Water harvesting ponds for improved agricultural production and income generation at Meket DawaChefa

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Abstract

This survey was conducted to: (i) evaluate the socioeconomic and technical situation of water harvesting technologies on farmers condition (ii) assess farmers awareness and perception on the use of introduced household water harvesting systems and adoption rate. The survey was carried out in selected kebeles from the two districts. Three representative kebeles from each district were identified for the survey. Structured questionnaire and systematic random sampling were in the survey. Sample households interviewed from the two study districts were 90. Primary data was collected through in-depth interviews of households, key informants, conducting focus group discussions, and observation. The technical and socioeconomic problems observed in both districts were described for further solution. The economic analysis focused on cost and benefit relationship of rain water harvesting techniques. The cost benefit analysis depicts that in semiarid regions both cemented and plastic lined type of WHS should be used to collect rain water and had positive net present value. The internal rate of return (IRR) was 160 % and the return on investment values was 387%. However, the cheapest way of rain water harvesting is geo-membrane which has IRR of 315 % and 179% at Meket and Dawachefa respectively. Geo-membrane together with the adoption of further seepage control techniques and improved water management technologies like drip system and pedal pumps should be used to maximize the benefit of harvested rainwater. It is concluded that for rain water harvesting to contribute to improved incomes and food security, smallholder farmers should be assisted to change from subsistent to commercial objectives with market oriented production of high value crops.

Key words: Water harvesting structures, Irrigation, lining material, Geo-membrane, cropping scheme

Introduction

Agriculture occupies a key position in the Ethiopian economy and more than 90 percent of the agricultural productions are generated from agriculture. Agriculture provides livelihood to more than 85 percent of the population and more than 87 percent of the economically active labor force is engaged in it. Nearly, 90 percent of the export earnings and more than 41 percent me from the agricultural sector (CSA, 2010).

Agricultural productivity is declining due to variable rainfall, frequent floods and recurrent droughts. The erratic nature and seasonal variability of rainfall constitute a major cause for frequent failures of crops and scarcity of livestock feed (Habtamu, 1999).

Water harvesting is usually employed as an umbrella term describing the whole ranges of methods of collecting and concentrating various forms of runoff (roof top runoff, overland flow, stream flow, etc.) from various sources (precipitation, dew, etc.) and for various purposes (agriculture, livestock, domestic consumption and other purposes) (Rejj *et al*., 1993). In the semi-arid areas, water harvesting is a direct productive form of soil and water conservation. Both yields and reliability of production can be significantly improved with this method (FAO, 1995).

Agricultural development based on water harvesting and irrigation is often considered a promising avenue for poverty alleviation in rural areas. The development of small-scale irrigation schemes through water harvesting techniques help to distribute runoff from time of excess rainfall to the shortfall season. Availability of water for a small garden usually

contribute to improve food security. Low-cost irrigation technologies can help smallholders' move from subsistence farming into growing cash crops. Factors influencing technology uptake are: (i) the existence of a market-driven demand for agricultural produces; (ii) a well-designed technology that is both appropriate and affordable for the local farming and manufacturing systems; and (iii) existence of a local private sector capable of mass production of reliable equipment as well as existence of effective private sector distribution networks for agricultural inputs and equipment.

The government of Ethiopia has invested in the construction of various surface water harvesting schemes including micro-earth dams and diversion weirs, as a result of which, some positive benefits have been recorded. In Amhara region many farmers had constructed water harvesting structures from concretes and geo-membrane. Meanwhile, the successes are very limited because the needs and aspirations of the farmers were not well considered in the planning, designing and implementation processes. Lack of focus on the selection of appropriate water harvesting technologies that fit to the local situation and

harvesting techniques was new to most of the development workers and farmers. Meanwhile, evidences on the extent to which improved water harvesting and irrigation technologies/techniques are adopted by and disseminated to farmers are not adequately available.

This survey was, therefore, conducted to study fa

harvesting technologies and socioeconomic condition of those technologies in the study districts from 2003/04 to 2010.

Objectives

The overall objective of the survey was to assess the awareness, perception and use of water harvesting technologies by farmers in the selected districts. Specifically the survey tries to: (i) evaluate the socioeconomic and technical situation of water harvesting

ion (ii) a

of water harvesting structures and technology characteristics that influence adoption rate and (iii) recommend the most profitable WHS for further scale up.

Scope of the Survey

The survey was carried out in the selected kebeles from the two districts from each district, three kebeles representative to the districts were identified for the survey. Results of the survey in relation to household water harvesting systems is primarily based on data collected from randomly selected sample of 90 farm households from 6 kebeles in the two districts. However, recommendations drawn out from this survey could be used in other districts having similar conditions.

Significance of the Survey

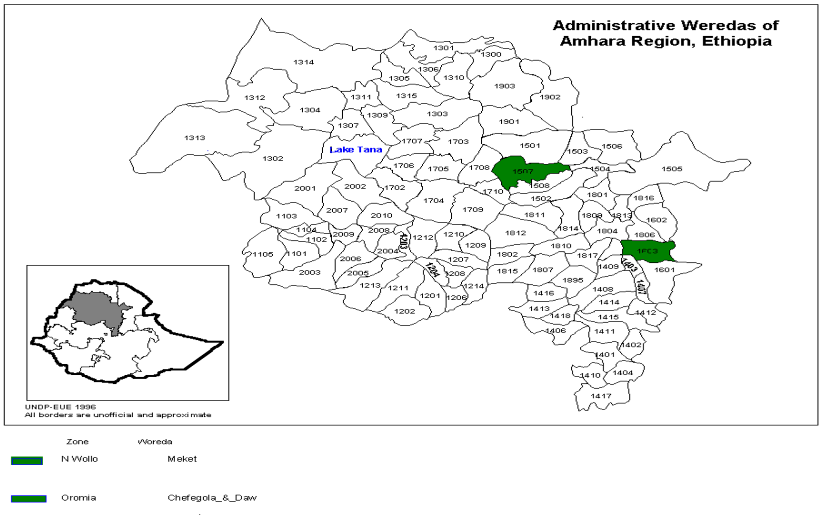
The findings of the study will serve to measure the current status of improved water harvesting and irrigation techniques in the selected districts. It will also be used as a basis for subsequent results-based monitoring and evaluation of the technologies. Causes of the successes or failures on improved water harvesting technologies were identified. Moreover socioeconomic and technical evaluations on water harvesting technologies were made.

Methodology

The study area

The study sites are located in the Amhara Region, North Wollo zone (Meket district) and Oromia Zone (DawaChefa district). In Dawachefa district the study was conducted in three peasant associations namely: Dodo, Riqqee and Chirt having an altitude ranging from 2000m to 2300m masl. While in Meket district the study was conducted in three peasant associations namely: Anjeb, Debrezebit and Timtemat having an altitude ranging from 2115m to 2900m masl (Fig.1).

Figure 1. Location of the study sites



The target districts were well-represented the agro-ecological zones (highland, midland and lowland) and relief features (plain & rugged topographies) of the region. The two districts in eastern Amhara (DawaChefa and Meket) receive bi-modal rainfall which is highly variable that necessitates the application of all possible options of irrigation so as to reduce crop failures.

Sampling Procedure, Data Collection and Analysis

Baseline data were collected from publications and records kept by the district, zonal and regional offices of agriculture. These data covered issues such as water harvesting, farming systems and socio-economic data. Also, supporting data were collected from the regional and district offices of Agriculture. Primary data was collected through conducting in depth interviews of individual households, key informants, focus group discussion and observation. Filed data were then collected through farm visits, and interviewing farmers using structured questionnaires. The structured questionnaire for household survey was reviewed and updated by group of researchers. Checklist to collect information from key informants and secondary sources, including topic guides to conduct focus group discussions with the beneficiaries were also developed. The key informants included in the survey were development agents, irrigation process owners, extension supervisors, and irrigation technicians. Information collected through key informants, focus group discussion, and observation was used to triangulate and further elaborate the findings from the analysis of interview.

A two stage stratified random sampling method was used to select farmers for the study. At the outset, the district was stratified into three categories, i.e., highland, midland and lowland. One Peasant Association (Kebele) from each stratum was selected. The second stage was selection of sample households from each sample kebele identified for the survey. For each technology 10 farmers were randomly selected for interviews. In total, 94 sample households out of which 64 and 30 farmers were interviewed for plastic lined and cemented type of WHS respectively. 4 questionnaires were discarded due to consistency problem. Data collected was processed using software-Statistical Package for Social Sciences (SPSS V16.0) and Excel. After employing data cleaning, coding, and encoding of both primary and secondary data descriptive statistics was applied for data analysis, and results of the analysis are presented in tables and diagrams.

Yield comparison was done based on gross margin analysis and investment analysis. Here cost and benefit relationship was used to identify the adoption of improved rain water harvesting techniques. Since decision to adopt is driven by profit motive, components of cost are investment cost, operating cost (land preparation, planting, weeding, thinning, harvesting and threshing costs), input cost (seed, chemical and fertilizer costs), maintenance cost, watering cost, cost of water and full contributions made by various partners to the development of RWH (the value of water considering alternative uses), cost of catchment area and treating the catchment and external cost (externalities, environmental destruction and health hazards, cost of de-silting etc). Components of benefit consist of direct and indirect benefits. Direct benefits are increased crop production and indirect benefits are support of appropriate infrastructures such as market, roads, transport and storage facilities.

The decision criteria (the costs of various alternatives) are compared and the cost effective alternative is selected. The cost alternative was compared with the benefits in a cost benefit analysis. Net Present Value (NPV) of the various costs and benefits is the decision criteria used to select the best alternative technology. The technology having the higher positive NPV or the lower cost benefit ratio (CBR) was selected. Then economic evaluation of rainwater harvesting was done based on two dynamic indices; financial net present value (NPV) and financial internal rate of return (IRR). Service life for WHS used for comparisons was 10 years. The discount rate used for calculations was 10% which is usual for economic calculations.

Gross benefit (GB) and Total cost (TC) can be computed using the formula:

$$\mathrm{GB} = \sum_{t=1}^{n} \frac{\mathrm{Bt}}{(1+\mathrm{i})^{\mathrm{t}}} \qquad (1)$$

$$\mathrm{TC} = \mathrm{C}_1 + \mathrm{C}_2 + \sum_{t=0}^{m} \frac{\mathrm{C3}_{\mathrm{t}}}{(1+\mathrm{i})^{\mathrm{t}}} + \sum_{t=1}^{n} \frac{\mathrm{C}_{\mathrm{t}}}{(1+\mathrm{i})^{\mathrm{t}}} \qquad (2)$$

Where:

B_t = Average gross benefit at the t^{th} year C_t = Average cost at the t^{th} year

i = discount rate

C_1 = Average investment on catchment areas

C_2 =Average investment on WHS (tanks and ponds)

C_3 th year

th year

n = calculation period of years (effective time of life of structures)

Then, NPV = GB-TC (3)

If NPV > 0, the scenario is accepted if not the scenario is not viable. The duration of time when the net revenue compensates for the total investment is total recovery period. In order to calculate the internal rate of return the solution of IRR in the Eq. (4) must be found, that is

$$\sum_{t=1}^{n} \frac{\mathrm{Bt}}{(1+\mathrm{IRR})^{t}} - [\, C_1 + C_2 + \sum_{t=0}^{m} \frac{\mathrm{C3_t}}{(1+\mathrm{IRR})^{t}} + \sum_{t=1}^{n} \frac{\mathrm{C_t}}{(1+\mathrm{IRR})^{t}} \,] = 0 \qquad (4)$$

Where, IRR is the internal rate of return. The IRR is acceptable if it is greater than the minimum expected interest rate.

Results and Discussions

Improved irrigation technologies addressed in this survey include: household water harvesting systems (hand dug wells and water harvesting structures either cemented or plastic type; water lifting devices (motor pumps, treadle pumps, rope and bucket, and rope and washer pumps) and water application methods or devices (drip system and watering can). It also includes improved water application or irrigation techniques like furrow, border and basin.

The results of the survey on household water harvesting systems give detail information about: (i) household characteristics; (ii) perception of households on water harvesting; (iii) technology characteristics that affect rate of adoption of improved water harvesting technologies; and (iv) technical and socioeconomic evaluation of WHS under smallholder farmers condition.

Table 1. Household characteristics

Household characteristics	Groups	Percent	Range
Sex:	Male Female	100 0	
Marital status	Single Married	6.67 93.33	
Education	Illiterate Grade 1-8 Grade 9-10 College	56.7 35.5 6.7 1.1	
Age	<15 years 15-64ears >64 years	53.5 45 1.5	Dependency ratio of 122%, every productive person feeds himself and additional 1.22 persons
Age and farming experience	Average age Farming experience Irrigation experience	43.8 years 29 years 7 years	25-68 years 7-50 years 0-20 years
Land holding	Average land size Irrigated land size Land ownership	1.26 ha 0.153 ha (Dawa Chefa) 0.035 ha (Meket) 100 % own land 50% both own and rent land	0.04-4.25 ha 0.01-0.32 ha (Dawa Chefa) 0-0.1 ha (Meket)

Current farm landholding and size of irrigable land by WHS

The average size of land holding is 1.26 ha with the minimum and maximum being 0.04 and 4.25 hectares. The average size of irrigable land per household for Dawa-chefa was 0.153 ha with the minimum and maximum being 0.01 and 0.32 ha. While the average irrigable land for Meket was 0.035 ha with the minimum and maximum being 0 and 0.1 ha respectively. Analysis of land title (ownership) shows that 100% of the households have their own land and 50% have both own land and rented land.

Awareness of farmers about household level water harvesting structures

harvesting systems showed that about 77.78% were aware of different systems of water harvesting. As a result of farmer-to-farmer knowledge transfer and knowledge transfer through experts and development agents of the district office of agriculture, there was no considerable difference between kebeles in the percent of farmers who have awareness on water harvesting systems.

The main sources of information for those households are neighboring farmers and extension workers. Regular extension services delivered by extension workers and farmer-to-farmer knowledge transfer are the key sources of information that help most of the farmers to know about water harvesting. Most of the households (61.11%) have participated in community meetings that promote water harvesting. Only few farmers have participated in field days (7.78%), experience sharing visits (6.67%) and trainings (7.78%) related to water harvesting.

Perception of farmers about household level water harvesting

According to the result of the survey, most of the households (95.66%) think that household level water harvesting systems can improve their income and food security. Whereas very few (4.44%) thought the opposite because they believed that: (i) water harvesting structures cannot provide adequate water for crop production; and (ii) water harvesting structures usually fail to harvest runoff. When group discussion was held with farmers and experts, only 1% of the households have water harvesting structures and 25% of the HHs need to have WHS in the future. Reasons for not having Water Harvesting were labor cost for excavation especially for the female household heads, costs for cement and masonry, lack of material support from the government, lack of training on how to establish and use WHS, failure of the constructed water harvesting structures by some farmers and lack of appropriate site to construct water harvesting structures.

Rate of adoption of improved irrigation technologies and techniques

Type of water harvesting technologies and percent of farmers who have these water harvesting structures in each Woreda are depicted in Table 2. However, among the surveyed 90 households, 26% had hand dug wells, 57% had water harvesting structures which is lined with plastic geo-membrane, 4% had cemented water harvesting structures, and only 5% used small springs.

Table 2. Number and percent of HHs who have different types of WHS up to 2010

District	Hand dug well			Plastic type WHS			Cemented type WHS		
	No	Current Status		No	Current Status		No	Current status	
		Functional	Not functional		Functional	Not functional		Functional	Not functional
Dawachefa	2	1	1	155	135	20	3	0	3
Meket	455	257	198	1350	360	990	100	58	42
Overall	457	258	199	1505	495	1010	103	58	45

Source: District office of Agriculture (May, 2011)

The rate of adoption of water harvesting structures is almost at its early stage (Table 3).

is limited to the first category of adopters. The reason for the limited adoption of these technologies may be limited technical skill, lack of financial capacity and risk taking ability. As evidence, the reason for 65% non- adoption of the technology was lack of financial and material resources. Therefore, adoption of improved irrigation technologies was mostly limited to those farmers having better financial resource.

Table 3. Rate of adoption of improved irrigation technologies

Se. No	Type of technology	Rate of adoption
1	Water harvesting structures	39.16 %
2	Water lifting devices	8.75 %
3	Water application / irrigation techniques	4.25 %
4	Irrigation systems	31.14 %

Source: Household survey (May, 2011)

Technical and Socioeconomic evaluation of water harvesting structures

Technical aspects of water harvesting

Based on the lining materials used, the types of water harvesting structures addressed in the survey were plastic lined and cemented types. For these types of structures major technical problems related to the lining materials were: deformation of the structures, inappropriate site for runoff collection, lack of silt trap, and size and shape of the ponds do not fit with the lining materials. According to farmers saying and personal observation the most serious problems associated with the water storage structures were siltation, evaporation and seepage. These problems occurred due to the absence of silt traps in the WH system and no shade that protects the reservoir from wind and direct sunlight and tear of the lining materials were among others. Moreover,

- Takes more land for construction
- Not capable of providing water for the cropping season as a single source.
- Lack of adequate characterization of the rainfall, evapo-transpiration and soil properties that help for the design of WHS.
- Tear of the plastic material during loading and unloading, Sharp objects and stones underneath torn the lining material and wrong plastic lining at steep side slope and folds and wrinkles due to oversized.
- No silt traps constructed in most of the ponds

Social aspects of water harvesting

Components of the social aspects of rain water harvesting are policy and legal frameworks, local institutions and equity. Land tenure is one of the policy and legal frameworks since rain water harvesting involves long term investment, long term and secure tenure system is desirable. In this respect farmers have land occupation and use right so the policy supports the construction of WHS. When conflicts and disputes arise on water rights, land ownership and use, local institutions such as kebele administrators, community based organizations, NGO and district administrators etc should support the farmers in resolving the conflicts. Equity in using WHS refers to fairness especially in distribution of resources and benefits from economic activities.

Allocation of WHS should not create inequality in ownership between men and women, individuals in the society and between leaders and the rest of the society, correcting it on time if already exists. In both districts female household heads do not have their own WHS so this implies that construction of WHS and technology transfer did not consider the interests of all groups.

Social problems observed in the survey

- To adopt WHS, 55% of the respondents fail due to fear of theft and 45% due to labor shortage.
- Farmers were given lining material without agreement and incurring cost; this hinders future expansion and leads to inappropriate use of the materials for other

purpose. So there must be cost sharing or credit arrangement when households participate in the technology use.

- At the group discussion most farmers responded that they were discouraged to construct WHS due to failure of water harvesting structures constructed by their neighbors.
- Year after year technology users need subsidy for improved input supply like pedal pump, improved seeds and fertilizers.

Marketing practices of the farmers

In both cases of the households interviewed, farmers sell their agricultural produces at district markets and local markets. On average, they walk 2 to 3 hrs to reach district markets and 0.5-1 hour to reach local markets. Farmers sell their agricultural products mainly within three months of harvest. The main sources of information about market for the farmers were: (i) friends/neighbors /relatives and (ii) traders. Pack animals were the main means of transportation for marketing of agricultural products. The farmers store their products in traditional silos, made of mud, or in underground storages. During the focus group discussion with the beneficiaries of irrigation schemes it was learned that the producers were not accustomed to get into pre-harvest contract agreements with customers. They directly carry their products to the market and sell it to any consumer.

Despite the price fluctuations, local markets and district markets seem to absorb the supply

district towns were the major users, especially of the vegetables supplied by the farmers. So, it is wise to be pro-active and make farmers aware of the opportunities to improve marketing of their agricultural produces. As the price of agricultural products is one of the main factors that determine feasibility of improved irrigation technologies, it has a di

irrigation technologies. Hence, for further adoption and scale up of improved irrigation technologies needs to improve the existing marketing system.

Economic aspects of water harvesting

The financial net present values for the types of WHS in the two districts were calculated (Table 5) s of the plastic type at Meket was greater than that of the cemented or concrete type. When the plastic type was used, the capital recovery period of the structures was less than 3 years.

Table 5. The average costs incurred and revenues obtained using WHS and rain fed.

District	WHS Type	Revenue RF ETB/ha	Revenue WHS ETB/ha	Average Cost of material ETB/pcs	Total cost WHS	Cost for WHS ETB/pcs	Input cost	Incremental income due to WH
Dawa chefa	Geo-membrane	12,365.83	31,911.10	4500.00	8024.46	7355.79	668.67	12,852.90
Meket	Geo-membrane	10,237.50	34,636.03	4500.00	6822.85	6228.13	594.72	18,746.45
	Cemented	8,625.57	29,005.50	9000.00	13601.17	12724.5	876.67	8,641.55

Source: own calculation based on survey

Returns to investment

The financial analysis of storage ponds from agricultural enterprises is presented in Table 6 and 7 below. The parameters considered in these analyses were net present value (NPV) and financial internal rate of return (FIRR). Initial investment costs of WHS were 7629, 6415 and 12901 ETB/pond in Dawachefa geo-membrane, Meket geo-membrane and Meket cemented types respectively. Maintenance and production costs were 829, 732 and 1146 ETB/pond/yr in Dawachefa geo-membrane, Meket geo-membrane and Meket cemented respectively.

Gross incomes from crop production were 34,812, 37,782 and 31,642 ETB ha^{-1} in Dawachefa geo-membrane, Meket geo-membrane and Meket cemented respectively. However, this calculation didn t include the water used for livestock and household consumption. In general, the benefits of storage ponds with a discount rate of 10%, the average NPV of 10 years was on average 25,764 ETB indicating that the WH technologies are financially profitable. Furthermore, the FIRR was 160% (average of the two types of WHS) which is higher than the discounted factor 10% indicating its financial profitability.

Table 6: Discounted benefit and discounted costs

District	Discounted costs ETB WHS/ha	Discounted costs ETB RF/ha	Discounted Revenue ETB WHS/ha	Discounted Revenue ETB RF/ha	Net Revenue WHS
Dawachefa Geo-membrane	7,629.23	2,043.70	34,812	13,490.00	27,182.88
Meket Geo-membrane	6415.33	1,255.03	37,785	11,168.18	31,369.43
Meket Cemented	12901.16	2,081.02	31,642	9,409.71	18,741.20
Average	**8981.91**	**1793.25**	**34746.33**	**11356.00**	**25764.52**

[redacted]

Source: own calculation based on survey

Table 7: NPV, Financial internal rate of return and Return on investment of WHS

Performance Parameters	Dawa chefa geo-membrane	Meket geo-membrane

Geo-membrane together with the adoption of water conserving methods like seepage control, drip system and pedal pumps should be used to maximize the benefit of harvested rainwater in both Districts. To contribute for poverty reduction, rain water harvesting for crop production should be integrated with improved irrigation management options like drip irrigation, improved agronomic practices and crop selection. Improved management implies selection of crops which have high value in the market (like garlic, onion, khat, fruits) and appropriate cultural practices (management of soil fertility), supply of improved varieties and timely socioeconomic interventions, and marketing strategy will help to achieve the objective of improving water productivity.

Recommendations

- Community based management, farmer participation in planning and cost sharing may help to manage these reservoirs and to overcome the problem of theft and sell of lining materials. Use of the technology in cluster may be the better solution for proper implementation of WHS and protect theft.
- Market improvement begins from production. Supports should be given to the farmers in the selection of marketable crops (high value crops), and improving the quality of products. In this regard, developing reliable improved seed and fertilizer supply systems and building the capacity of farmers are vital.
- Though technologies for various conditions are available many of them are not widely adopted. This can be attributed to technical, socioeconomic and policy factors, but most importantly the lack of community participation in the development and implementation of these technologies. So water harvesting techniques should be selected according to the biophysical and resource availability and must be implemented accordingly without enforcing technologies which are not appropriate to the locations.
- Training should be given to some volunteer and knowledgeable farmers on maintenance of WHS from each district. Then the trained farmers can give services to other farmers with reasonable cost.
- Developing a regulatory system on utilization of geo-membrane is also very important to mitigate the problems related to geo-membrane misuse by the farmers. For example,

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Sep 1 Oct 2004, Brisbane, Australia. Published on CDROM. Web site www.cropscience.org.au

Hatibu N. and H.F. Mahoo [eds] (2000). Rainwater Harvesting for Natural Resources Management: A planning guide for Tanzania. Technical handbook No. 22, ISBN 9966-896-52-x, Sida Regional Land Management Unit (RELMA), Nairobi. 136 pp

Kunze, D. (2000) Economic Assessment of Water Harvesting Techniques: A demonstration of Various Methods. Quarterly Journal of International Agriculture.39 (1): 69-91

Rejj, C., P. Mulder and L. Begemann, 1993. Water Harvesting for Plant Production: A comprehensive review of literature. Third printing. The World Bank. Washington, D.C.

Rogers, M. and F. Shomeker, 1971.Diffusion of Innovations.Second edition.Free press of Glencoe. New York.

Tian .Y, Li Fengmin, Liu.P, 2002. Economic analysis of rainwater harvesting and irrigation methods, with an example from China. Web site www.elsevier.com/locate/agwat

ANNEX

Table 8. Net incomes from major crops at Dawachefa and Meket

Crops/systems	Mean gross value (ETB/ha)	Costs of inputs (ETB/ha)	Net income (ETB/ha)
Teff rainfed both locations (ETB/ha)	10234	2873	7361
Wheat rainfed Meket (ETB/ha)	8619	1717	6902
Sorghum rainfed Dawachefa (ETB/ha)	12359	2516	9843
Average rainfed Meket (ETB/ha)	10285	2295	7990
Average rainfed Dawachefa (ETB/ha)	13481	2686	10795
Onion seedling with WH (ETB/100m^2)	2737	884	1853
Chat and onion rainfed Dawachefa plastic (ETB/ha)	31909	6613	25296
Onion , vegetables and fruit rainfed Meket plastic (ETB/ha)	34629	7565	27064
Onion , vegetables and fruit rainfed Meket Cemented (ETB/ha)	31807	5865	25942
Incremental income due to WH (ETB/ha)	35513	8075	27438

Table 9. Average total family labor inputs (man-day) and gross return to family labor (ETB/man-day)

Crops/systems	Total family labour	Return to family labor (ETB/man-day)
Teff rainfed	130 (man-day/ha)	76.5
Wheat rainfed	90 (man-day/ha)	92
Sorghum rainfed	100 (man-day/ha)	99
Seedling production with WHS	15 (man-day/100m^2)	138
Onion and chat WHS	180 (man-day/ha)	160
Onion, vegetables and fruit WHS	175 (man-day/ha)	180163
Onion, vegetables and fruit WHS	180(man-day/ha)	161
Incremental labor due to WHS	193(man-day/yr)	