participant farmers, there are no any signs of tangible efforts made by development and research institutions that gave enough attention towards addressing the rigorous demands of risk minimisation in the area. Although farming communities in those areas have managed to deal with their environmental constraints through different locally innovated technologies and adoptive socio-cultural set-ups, there exist obvious gaps in terms of providing research and development support to improve promising traditional practices. This would mean denying opportunities to communities' both from sharing their knowledge to communities in other areas and the capacity to up grade on local technologies. On the other hand, the lack in visible external interventions towards long-term enhancement of the risk management capacity of poor farmers (e.g. improving existing traditional practices) will limit the contribution of the traditional RWH to sustainable food security in the study area and other areas with a comparable setting. Moreover, in the absence of focus on creation of alternative livelihood opportunities and improvement of the institutional and structural status of the area (extension, markets, credit and infrastructures …etc) the sustainability of the existing farming systems and production practices seems unreliable.

iv) Land Tenure: The study indicated that the average land holding sizes of households in the area ranges from 1 - 1.75 ha. Moreover, there is an obvious trend of shrinking land holding from time to time which has already been below the optimum holding size to provide a living with the available technology being used by the community. No doubt, a decreasing trend of land holding size affects the competence of land users to cope with their problems including their investment on improved technologies. Another constraint for investment on sustainable rainwater harvesting systems noticed during the PRA study was absence of land ownership. Due to absence of clear land ownership right, farmers cultivate the land under temporary arrangements and expect the land to be taken away from them during the next land redistribution. Under these conditions, farmers may perceive investment on a long-term land improvement (construction of high labour input structures, conserving riverbank erosion etc.) as inappropriate because they are unlikely to reap the benefit of their work. Therefore farmers prefer least or no investment technologies, which is, in most case less effective to improve the productivity of land.

v) River bank erosion: Focus group discussions have revealed that in spite of the positive impact of runoff water diversion on the livelihood of the farming community, the flood in the seasonal river course has caused riverbank erosion. This has damaged a large portion of cultivated land along the *Gobu* river. On the other hand, control of riverbank erosion requires high labour input during construction, which is difficult to afford by subsistence farming.

vi) External influences: One of the problems that were repeatedly mentioned during PRA studies was the change of the *Gobu* river course by a blocking structure made by a road construction project. Consequently, the flood yield of the last season from the river was very minimal and has affected production of crops in the downstream of the blocking structure while it enabled a greater supply of the floodwater to another group of farmers in Tigray Region. The community was not consulted or warned during this action, which, farmers said, affects their survival. The farmers' concern is the possibility of this 'temporary' diversion to remain permanent.

3.6 Opportunities and Prospects

There is a wealth of indigenous knowledge, which can be tapped in developing appropriate and sustainable use of rainwater harvesting techniques with minimum external support. Farmers are aware that shortage of water is the most formidable challenge to sustainable use of land resources in general and to crop and livestock production in particular. Therefore rainwater harvesting techniques are coined with survival strategy of the farming community and sustainable production is impossible without runoff diversion. In this respect, no other (exotic) techniques have been interfering and traditional techniques alone continue to be productive and sustainable because it is simple, flexible and based on long experience of local conditions related to culture and environmental components.

3.7 Sustainability of the RWH Technology

Different aspects of sustainability have been assessed in order to determine as to whether the traditional RWH system in point qualifies/ promises to be sustainable. For this, usual indicators of sustainability including technical, social, environmental, economic and institutional aspects have been considered. The prerequisite for technical sustainability is that the technique (skill) and materials used for infrastructure are locally available. In this regard, the assessment has confirmed that no external input, be it technological or material, are required for the system. Only farmers' indigenous knowledge developed and improved over time through experience and the local resources are needed to realise it. Therefore, it is obvious that the system is technically sustainable. Similarly, having been evolved within the local socio-cultural system, the technology doesn't involve any change in the social setting. The community has established its own mechanism to observe a fair benefit of all the members on a participatory and equity-based manner. As a result, there are no major risks of benefit disparities that may endanger the social sustainability of the RWH system.

The system has been proved to be environmentally friendly. With the prevailing water management technology and mode of utilisation, there doesn't seem to arise a major environmental risk. In fact, environmental sustainability could be influenced with other factors like population growth which causes land shortage its consequences or the change in the climatic trend … etc. Nevertheless, these factors are not directly linked with the use of the technology. The sustainability of the technology in terms of economic and institutional aspects emanates from the fact that the resources needed to maintain them are already there and continue to exist. The traditional institutional set up to govern the system has, among other things, been based on the cultural values and norms of the community, which implies that no external enforcement or support is needed to sustain it. As the economics of the system depends on the labour input and the available rainfall, where farmers are always ready to participate in the excavation or maintenance of mother-*Melléé*s and subsidiary structures and the rainfall could be little or more in spite of the technology. Therefore, one may safely conclude that, as far as the technology is considered, there are no risks of unsustainability.

3.8 Adaptation, Scaling-up Prospects and Approaches

Rainwater harvesting technology is practiced in most parts of *Kobo Woreda* and the neighbouring area in the Tigray regional state. However, despite similarities in many places in the other parts of the country, adoption has been limited. It is evident that the technology has made an impact on improving the livelihood of the community. This is observed from the better standards of living (i.e. good health, improved housing structures and general socio-economic well being) of the community in the study area as compared to situations of farming communities in other moisture-stressed areas of the country.

The prospects for scaling-up of the traditional RWH technology (in *Kobo* area) are also highly promising. This is due to its being, among other things, technically simple, economically and socially feasible, environmental friendly and sustainability. Moreover, existence of other areas with comparable environmental settings (suitability) but facing food insecurity challenges due to lack such technologies also creates the demand for its use. There are many places in the country with similar landscape to that of *Kobo Woreda,* i.e. mountainous and hilly topography, which drain to seasonal rivers that cause flooding on the lowland plains during rainy seasons. The socio-economic aspects of the people in the lowland plains are also nearly the same with a livelihood that depends on livestock and agricultural production (agro-pastoralist). In view of its enormous potential as an opportunity to realise food security, the traditional RWH system in point deserves to be scaled-up (extended) to benefit other needy farming communities.

There are different approaches/strategies to facilitate the adaptation of the technology to other needy areas. However, the most widely accepted approaches mainly involve that of following varieties of participatory research and development (PR&D) methods to facilitate adaptation of technologies. Some of these include Participatory Technology Development (PTD), Farmer-to-Farmer Extension (FFE), Farmers' Field Schools (FFS) ...etc. Nevertheless, some of these participatory methods could mean the same thing or closely interlinked in their applications.

4. Recommendations

- The effort made by ERHA to implement this case study is commendable and, is envisaged that similar endeavours will continue. In addition, based on the findings of this and other case studies, ERHA should also make its responsibility and take the lead to prepare a guideline/manual on RWH technologies through seeking support from potential funding agencies. The current policy framework and development strategies of the Federal and Regional governments of Ethiopia also seem to favour promotion of RWH interventions and ERHA should take advantage of this.
- In order to ensure sustainability and improved performance of the traditional RWH practices and the farming system as a whole, the communities, relevant government agencies and other development actors in Kobo area need to give adequate attention to overcome the prevailing limitations in the agricultural production. Some of the interventions in this regard include control of the severe river bank erosion along the *Gobu* river course, avoiding external influences entailing adverse effect on the agricultural production and livelihoods of the people (e.g. blocking of the river course) and improving the equitability aspects of the runoff distributions among the *Aba-hagga* members.
- So far, only a little has been done to understand traditionally practiced RWH technologies in many parts of Ethiopia. On the other hand, such local innovations and practices hold enormous potentials to address the prevailing food insecurity in the country. Thus, local learning/training and research institutions should support applied research initiatives aimed at understanding existing RWH technologies and improving on their performance. To this end, the relevant institutions need to explicitly indicate their intentions and practically demonstrate by working with local communities in the collection and documentation of information on traditional technologies and alternative options to up date them. Such endeavours also require the collaborative and complimentary roles of the various institutions as an on going and participatory activity.
- Currently, the issues of promoting RWH technologies and improved water management as a viable option to attain food security and food self-sufficiency in semi-arid areas has been emphasised by the Ethiopian Government. Different strategies have also been employed to realise the same. However, the primary focus for technology choices should be based on local innovations and traditional practices of the farming communities in the country for all the benefits of such an approach. Moreover, in order to improve the productivity of technologies in these areas, incentive must be provided to the farmers, since they operate at subsistence level and consequently have very little risk absorbing capacity. Supporting the farmer by providing extension service, hand tools and wherever necessary credit etc. can enhance rainwater-harvesting efforts. To supply the necessary services for proper implementation and maintenance of diversion ditches, adequate guidelines and training manpower is needed.

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