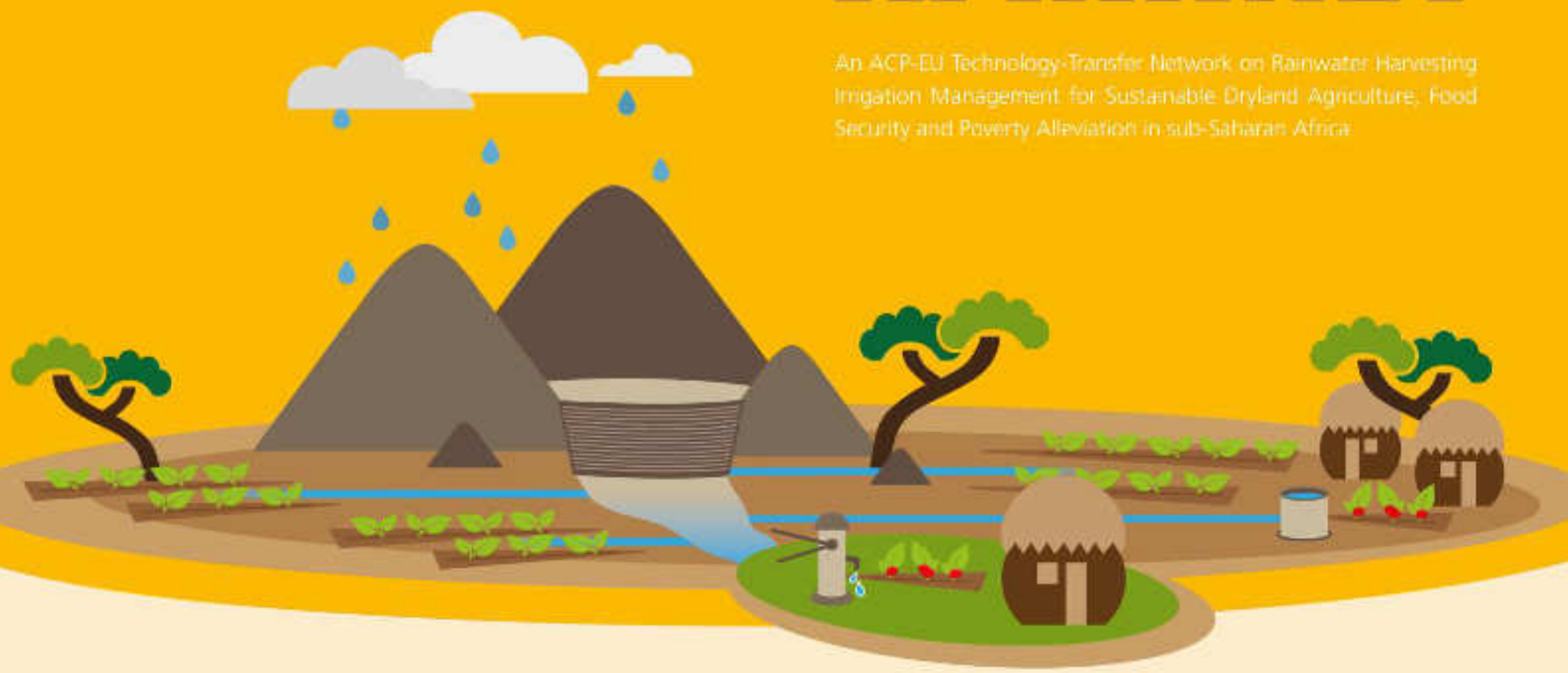
APRHINET

An ACP-EU Technology-Transfer Network on Rainwater Harvesting Irrigation Management for Sustainable Dryland Agriculture, Food Security and Poverty Alleviation in sub-Saharan Africa



TECHNOLOGY TRANSFER NETWORK ON RAINWATER

Baseline Report on RWH and SSI in Ethiopia

Funded by the European Union

ABOUT AFRHINET

AFRHINET is a three-year project which focuses on fostering the knowledge and use of rainwater harvesting technologies for supplemental irrigation in rural drylands of sub-Saharan Africa. The project focuses on the implementation of integrated capacity-building activities, the development of research and technology-transfer centres, and the setting-up of a transnational network of multivariate relevant actors. The action of the project takes place in Ethiopia, Kenya, Mozambique and Zimbabwe.

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Contents

Chapter 1

Analysis of Political and Institutional Framework in the Field of Rainwater Harvesting Irrigation (RWHI)

1.1. Introduction

Agriculture in Ethiopia is heavily reliant on rainfall and productivity and production are strongly influenced by climatic and hydrological variability that are reflected as dry spells, droughts and floods. Droughts and floods are endemic, with significant events every 3 to 5 years, with increasing frequency compared to two or three decades ago. Droughts destroy watersheds, farmlands, and pastures, contributing to land degradation and causing crops to fail and livestock to perish.

The Ethiopian Water Sector Development Program, EWSDP (MoWR, 2002) shows that the potentially irrigable land of the country is 3.7 million ha. Nevertheless, according to recent information from the MoWR, the total land area of traditional small scale irrigation developed up to the end of the 2005/06 budget year was 346.3 thousand ha. The same source as well indicates that the total land area brought under large & medium irrigation in 2010 was only 151,558 ha.

Rainwater harvesting is a simple and low cost water supply technique that involves the capturing and storing of rainwater from roof and ground catchments, as well as from intermittent or ephemeral watercourses for domestic, agricultural, industrial and environmental purposes. When surface run-off is collected in reservoirs, it can be used for the meeting water demands in periods of low or no rainfall as well as for the management of floods and droughts. Surface runoff can also be used for recharging soil storage and groundwater replenishment, that impacts positively on springs and shallow wells. Rainwater harvesting yields numerous social and economic benefits, and contributes to poverty alleviation and sustainable development.

This baseline study is intended to know the rainwater harvesting technologies that are currently being used for small-scale irrigation in Ethiopia. The study focused on identifying suitable technologies and collecting technical guidelines for the major technologies available in Ethiopia. It also suggests the ways to adapt the current technical guidelines to the local context. The baseline study is expected to guide the next project activities, especially: capacity-building, RTTCs and demonstration trials.

The objectives of the study are the following:

- Assess the available practices and technologies, technical capacity, socio economic and climatic conditions RWHI and sustainable dryland agricultural water management
- Map the best practices of integrated rainwater harvesting and small scale irrigation in the country
- To analysis of research and innovation needs in the field of rainwater harvesting and/or small-scale irrigation
- To assess the technology-transfer and market-oriented needs of rainwater harvesting and/or small-scale irrigation
- Identify the national capacity and training needs in the field of rainwater harvesting and/or small-scale irrigation; and
- Analyse the policy and institutional framework in the field of rainwater harvesting and/or small-scale irrigation

This base line study is prepared by a team of experts from AAU, MoWIE, Water Aid, and Rain Water Foundation. The study employed a mixed approach and hence the types of data collected are both qualitative and quantitative in nature. The data source generally includes in-depth study of available reports; detailed interviews with relevant institutions/people using structured questionnaires and focus group discussions. The draft report will be presented in a one day multi-stakeholder workshop and validated before the final print.

1.2. Definition of RWHI Generators

Rainwater Harvesting is when the precipitation is collected from a small/large surface area (catchment) and directed through channels to a storage facility or to a nearby field or retained at the site itself (in-situ). The rain-water harvesting techniques most commonly practiced in Ethiopia today are run-off irrigation (run-off Farming), flood spreading (spate irrigation), in-situ water harvesting (ridges, micro basins, etc.) and roof water harvesting. These techniques, though dates back in the antiquity, their importance has not been recognized until very recently, it was following the devastating drought and famine of the 1980s.

Water harvesting can be undertaken through a variety of ways including: (i) capturing of runoff from rooftops, (ii) capturing of runoff from local catchments, (iii) capturing of seasonal floodwaters from local streams, (iv) conserving water through watershed management RWH systems can generally be categorized into two as (i) in-situ water conservation practices, small basins, pits, bunds/ridges; and (ii) runoff-based systems (catchment and/or storage).

A wide variety of water harvesting techniques for many different applications is known. Productive uses include the provision of domestic and livestock water; concentration of runoff for crops, fodder and tree production and, less frequently, water supply for fish and duck ponds. An excellent overview on land and water conservation technologies and small- to medium-scale irrigation in Ethiopia is presented by WOCAT (http://www.fao.org/ ag/agl/agll/wocat/ wocatqt.asp). It lists seven technologies specific for Ethiopia, while many others from other countries apply in some areas. Oweis et al. (1999) reviewed water harvesting methods used in winter rainfall areas (>100 mm per year) and in summer rainfall areas (>250 mm). They give an excellent overview of the theory of catching, concentrating and storing water, and how this relates to rainfall characteristics, landscape and crop demands. The principles have been known and applied for millennia. Practical designs are given, yet the authors note that recent attempts to encourage more farmers in semi-arid zones are often disappointing. They give the following reasons for lack of adoption: (i) people often do not understand the principles and get inadequate training, (ii) transaction costs are high, (iii) outside institutions are often needed to get started, (iv) too little focus on 'risk' and how to handle it, and (v) cooperation with other people is difficult. The fact that many farmers in semi-arid regions do not own the land they farm is another reason why investments in water harvesting are low. Not mentioned in the review, but likely also to be a cause of slow uptake, is that many of the farmers in semi-arid regions have more experience of being herdsmen than being cultivators. Kunze (2000) showed that, although profitability of water harvesting can be significant at the field level, it might still be negligible if only applied to a small part of the farm.

RWH systems are generally categorized into two; *in-situ* water conservation practices, small basins, pits, bunds/ridges; and runoff-based systems (catchment and/or storage). The storage system is usually used in supplemental irrigation. The *in-situ* systems, which enhance soil infiltration and water holding capacity, have dominated over storage schemes in Ethiopia until recently. Despite the additional costs involved in storage schemes, the recent trend shows there is a relatively high degree of adoption. Surface runoff from small catchments and roadside ditches is collected and stored in farm ponds holding an average of about 60m3 of water. This storage is not significant in volume but sufficient for supplementary irrigation of vegetables. The use of these systems can be extended to crop fields and larger plot sizes can be warranted through larger sizes of storage combined with efficient water application methods, such as low-pressure drip irrigation methods. Hence, rainwater harvesting is a useful means to overcome the recurrent erratic rainfall and dry spell conditions, which often result in crop failures in Ethiopia.

There is a huge scope for irrigation in terms of land and water resources, and there is a strong argument for targeted irrigation investments as a means to promote highly productive commercial agriculture. However, given the relatively high costs of development of irrigation and low global prices of staple grains, combined with the relatively modest performance of irrigated agriculture in Ethiopia, development of irrigation alone may not be the most appropriate investment to achieve household and national food self-sufficiency. An integrated approach to improving the productivity of rainfed agriculture, through a combination of RWH, better management of land, especially fertility, supplementary irrigation using low cost micro irrigation technologies, and improved varieties can lead to a doubling of rainfed yields over the next 10-15 years for a relatively lower per ha and per capita investment than is required for formal irrigation investments. SSI can be an important part of the overall investment package as it enables farmers to engage more effectively in commercial high-value agriculture.

Over the last three decades however, interest in rainwater collection has steadily increased both in regions where they have been used traditionally and those where the technology was previously unknown. The main reasons for this are:

- Increase in population, and the rise in awareness and demand of people for safe/fresh water;
- The development and increase in the number of urban centres and settlements;
- The rapid expansion of irrigated agriculture and industrialization; and
- The degradation of natural resources such as forests, and increased pollution fresh water sources.

1.3. Institutional Framework of the RWHI Sector

1.3.1. Policy Makers

The Ethiopian Federal Ministries mainly Ministry of Water Resources, Minister of Agriculture and Rural Development, Federal Environmental Protection Authority, Ministry of Health in its Rural Development Policy & Strategy, Minister of Finance and Economic Development and Food Security Coordination Bureau are among policy makers regarding rainwater harvesting for small scale irrigation. But, in the policy document of Ministry of Water Resources (2000), the only rainwater harvesting statement that we can find is in the general policy objective No.15, which states as: ***Promote and enhance traditional and localized water harvesting techniques in view of the advantages provided by the schemes' dependence on local resources and indigenous resources.*** In the first instance, the term *water harvesting* is used instead of *rainwater harvesting* and concept of water harvesting is not explained in the glossary part. Secondly, this statement lacks specification and too general that further hinders the overall performance of rain water harvesting. Better than minister of water, more is incorporated about rainwater harvesting in the policy document of Ethiopian Water Sector Strategy (2001).

When Ministry of Agriculture and Rural Development (MoARD) was restructured in 2002, formulating policies on water harvesting and small-scale irrigation were among the powers and duties vested to it. Since then, MoARD has been promoting household based rainwater harvesting systems, has prepared rainwater harvesting courses and launched Rainwater Harvesting Extension Packages. Ministry of Finance and Economic Development under its policies for Sustainable Development and Poverty Reduction Program (2002) explains the need for rain water harvesting for small scale irrigation. It states the need for adopting strategies and technologies for improved utilizations of runoff and flood water for irrigation. The revised Food Security Strategy (2002) also promotes technologies to undertake rainwater harvesting and management at household level.

In general, a clear rainwater policy is required that can explain the need of legislation on water rights, distribution and utilization and means of how to secure rainwater rights. The roles and responsibilities of the federal and regional governments, civic societies and NGOs should be clearly stated in the policy document. Besides to this, policies which show the integrated management of rainwater harvesting are needed to fully manage and use opportunities of rainwater harvesting for development issues.

1.3.2. Regulator

After the formulation of the policies, strategies and programs, the mandate of regulating rainwater harvesting for small scale irrigation is under Minister of Agriculture and Rural Development while the Ministry of Water, Energy and Irrigation regulates medium and large scale irrigation projects. At regional level these mandates are not clear and are communally shared between the Bureaus of Agriculture and that of Water Resources which creates gaps in ownership of some activities. This in turn results in lack of accountability where each thinks that the other should have done. It is not always clear which institution is responsible for the maintenance and rehabilitation of rainwater schemes. In addition, the roles and responsibilities of Bureaus of Water Resources and Bureaus of Agriculture for some irrigation advisory services lack clarity. So we can say mandate of irrigation among this rainwater harvesting for small scale irrigation development is shared amongst MoARD, MoWR at the federal level and BoARD[1] and BoWR[2] at regional level.

[1] Bureau of Agriculture and Rural Development
[2] Bureau of Water and Resources

1.3.3. Institutional Setup /Supervising

Based on the recent restructuring, federal level responsibilities with respect to development, planning and development of large- and medium-scale irrigation projects fall within the mandate of the MoWR. The small-scale irrigation and water harvesting schemes are planned, implemented and governed under the MoARD at the federal level. The institutional set-up and accountability issues vary from region to region, and are not stable. As a result, there is confusion on mandate, resulting in some cases of scheme failure due to lack of accountability. Some of the regional bureaus' mandates involve planning, design and construction of small-scale irrigation schemes and handover to another bureau for management, operation and maintenance. In the regions of Amhara3, SNNP4 and Tigray, the planning, design and construction of small-scale irrigation is carried out by the regional Irrigation or Water Bureaus and the schemes are then handed over to the Agricultural Bureaus for further implementation, operation and maintenance. This institutional form has led to unsustainable development in many instances. In some other regions, such as Oromia, irrigation schemes are fully implemented by the Oromia Irrigation Development Authority (OIDA). The Authority has its own extension wing and Development Agents (DAs).

1.3.4 System Operation

In rainwater harvesting, we can say there is involvement of governmental and nongovernmental organizations, private sectors, local communities. For instance, government organizations involved in rain water harvesting for small sale irrigation are:

- ✓ Bureaus of Agriculture
- ✓ Agricultural Research Institutes
- ✓ Bureau of Water
- ✓ Bureau of Co-operatives
- ✓ Oromia Irrigation Development Authority (OIDA)
- ✓ Irrigation Development Authority (in case of SNNPR)
- ✓ Rural Development Coordination Office (in case of SNNPR)

Non-governmental organizations and donors are also involved in the name of Integrated Rural Development Projects to undertake rainwater harvesting interventions. Among these:

- ✓ The Ethiopian Rainwater Harvesting Association
- ✓ United States Agency for International Development
- ✓ Swedish International Development Agency,
- ✓ Ethiopian Social Rehabilitation and Development Fund,
- ✓ German Development Cooperation,
- ✓ Canadian International Development Agency,
- ✓ International Fund for Agricultural Development (IFAD),
- ✓ CARE Ethiopia,

- ✓ Organization for Rehabilitation and Development in Amhara
- ✓ Japan International Cooperation Agency
- ✓ Relief Society for Tigray,
- ✓ Catholic Relief Service
- ✓ Farm Africa,
- ✓ World Vision, Lutheran World Federation

Involvement of the private sector is also the direction of the policy of Minister of Water Resources under its general policy objectives No 14. As a result there is a strong involvement of households and local associations like Selam and Wolita Rural Development. But many farmers in semi-arid regions do not own land for water harvesting.

Ethiopia in generally has considerable experience of planning of rainwater harvesting practices for small scale irrigation use. According to Birhanu et al., (2014), the most widely applied is the participatory rain water harvesting approach which was applied in moisture-stressed areas in Ethiopia. This has given hopes that the scheme will be sustainable. However, Moges et al., (2011) suggest that uptake of rain water harvesting systems by smallholders in Ethiopia is limited and the available information. He also suggests that this is associated among others with poor planning and implementation in Ethiopia, Generally, according to Abdulkarim (2002), the Water harvesting system planning and design considerations shall include: Socio-Economic, Agronomic, and Environmental and Institutional/legal aspects.

According to the report of Ministry of Agriculture and Rural Development (2011), the plan for accelerated and sustainable development to end poverty (PASDEP) paper represents the second phase of the Poverty Reduction Strategy Program (PRSP) process, which has begun under the Sustainable Development and Poverty Reduction Program (SDPRP), was also planned to promote and strengthen small-scale irrigation schemes, and improved water use efficiency, including strengthening water harvesting and utilization practices through provision of appropriate technologies. Accordingly, 487,000 hectares of land are planned to be cultivated by the use of irrigation. The extension and training programs will receive particular attention to enhancing farmers' capacities to use water resources efficiently, and help to build the community-level institutional structures necessary for effective irrigation and water resource management. In addition to this, 470,000 water reservoirs/ponds were planned to be constructed for water harvesting and 58,750 hectares of land was planned to be cultivated through irrigation using the water to be harvested at household level in areas of food security. Although the planning period is close to the end, it is not yet known as to how much of the plan was achieved and how effective it was.

1.3.5. Some of the challenges in Rainwater Harvesting Planning

Many government agencies and private sectors/ NGOs lack the technical capacity and tools necessary for efficient irrigation planning and implementation (Seleshi, 2010). No national database is available on existing irrigation projects or irrigation needs, which could make data accessible from the federal to the local level. There is also no reliable baseline data at any level, making it difficult to plan, coordinate, budget, or manage irrigation schemes, e.g., rainwater harvesting baseline estimates vary significantly, from 40,000 to 800,000 hectares.

There is a need to improve communication, community consultation and involvement in project planning and implementation, proper design with adequate timing and reference to local information and indigenous knowledge, technology choice and market related issues, as well as adequate baseline studies prior to implementation. Ambitious irrigation planning without securing sufficient skilled manpower, local capacity to run the schemes (management, financial, and technical capacity) have also been alluded to in nearly all regions as a source of failure. Scheme design or design of irrigation structures should fully incorporate farmer's indigenous knowledge and traditional experience, and take local level capacity into consideration (Ibid).

The report of Ministry of Agriculture (2011) illustrates that at all levels, there exists low institutional capacity which is critical to enhance development of small scale irrigation with respect to development planning, design, implementation, and operation and maintenance including irrigation advisory services. Similarly poor linkages and limited capacities were identified to exist in agricultural research centres and water users' associations.

1.3.6. Environmental Issues

The implementation of small scale irrigation through rain water harvesting has many environmental problems. Some of these include:

(a) In Tigray region, negative impacts of rainwater harvesting were observed like soil salinity and erosion. Furthermore, water related health hazards such as malaria, schistosomiasis, water borne disease and the like are potential consequences. Specially, malaria has become a growing concern in micro-dam areas with altitude lower than 2000m. Therefore, these are the areas that need close monitoring to mitigate ill effects on human health and reduce environmental degradation (Mintesinot and Mitiku, Ud).

(b) In rainwater reservoirs, erosion of catchments leading to increased sedimentation, which reduces the storage capacity of the reservoirs. One opportunity is that farmers are well aware of the problem and are willing to invest in sustainable land and water management interventions (Mitiku and Sorssa, 2002).

(c) According to Carter and Danert (2006),Water demands in the catchment (for irrigation and other uses) in Ethiopian current ecosystems and ecosystem services are generally likely to bring environmental impact, risks of water logging, salinity, erosion and nutrient mining.

(d) Poor drainage facilities have also been found to cause further aggravation of the magnitude of water logging and salinity hazard.

The overall understanding to be drawn from the above narrative is that, the planning of small scale irrigation through rain water harvesting requires considering the benefits as well as countering measures to avert the environmental impacts stated in the above.

1.3.7. Promotion

The promotion and application of rainwater-harvesting techniques as alternative interventions to address water scarcity in Ethiopia was started through government-initiated soil and water conservation programs. The tasks of awareness raising and promotion activities were conducted through workshops, seminars, radio/TV programs, newspapers, exhibitions, etc. In line with this, the Ministry of Agriculture (MoA) has been making some efforts towards the development and promotion of rainwater-harvesting technologies as part of its extension program. However, underdeveloped status and low investment capacity of the Ethiopian private sector has to play its part in the promotion of rainwater-harvesting technologies. According to Mitiku et al., (2002), some NGOs have been involved in promotion of rain water harvesting.

1.3.8. Conflict Resolution

According to Mitiku and Sorsa (2002), generally, when rain water harvesting system is individually owned, it has less likelihood to bring about conflict among users. However there are instances it can be followed by different forms of conflicts. These include:

- Conflicts between use of land for small scale irrigation and for grazing in areas;
- Conflict between upstream and downstream users; and
- Conflict due to absence of policies regarding abstraction rights

According to Carter and Daner (2006), policies regarding abstraction rights exist on paper but there is little experience of putting them into practice. As a consequence, the legal or regulatory framework for resolving issues over water rights is absent in practice. Although communities tend to start off trying to resolve such conflicts peacefully, these attempts are not always successful. Thus, management, operation and maintenance are critical measures to be considered for sustainability of WH system which involves: organizing farmers for maintenance, resolving conflicts and distribution of water to the beneficiaries. The conflict resolving measures can be of different forms one of which is traditional way as is evidenced in traditional conflict resolution mechanisms in the middle Awash and north Afar.

1.4. Policy Framework of RWHI Generation

1.4.1. RWHI in the Political Constitution

The Ethiopian constitution has several provisions which have direct policy, legal and institutional significance for the management of the water resources of the country. Article 40(3) of the Constitution provides for the public ownership of both rural and urban land as well as all natural resources. Thus, the water resources of the country both surface and underground waters are part of the public domain and are therefore vested in the State. The constitution provides mandate for the Federal Government to enact laws for the utilization and conservation of land and other natural resources including water resources of the country (Article 51.5) while the Regional States have the mandate to administer land and other natural resources in accordance with federal laws (Article 52.2d). This means that Regions have to abide by the laws of the Federal Government in administering and managing the water resources within their Regions.

More specifically, the Constitution demands that the Federal Government shall determine and administer the utilization of the waters or rivers or lakes linking two or more States or crossing the boundaries of the national territorial jurisdiction (Article 51(11)). This gives the Federal Government very broad powers as regards water resources management, determination and regulation of the use, allocation and protection of the water resources of the country as well as its administration since almost all the major water resources in the country are shared by two or more Regional States and therefore "link" the Regional States. Since powers not given expressly to the Federal Government are reserved to the Regional States (Article 52.1), this indicates that water resources which are confined within a certain region will be administered by the respective Regional States subject to the laws issued by the Federal Government. This contradicts to the principles of Integrated Water Resources Management (IWRM) and the river basin approach that are both pillars of the Ethiopian Water Resources Management Policy (WRM Policy) and there is no provisions addressing inter-sectorial coordination and linkages.

One other important provision of the Federal Constitution is that the Federal Government may delegate its powers and functions granted to it under Article 51 of the Constitution to Regional States (Article 50.9 of the Constitution). In other words, the executive arm of the Federal Government responsible for water resources currently the Ministry of Water Resources and Energy (MoWRE)) may delegate some of it powers and responsibilities given to it by law to Regions when it deems it necessary for the effective management and administration of the water resources of the country. It is only through delegation, therefore, that Regional States may exercise the functions given to the Federal Government under the Constitution. Therefore, the constitutional provisions regarding the management and administration of water resources in Ethiopia indicates that it is the Federal Government that is given a more or less centralized authority for water resources planning and management in Ethiopia. Regional States have limited powers with respect to issuing laws and decision-making regarding the allocation and use of the water resources of the country, unless they are specifically delegated some of the mandates given to the Federal Government by subsidiary laws and hence centralization vs. decentralization is not clearly addressed.

The Federal system of Government also recognizes the importance of decentralized management and the active participation of the respective regional states and other stakeholders in the development and management of natural resources including the water resources of the country. Stakeholders' participation in national development activities and to be consulted in with respect to projects affecting their communities and, more specifically women, is preserved as a right in the Constitution (Articles 43(2) and 35(6)).

1.4.2. RWHI in the National Development Plans

A. **Agricultural Development Led Industrialization (ADLI) policy**: Ethiopia's Agricultural Development Led Industrialization (ADLI) policy has been a strategic pillar in the development programs of the country since the early 1990s. Its goals were to derive agricultural growth and tremendously boost smallholder irrigators' productivity in rural and pastoral areas of the country (S.B. Awulachew, 2010).

B. **Rural Development Policy and Strategy of Ethiopia**: Drought-prone regions of Ethiopia are given special attention in the Rural Development Policy and Strategies (MoFED, 2003 cited in) and development intervention is cantered on ensuring food security. The strategy is based on small scale water resource development including water conservation and medium-size irrigation dam construction for growing high value products and sedentary livestock production for the pastoral areas. This is again an indirect reference to the use of rainwater harvesting. The only sustainable way that water conservation and irrigation can be done in such localities is by way of harvesting rainwater (Yohannes Aberra, 2014).

C. Environmental Policy (1997): The Environmental Policy of Ethiopia, (FDRE, 1997) which was designed by the Environmental Protection Authority in collaboration with the then Ministry of Economic Development and Cooperation, was adopted and issued in April 1997. The Policy has incorporated sector specific environmental policy provisions for water resources and related sectors. The specific policy guidelines pertinent to the management of water resources aim to: involve water resource users in the management of water policies, programmes and projects; ensure consideration of environmental health hazards in the design, construction and use of dams and irrigation systems; integrate the rehabilitation and protection of wetlands and upstream forests into the conservation, development and management of water resources; promote the protection of the interface between water bodies and land; and subject all major water conservation, development and management projects to the environmental impact assessment process.

D. Water resource management policy: The basic policy document applicable for the water sector in Ethiopia was issued in 1999 in the form of the Water Resources Management Policy (MoWR, 1999). This was followed by the development and adoption of the National Water Sector Strategy in 2001 and the Water Sector Development Programme in 2002. The goals and objectives of these documents were subsequently incorporated into the overall development policy framework set out in the Sustainable Development and Poverty Reduction Program (SDPRP). Thus, the water resources management policy, strategy and programme formed the applicable policy framework for the water sector. As with any policy, it is basically an instrument for achieving the intended goals and objectives in a given sector. The policy recognizes that it is based on the constitutional provisions for water resources management and the overall macro-economic, social policies and development policies of Ethiopia.

The general objectives of the policies are:

- development of the water resources of the country for economic and social benefits of the people, on equitable and sustainable basis;
- allocation and apportionment of water based on comprehensive and integrated plans and optimum allocation principles that incorporate efficiency of use, equity of access, and sustainability of the resource;
- managing and combating drought as well as other associated slow on-set disasters through efficient allocation, redistribution, transfer, storage and efficient use of water resources;
- combating and regulating floods through sustainable mitigation, prevention, rehabilitation and other practical measures; and
- Conserving, protecting and enhancing water resources and the overall aquatic environment on sustainable basis.

With respect to the fundamental principles that should inform water resources management, the Policy states that: Water is a natural endowment commonly owned by all the peoples of Ethiopia; As far as conditions permit, every Ethiopian citizen shall have access to sufficient water of acceptable quality, to satisfy basic human needs; In order to significantly contribute to development, water shall be recognized both as an economic and a social good; Water resources development shall be underpinned on rural-cantered, decentralized management, participatory approach as well as integrated framework; Management of water resources shall ensure social equity economic efficiently, systems reliability and sustainability norms and Promotion of the participation of all stakeholders, user communities; particularly women's participation in the relevant aspects of water resources management.

With regards to the irrigation policy of the country, one of its specific objectives stress among others, the development and enhancement of small scale irrigated agriculture and grazing lands for food self-sufficiency at the household level which linked with rainwater harvesting.

The above policy provisions shows that the State holds water resources in public trust and the water resources development and management should be strengthened by a decentralized approach by ensuring the participation of all stakeholders in decision-making in all aspects of water resources management.

Ethiopian water resources management policy has been directly related to rainwater harvesting and small scale irrigation. The policy document has statements in its opening, which shows the importance of rainwater harvesting. Water resources in Ethiopia are uneven in their spatial and temporal distribution. Two of the five general policy objectives-manage and combat drought and floods through efficient storage and rehabilitation measures are actions which can better be achieved through the implementation of appropriate rainwater harvesting technologies. Moreover, three of the six principles of the policy, which include decentralized management, participatory approach, equity, efficiency, reliability and sustainability, are consistent with the water resource management approach characteristic of rainwater harvesting systems. Irrigation policy emphasizes the need to develop and develop small-scale irrigated agriculture and grazing lands for food self-sufficiency at the household level. This is a policy area that is inseparability linked with rainwater harvesting.

The Sustainable Development and Poverty Reduction program, SDPRP lasts for three years between 2002/3 to 2004/5, which is also referred to as plan for accelerated and Sustained Development to end poverty (PASDEP), listed rainwater harvesting alongside small scale irrigation as one of the major thrusts of Ethiopia’s sustainable development and poverty reduction program. PASDEP I years were full of events with regards to rainwater harvesting. The widespread pond program was not a successful endeavour in many places creating among policy makers and planners a sense of disillusionment with the technology. At the end of the final year of PASDEP I PASDEPII was launched for the following five years (2004/5-2009/10). Unlike the previous, rainwater harvesting was just mentioned as one of the several development approaches in the moisture stressed areas. The current National plan period (2010/11-2014/15), PASDEP III is known as the Growth and Transformation plan, GTP, (FDRE, 2010). The main objectives to be attained during this plan period are poverty eradication and the Millennium Development Goals. Rainwater harvesting is barely named in the plan document (Yohannes Abera, 2014).

The current Growth and Transformation Plan (GTP) (MoFED, 2010 cited in Tesfaye Zeleke et al.. 2014) provides more resources to developing irrigation on all scales, and puts equal emphasis on big commercial farmers. According to FDRE (2010–2014/15), Ethiopia specifically plans to add 658,340 ha of medium- and large-scale irrigation by 2014/15, which is five times the number (i.e., 127, 243 ha) developed during the base year (2009/10). Similarly, the projected development of SSI is an increase of additional 1,000,000 ha by 2014/1.

1.5. Legal and Regulatory Framework of the RWHI Sector

1.5.1. General Laws

The management of water resources involves key activities that have to be undertaken as the core functions of dedicated water sector institutions. These functions generally include the following three categories: Water resource management comprising the allocation of water rights (or rights to use water), management and control of abstractions from water sources, management and control of water quality, overall responsibility for developing water resources, and catchment management roles and responsibilities; Water supply provision undertake the management of infrastructure for transmission, storage, and treatment; management of retail water and sanitation services (distribution); and, setting of tariffs and standards for service delivery. Sector functions include monitoring of water resources and water usage, information management, and education, training and capacity development. The major enabling and substantive laws applicable to the water sector that have been promulgated since the adoption of the Water Resources Policy include:

A. Water Resources Management Proclamation (Proclamation No. 197/2000)

The Ethiopian Water Resources Management Proclamation, issued in March 2000 (Proclamation No.197/2000), is currently the basic legal instrument governing the management, planning, utilization and protection of water resources in Ethiopia. The Proclamation provides the fundamental principles that need to be taken into account for the management and administration of the water resources in the country (Article 6). The basic thrust of these fundamental principles is that water resources management and administration in the country should be based on the Ethiopian WRM (currently the Ministry of Water Resources and Energy) Policy the Integrated Basin Master Plan Studies and the water resources laws of the country. It also stipulates that the management of water resources of Ethiopia shall be based on a permit system (Article 6). The MoWR is designated as the “Supervising Body” at the federal level where it pertains to water resources at the central level, or any organ delegated by the Ministry. The latter is further elaborated in Article 8.2 of the Proclamation which says, “The

Supervising Body may, where necessary, delegate its powers and duties to the appropriate body for efficient execution of its duties.

B. Water Resources Management Proclamation (Proclamation No. 471/2005);

The major piece of legislation defining the mandates of the MoWR is the Definition of Powers and Duties of the Executive Organs of the Federal Democratic Republic of Ethiopia Proclamation (Proclamation No. 471/2005). The powers of the Ministry under this proclamation include the following mandates pertinent to water sector monitoring (article 27): undertaking basin studies and determine the country's ground and surface water resource potential in terms of volume and quality, and facilitate their utilization; determining conditions and methods required for the optimum and equitable allocation and utilization of water bodies that flow across or lie between more than one Regional States among various uses and the regional States; undertaking studies and negotiations of treaties pertaining to the utilization of boundary and trans-boundary water bodies, and follow up the implementation of same; cause the carrying out of study, design and construction works to promote the expansion of medium and large irrigation dams; and, ensuring the provision of meteorological services.

C. Water Resources Management Regulations (Council of Ministers Regulation No. 115 /2005)

The Ethiopian Water Resources Management Regulation was issued by the Council of Ministers in March 2005 (Regulation No. 115/2005). The objective of the Regulation is to give detailed provisions for the effective implementation of its parent legislation, the Water Resources Management Proclamation. A review of the Regulation shows that it is mainly a further elaboration of the Proclamation providing in detail the main requirements for the issuance of permits for different uses of water; construction works; waste water discharge as well as providing the conditions for the issuance, renewal, revocation etc. of such permits. It also provides provisions for fees for application for permits as well as the requirements of water charges to be paid for different uses of water although the amount of charges payable are left to be determined by the Council of Ministers and issued in a subsequent regulation (Article 31.4) (Imeru Tamrat(2008).

D. River Basin Councils and Authorities Proclamation (Proclamation No. 534/2007)

The approach taken in Ethiopia currently is to decentralize water resources planning and management functions to regional state at the basin level. Accordingly, River Basin Organizations (RBOs) are to be established phase-by-phase in each of the river basins of the country and most of the functions of the Federal government delegated to such river basin organizations. The River Basin Councils and Authorities Proclamation was issued in July 2007 (Proclamation No. 534/2007). The Proclamation is envisaged as an enabling legislation for the establishment of regional bureaus (RBOs) for each river basin of the country by subsequent subsidiary legislation. To this effect, the Proclamation provides that River Basin High Councils and Authorities shall be established by Regulations to be issued by the Council of Ministers (Article 3.1). In other words, the Council of Ministers is given the mandate to create specific regional bureaus (RBOs) through more detailed regulations which will further elaborate the powers and responsibilities of the RBOs to be established in the respective basins of the country. The Proclamation also provides for the possibility of merging two or more river basins under the jurisdiction of a single RBO (Article 3.2). The Proclamation provides for a two-tier organizational set-up for the RBOs to be established, namely, River Basin High Councils being the highest policy and strategic decision-making body and River Basin Authorities, which will be the administrative/technical arm of the respective Basin High Councils.

Though not directly related to Rain Water Harvesting and Small Scale Irrigation, there are also other laws relevant to the water sector in general such as: Council of Ministers Regulation to Establish Abay Basin High Council and Authority (Regulation No. 151/2008) issued by the Council of Ministers as per article 21/1 of Proclamation No. 534/2007 are enabling and substantive laws applicable to the water sector.

1.5.3. Technical Standards

(i) Planning and Identification of SSI Schemes

The process of planning in SSI should preferably start with understanding of what already exists and by assessment of the potential. There were some efforts by different organizations to make inventory of the existing schemes. However, they are all incomplete and fragmented as different organizations have done the inventory in an isolated manner having little/no information exchange among them (Yalew Belete et al.,., 2011). Furthermore, the data collected are by and large incomplete or insufficient to assist the overall planning.

(ii) Study, Design and Construction

Appropriate guidelines and manuals to facilitate production of standardized study, design, and quality control is an essential one. To this effect knowledge and adequate capacity for database generation and management is basic. In addition, laboratory facilities for soil and water analysis, proper consultation of beneficiaries and all stakeholders at each stages of project implementation is the other critical issues which affects operational efficiency and sustainability. Furthermore, availability of field and office equipment, laboratory facilities for soil and water analysis and agro-meteorological stations at schemes level are identified as critical in the study, design and irrigation water management (ibid).

(iii) Operation and maintenance of SSI schemes

Clear and transparent operation and maintenance manual is one of the essential elements affecting SSI scheme. Agricultural offices at woreda level, which are expected to play a pivotal role in this respect, do not have the necessary staff and commitment in most cases (ibid). Proper diversion, regulation, storage and controlling structures are among the major issues in operation and maintenance of SSI scheme particularly in the traditional schemes.

1.6. Analysis of Potentials and Barriers for RWHI Generation Regarding the Political and Institutional Frameworks

1.6.1. Opportunities

The main opportunities are:

1. Strong political will from government leadership that is the government emphasis on the development of irrigation and water resource management by enactment of different laws and proclamations.
2. Conducive SSI sub-sector policy environment: the water resource management policy (1999) is one of the area of focus of the government for small scale irrigation development and High emphasis and priorities accorded to SSI in the development plan of the country
3. Abundant water resources that can be tapped for irrigation use: Ethiopia has significant rainfall. Based on grid-based average annual rainfall and the land area, it is estimated that Ethiopia receives about 980 billion (~1 trillion) cubic meters (m^3) of rain a year (Seleshi Bekele, 2010).
4. Ethiopia comprises 112 million hectares (Mha) of land. Cultivable land area estimates vary between 30 to 70 Mha. Currently, high estimates show that only 15 Mha of land is under cultivation. For the existing cultivated area, the estimate is that only about 4 to 5 percent is irrigated, with existing equipped irrigation schemes covering about 640,000 hectares. These irrigation schemes vary widely in size and structure, from micro irrigation (RWH), to river diversion, pumping, and small or large dams, etc. However, it is estimated that total irrigable land potential in Ethiopia is 5.3 Mha assuming use of existing technologies, including 1.6 Mha through RWH and ground water (ibid). This means that a significant portion of cultivated land in Ethiopia is currently not irrigated and hence there are potential opportunities to vastly increase the amount of irrigated land.
5. Government effort to encourage private sector involvement in the study, design and development, including management of irrigation

1.6.2. Barriers

The government of Ethiopia has increased its focus on irrigation development and dedicated more resources to it. But while targets have been ambitious, deliveries have failed to meet many of the irrigation targets. A significant gap between plans for irrigation projects (number of projects, number of hectares to be irrigation) and the actual construction or delivery of these projects has been observed. For example

MoWR planned to construct 128,000 hectares of medium- and large-scale irrigation schemes in the original PASDEP plan, but actually constructed projects covering only about 43,000 hectares by 2010, which is 66 percent below target. In the same plan, MoARD planned 389,000 hectares for small-scale irrigation projects but was able to implement only 285,000 hectares by 2010 (27 percent less than planned) (S. B. Awlachew, 2010). In addition, there is underperformance of existing irrigation schemes. Many irrigation projects are operating significantly under their design capacity. These constraints are caused by some of the factors mentioned bellow.

1. Institutional Mandate and Accountability

Based on the recent restructuring, federal level responsibilities with respect to development, planning and development of large- and medium-scale irrigation projects fall within the mandate of the Ministry of Water Resource (MoWR, now the Ministry of Water, Irrigation, and Energy, or MoWIE) The small-scale irrigation and water harvesting schemes are planned, implemented and governed under the Ministry of Agricultural Rural Development (MoARD) at the federal level. The institutional set-up and accountability issues vary from region to region, and are not stable. As a result, there is confusion on mandate, resulting in some cases of scheme failure due to lack of accountability. Some of the regional bureaus' mandates involve planning, design and construction of small-scale irrigation schemes and handover to another bureau for management, operation and maintenance. In the regions of Amhara, SNNP and Tigray, the planning, design and construction of small-scale irrigation is carried out by the regional Irrigation or Water Bureaus and the schemes are then handed over to the Agricultural Bureaus for further implementation, operation and maintenance. This institutional form has led to unsustainable development in many instances. In some other regions, such as Oromia, irrigation schemes are fully implemented by the Oromia Irrigation Development Authority (OIDA). The Authority has its own extension wing and Development Agents (DAs) (S. B. Awulachew, 2005).

2. Institutional Capacity and Capability

Across many levels of the government (from *kebele*/*woreda*, to regional/zone and federal level), there are significant institutional challenges that prevent irrigation plans from being fully implemented. These include no standardized approach across agencies for mapping/monitoring existing projects; lack of institutional memory; and insufficient technical staff. Decision makers also do not have guidelines or systems for prioritizing investment decisions and project pipelines, which prevents efficient ranking and budgeting based on needs and resources (Seleshi Bekele, *et al.,* 2010). Lack of transparency on existing and planned schemes (especially small scale) and insufficient inter-ministerial and federal/regional information sharing; Lack of clear project prioritization guidelines for effective trade-off decisions Additionally, shortage of funds, execution capacity and capability.

3. Technical Capacity and Tools

Many government agencies and private sector/ NGO stakeholders lack the technical capacity and tools necessary for efficient irrigation planning and implementation. No national database is available on existing irrigation projects or irrigation needs, which could make data accessible from the federal to the local level. There is also no reliable baseline data at any level, making it difficult to plan, coordinate, budget, or manage irrigation schemes (Seleshi Bekele, *et al.,* 2010).

4. Socio-economic constraints

As stated by Yalew Belete *et al.,.,* 2011 the socio-economic constraints that affect irrigation development are:- Inadequate community involvement and consultation in scheme planning, construction and implementation of irrigation development; Poor economic background of users for irrigation infrastructure development, to access irrigation technologies and agricultural inputs, where the price increment is not affordable to farmers; Increasing conflicts between upstream and downstream users for the available resources; Lack of or low level of awareness of users about irrigated agriculture; Increasing evidence of land fragmentation restricted diversification of high value crops; Poor physical infrastructures for the development of irrigated agriculture.

5. Inadequate policies and regulations

The GOE lacks a regulatory framework for many issues surrounding irrigation schemes, including water fees, water rights, water conflict resolution, incentives for collaboration between the local, regional, and federal levels; incentives for accurate reporting of current projects, etc. All of these gaps increase the risk and uncertainty of many irrigation schemes and prevent many projects from being realized (Seleshi Bekele, *et al.,* 2010).

6. Human capacity

Human capacity is limited across multiple government and private sector actors. This includes a shortage of skilled workers (e.g., engineers, designers) to build and maintain projects and a lack of basic irrigation skills among farmers and development agents to operate and maintain small-scale projects (Seleshi Bekele, *et al.,* 2010).

1.7. Key lessons/opportunities for RWH

As discussed in the earlier sections, the country has substantial water resource potential. What is constraining production is access to appropriate water and land management technologies, infrastructure and institutional support services (including roads, markets, financial institutions), and an enabling environment for effective private sector involvement. The lessons with rainwater harvesting vary from one part of the country to the other, while huge opportunities exist for supporting RWH on a sustainable basis. Some of these opportunities and lessons are highlighted below:

- Several NGOs and regional bureaus have assessed the water potential in their areas of operation to be huge. If this is exploited efficiently, it would contribute significantly towards poverty reduction and to solving the country's food security problems, especially if irrigation of food crops, along with high value crops, is emphasized.

- All the communities covered in the surveys indicated willingness to participate in any form of water harvesting intervention that will improve their current livelihoods. This is a good opportunity that reflects a potential for local level participation and cooperation. This willingness should be taken advantage of especially during the planning and implementation of water harvesting projects, thorough community consultations, which is critical for sustainability once the active support phase has ended.
- Large numbers of donors, NGOs and the Ethiopian government are willing to support initiatives of rainwater harvesting in Ethiopia. Perhaps the most direct impact of water harvesting on food security is through livestock (main use of many ponds), which could be supported along with conventional use for irrigation. Research institutions (including IWMI) are also interested in collaboration through research and professional guidance to facilitate successful implementation and to achieve positive food security impacts.
- A wide range of rainwater harvesting technologies now exist worldwide (e.g. in Asia, Southern Africa and Western Africa, etc.); the issue is mainly that of access, adaptation and adoption, and also the creation of local community level institutions for successful implementation.

Most regions in Ethiopia obtain rainfall amounting to over 600 mm, albeit with spatial distribution and unreliable temporal availability. If this rainfall could be better used through rainwater harvesting to overcome dry spells, it could provide reliable food production at least once, or possibly twice a year. Areas with more rainfall could also be made productive through soil moisture maximization and shallow well development, etc., to achieve a higher cropping intensity.

Chapter 2

Analysis of Research and Innovation Needs in the Field of Rainwater Harvesting and/or Small-Scale Irrigation

2.1. Introduction

Research comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. It is used to establish or confirm facts, reaffirm the results of previous work, solve new or existing problems, support theorems, or develop new theories. The primary purposes of basic research (as opposed to applied research) are documentation, discovery, interpretation, or the research and development (R&D) of methods and systems for the advancement of human knowledge. There are several forms of research: scientific, humanities, artistic, economic, social, business, marketing, practitioner research, etc. Innovation is a new idea, device or process. Innovation can be viewed as the application of better solutions that meet new requirements or existing market needs. This is accomplished through more effective products, processes, services, technologies, or ideas that are readily available to markets, governments and society. Innovation differs from invention in that innovation refers to the use of a better and, as a result, novel idea or method, whereas invention refers more directly to the creation of the idea or method itself. Innovation differs from improvement in that innovation refers to the notion of doing something different rather than doing the same thing better.

In an effort to address the problems of recurrent drought, famine and food insecurity, attempts are made to harvest rainwater for use in small scale irrigation schemes. It is recognized that harvesting of rainwater with proper small scale irrigation and agronomic services and vital support for proper watershed management will result in microclimatic and environmental changes with positive impact on sustained productivity (Awulachew et al.,., 2005, Gezahegn et al.,., 2006). Withstanding the importance of these positive impacts on increased agricultural productivity and improved community welfare, the potential negative impacts of water sources development is minimal in this case.

Promotion of water related technologies in Ethiopia, at small and large scales, makes good sense for a number of reasons, and there are basically good opportunities for both. Large scale irrigation schemes and technologies are relatively well known and the government has already plans to promote these systems actively. Some types of small scale technologies including rainwater harvesting and small scale irrigation technologies, however, are still relatively new in

Ethiopia. Hence the aim of this section is to analyse research and innovation needs in the field of rainwater harvesting and small scale irrigation in Ethiopia

2.2. Available and Planned Institutions and Main Research Areas

The institutions, which are directly involved in the research, design, implementation, and maintenance of the rainwater harvesting structures, are shown in Table 2.1 below.

Table 2.1: Institutions involved in rainwater harvesting

Institutions		**Involvement**			
Category	Name	Re-search	Design	Implemen-tation	Main-tenance
Government (federal/ Regional)	Water Bureau		√	√	√
	Irrigation Bureau		√	√	√
	Agriculture/Rural Development	√	√	√	√
	Education bureau (at schools)			√	√
NGO and Civil Societies (local/ international)	RiPPLe	√	√		
	ECC-SDCOH	√	√	√	√
	Oxfam		√	√	√
	CRS	√			
	IRC		√	√	√
	ZOA		√	√	√
Higher learning Institutions	Arba Minchi U	√	√		
	Haramaya Uni	√	√		
	Hawassa Uni	√	√		
	What about Mekelle University and Rift Valley University?				
Private Enterprise					

The institutions, which are directly involved in the research, design, implementation, and maintenance of small scale irrigation, are shown in Table 2.2 below.

Table 2.2: Institutions involved in small scale irrigation

Institutions		**Involvement**			
Category	Name	Re-search	Design	Implemen-tation	Main-tenance
Government (federal/ Regional)	Water Bureau		√	√	√
	Irrigation Bureau		√	√	√
	Agriculture/Rural Development	√	√	√	√
	Education bureau (at schools)			√	√
NGO and Civil Societies (local/ international)	ECC-SDCOH		√	√	√
	IRC		√	√	√
	CRS		√	√	√
	World Vision		√	√	√
	IFAD	√	√	√	√
Higher learning Institutions	Arba Minchi U	√	√		
	Haramaya Uni	√	√		
	Hawassa Uni	√	√		
Private Enterprise	Yirgalem Construction Enterprise		√	√	√

The respondents suggested RWH can be improved and extended through:

- Better training
- Linking of training institutions and government extension services
- Improvement of the awareness of decision makers;
- More applied research to adapt recognized RWH techniques
- Better documentation of projects detailing with best practices and lessons learnt
- Better cooperation between projects and RWH interventions
- Regular contact and information exchange with communities
- Integration of rainwater harvesting interventions with other activities
- A longer-term commitment by donors and government to support RWH
- Institutionalization of RWH guidelines, manuals and technical papers
- Enhancing sense of ownership for communal structures by the communities
- Establishing central data base for RWH information and relevant

- design guidelines and manuals
- Appropriate means for funding community based RWH

The main Institutional Gap Analysis

The collected primary and secondary data shows the following main institutional gaps:

1. **Implementation gaps**: Ethiopia has a relatively comprehensive policies and strategies but many of these are not implemented efficiently and effectively. Most of this is attributed to institutional capacity weaknesses (Woldeamlak, 2009). Specifically it concerns how small scale irrigation and rainwater harvesting activities are organized from the technical and budgetary perspectives, as well has how the available human, financial and physical resources are used. The Government has already embarked on the task of rectifying these problems within MoARD via the civil service reform process. To this end MoARD is piloting a programme budgeting approach under the guidance of MoFED. This will enable performance to be monitored against budgets and measurable targets.

2. **Capacity limitation**: There are systemic capacity limitations at all levels and in all of the sectorial institutions, but the problem is most severe at the woreda level. Capacity limitations include human resources, working premises, equipment, communications, machinery, furniture and other facilities. The civil service reform process aims to make the most efficient use of available resources, but resource limitations also need to be addressed. ATVETs and FTCs require capacity building in order to upgrade the skills of DAs and Subject Matter Specialists, and to provide then with the essential small scale irrigation and rainwater harvesting technologies (Awulachew and Bekele, 2010).

3. **Responsibility gap**: Responsibility for irrigation development is shared amongst MoARD, MoWE, and regional Bureau of Water Resources. Whilst demarcation of responsibilities for construction of small, medium and large irrigation schemes is well defined, the responsibility for operation and maintenance, including the role of water user associations is less certain (Awulachew et al.,., 2007). Given the prominence of irrigation in Ethiopia's food security plans, there is also a need to strengthen planning and design of small scale irrigation schemes, including community participation and environment impact assessment, and to strengthen irrigation extension services and water user associations.

4. **Issue of land tenure**: Despite the proliferation of policy documents, the issue of land tenure has yet to be fully resolved in a manner which can give a strong perception of security to smallholder farmers. This area of national policy is in a state of flux however, and the government has announced that there would be no further redistribution of land.

5. **Gulf between policy and actual practice**: The gulf between stated policy and actual practice is often deep (Amare, 2013). One notable example is that despite the existence of federal legislation on the subject of water resources management (the Ethiopian Water Resources Management Proclamation No. 197/2000), water abstraction is not tightly controlled or enforced. There would appear to be a lack of

political will and/or insufficient resources at both federal and regional levels to enforce a law which requires "the Supervising body" (defined as the Ministry of Water Resources or any other "appropriate body") to keep an inventory of water resources and registration of actions with respect to applications for water abstraction, issue of permits for this and other purposes, and collect water charges from users (Teshome, 2006).

Research Needs

According to the respondents, the research needs in RWHI are:

- Policy research
- Institutional research
- Socioeconomic and market research
- Research to enhance yields in irrigation schemes
- Water technologies
- Hydrological research
- Environment and health
- Gender research
- Geological and drainage catchment

Universities (like Arbaminch, Haromaya, and other working in the water development sector), Ministry of Water Resource, NGOs (like RAIN Foundation, RiPPLE, IRC, etc.), Ethiopian Water Resource Development, Regional Research Centres and Research Institute, etc. are dealing with research on water harvesting.

2.3. Main Research Outputs and Outcomes

Key features of the RWHI in Ethiopia

The collected primary and secondary data reveals that the rainwater harvesting and small scale irrigation in Ethiopia are characterized by (a) low service levels; (b) limited financing and spending; (c) decentralization and capacity constraints; and (d) low involvement of the private sector or civil society. Rainwater harvesting coverage is relatively low. Disparities are also evident among national regional states. Delivery capacities vary between the more developed regions of Oromia, Amhara, Southern Nations, Nationalities and People's Region State (SNNPRS), Tigray, Harari and the emerging regions of Afar, Somali, Benishangul-Gumuz and Gambella (Yazew et al.,., 2006). Shortage of finance is detected to be a major bottleneck for expanding service levels, or improving service sustainability, at least at woreda level. This is attributed to a shortage of national budgets, limited capacity to absorb existing budgets at local level and weak revenue generation for self-financing at local levels. Decentralization processes have been partial and incomplete and there is an acute shortage of qualified and trained human resources, particularly at lower tiers of government (World Bank, 2008). In spite of increasing levels of stakeholder involvement in decision making, the involvement of the private sector or civil society in the design, construction, operation and maintenance of water supply systems is relatively low (Desta, 2010).

Constraints, knowledge gaps and future opportunities of RWH for SSI

The identified constraints of RWH for SSI were:

- Lack or inadequacy of baseline studies
- Poor technology choice
- Low yields
- Property rights
- Too small landholdings
- Conflicts in water use and use rights
- Marketing and market access
- Dependency syndrome
- Institutional arrangements and instability
- Lack of training to handle technologies; lack of extension services
- Lack of start-up capital or access to credit to initiate venture
- Poor linkage between research and extension in the area of small scale irrigation

The identified knowledge gaps were:

- Faulty design
- Lack of knowledge on use of modern small scale irrigation technology
- Poor water management
- Poor land management
- Poor input utilization
- Poor management capacity
- Lack of information and database
- Lack of post-harvest technology and management

The suggested future opportunities are:

- High water potential
- High commitment of the government of Ethiopia, donors and NGOs to support rainwater harvesting and small scale irrigation management and development activity at local level
- Opportunity for implementing multiple use of water systems (MUS); and
- Opportunities for improving knowledge of policy makers, planners, designers, contractors and development agencies through education, training, dialogues and participation

2.4. Conclusions and/or Recommendations

The government institutions those are involved in rainwater harvesting are Water Bureau, Irrigation Bureau, Agriculture and Rural Development Office and Education bureau (at schools). All of them are involved in implementation and maintenance of rainwater harvesting structures. Most of them are involved in the design of those structures. Only the Agriculture and Rural Development Office is involved in the research activities. The NGOs and civil societies involved in the rainwater activities are RiPPLe, ECC-SDCOH, Oxfam, CRS, IRC and ZOA. All of them are involved in the design, implementation and maintenance of the rainwater harvesting structures. RiPPLe, ECC-SDCOH and CRS carry also some research works. Higher institutions such as Arba Minchi University, Haramaya University and Hawassa University are also involved in research and design of water harvesting structures.

Government Institutions involved in small scale irrigation activities are Water Bureau, Irrigation Bureau, Agriculture and Rural Development Office and Education bureau (at schools). Agriculture and Rural Development Office carries out research, design, implementation and maintenance in small scale irrigation. Education bureau carries out implementation and maintenance works at school level. The others carry out design, implementation and maintenance. The NGOs and civil societies those are involved in small scale irrigation ECC-SDCOH, IRC, CRS, World Vision and IFAD. IFAD carries out research, design, implementation and maintenance in small scale irrigation. The rest are involved in design, implementation and maintenance. Higher institutions such as Arba Minchi University, Haramaya University and Hawassa University are also involved in research and design of water harvesting structures. A private enterprise called Yirgalem Construction Enterprise is also involved in the design, implementation and maintenance of small scale structures.

The questionnaire, interview and field visits, which were used as tools for the data collection, revealed that the main constraints of rainwater harvesting for small scale irrigation are lack or inadequacy of baseline studies; poor technology choice; low yields; property rights; too small landholdings; conflicts in water use and use rights; marketing and market access; dependency syndrome; institutional arrangements and instability; lack of training to handle technologies; lack of extension services; lack of start-up capital or access to credit to initiate venture; and poor linkage between research and extension in the area of small scale irrigation

The identified main knowledge gaps were faulty design; lack of knowledge on use of modern small scale irrigation technology; poor water management; poor land management; poor input utilization; poor management capacity; lack of information and database; and lack of post-harvest technology and management. The identified research needs in RWHI were policy research; institutional research; socioeconomic and market research; research to enhance yields in irrigation schemes; water technologies; hydrological research; environment and health; gender research; and geological and drainage catchment.

There appears the necessity of improving and extending the use of rainwater harvesting for small scale irrigation through:

- Better training
- Linking of training institutions and government extension services
- Improvement of the awareness of decision makers;
- More applied research to adapt recognized RWH techniques
- Better documentation of projects detailing with best practices and lessons learnt
- Better cooperation between projects and RWH interventions
- Regular contact and information exchange with communities
- Integration of rainwater harvesting interventions with other activities
- A longer-term commitment by donors and government to support RWH
- Institutionalization of RWH guidelines, manuals and technical papers
- Enhancing sense of ownership for communal structures by the communities
- Establishing central data base for RWH information and relevant
- design guidelines and manuals
- Appropriate means for funding community based RWH

The following future opportunities of RWH for SSI were identified:

- High water potential
- High commitment of the Ethiopia government, donors and NGOs to support rainwater harvesting and small scale irrigation management and development activity at local level
- Opportunity for implementing multiple use water systems (MUS), with regions coordinating sub-activities. Effective utilization of scheme infrastructure through diversification of uses to meet various needs for water such as domestic, irrigation, livestock and hygiene is the most important.
- Opportunities for improving knowledge of policy makers, planners, designers, contractors and development agencies through education, training, dialogues and participation

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Chapter 3

Analysis of Regional Capacity and Training Needs in the Field of RWHI

3.1. Introduction

Community capacity building (CCB), also referred to as capacity development, is a conceptual approach to development that focuses on understanding the obstacles that inhibit people, governments, international organizations and non-governmental organizations from realizing their development goals while enhancing the abilities that will allow them to achieve measurable and sustainable results. Capacity building often refers to strengthening the skills, competencies and abilities of people and communities in developing societies so that they can overcome the causes of their exclusion and suffering. Training is the acquisition of knowledge, skills, and competencies as a result of the teaching of vocational or practical skills and knowledge that relate to specific useful competencies. Training has specific goals of improving one's capability, capacity, productivity and performance. Training is required to maintain, upgrade and update skills throughout working life.

The issue of capacity building has become a major priority within the global conventions, the Global Environment Facility (GEF) and the international community. Recent events such as the World Summit on Sustainable Development (WSSD) and the Second GEF Assembly reaffirmed the priority of building the capacity of developing countries. The GEF Secretariat, in consultation with the Implementing and Executing Agencies, is developing a strategic framework to give greater focus to capacity building in the GEF. In May, 1999, the GEF Council, aware of the growing importance being assigned by the conventions to capacity building as well as the fragmentation of efforts to address this need, approved the 18-month Capacity Development Initiative (CDI) as a strategic partnership between the GEF Secretariat and UNDP, for the preparation of a comprehensive approach for developing the capacities needed at the country level to meet the challenges of global environmental action.

In Ethiopia even though, the relevant government bodies and most policy makers have recognized the danger of the climate change on water resources, they are facing great challenge on how to put in place sustainable strategies, over a wider scale, to use rainwater-harvesting technology as part of climate change adaptation. This gap calls for critical work on the area. The focus should be to identify the regional capacity and training needs in the field of rainwater harvesting and small scale irrigation and also to identify the lacking capacity in the area.

3.2. Identification of Regional Existing Capacities

Currently, there are plans and on-going implementation by government and other concerning bodies like universities to build national and regional capacity in terms of water technology and agriculture. Twenty five (25) Agricultural TVET and 6 water TVET colleges, as well as the envisaged thousands of Farmers Training Centres (FTCs), are expected to train and add tens of thousands of field level technicians. The Agricultural Technical, Vocational Education and Training (Agri-TVET) programmes (rainwater harvesting and small-scale irrigation curricula) can be used as an opportunity to all people involved in land and water use management.

Availability of indigenous rainwater-harvesting techniques and practices is a promising potential to address water shortage problems. Socio-economic studies about indigenous knowledge, attitude of the community towards land and hydrology is vital. Notwithstanding, the bulky challenges faced the implementation of RWH systems, there have been gains from the adoption of the technology that has to be expanded. One example is the benefit brought by RWH is the rehabilitation of the environment, significant reduction of erosion, and increasing infiltration and vegetation cover (Nyssen et al.,., 2008). The other is the possibility created by RWH for the planting of onions, which raised farmers' income higher than what they used to get from rain-fed teff and wheat combined (Akalu et al.,., 2010). Moreover, while the lack of participation of farmers in the planning and implementation of both micro-dam and pond construction, and the resulting low adoption was typical (Daniel, 2007), the construction of stone bunds and soil bunds in Tigray region showed better participation and adoption compared to that of the more complex structure (Katoa et al.,., 2011).

Oromia Region

Smallholder irrigation (SSI, MI [meaning of the acronyms] and RWH) activities in Oromia include some 161 small-scale irrigation schemes under the implementation and management of the Oromia Irrigation Development Authority (OIDA) (Awulachew et. al 2005). Apart from those implemented by OIDA, donors and NGOs, such as IFAD, ADF, JICA, ESRDF [meaning of the acronyms], etc. are also involved in irrigation development. There are also irrigation initiatives by private investors, as well as state farms. The number of schemes varies significantly across zones, but most are concentrated in the Zones of Arsi, East Hararge, East Shewa and East Wollega, and on average around twelve schemes per zone. SSI schemes implemented in the region are diverse, especially in terms of water sources. Some schemes procure water through river diversions, while others are either pump schemes, drip irrigation schemes, or schemes relying on various forms of water harvesting.

Surface ponds, traditional irrigation structures, flood diversions, as well as hand-dug wells, are the major water harvesting technologies in use. The choice of beneficiaries for these interventions largely depends on the resource potential of the beneficiary communities, and is usually demand-driven. That is, projects are usually initiated as a response to some form of need, interest or demand expressed by the beneficiary communities, either explicitly or implicitly. The existence of indigenous knowledge, especially in traditional schemes, sometimes creates a demand for the intervention, as well as a higher level of food security observed in these communities.

According to OIDA's plan, for the period 2004-2007, there is a plan to bring about 7,856 ha of land under irrigation, mainly small-scale modern, and about of 8,500ha land under traditional irrigation, which are expected to benefit about 31,400 and 34,000 households respectively. The planned small scale modern scheme is nearly 60 percent of currently existing schemes of the same category, and if properly planned, there may be good potential for achieving significant food security and poverty reduction impacts. This initiative will include the construction of about 90,000 hand dug wells and 638,500 ponds to cover 21,855 hectares of irrigation land, benefiting 728,500 households. Furthermore, a water-harvesting scheme of about 185,000 hectares is planned, to benefit about 370,000 households. The impacts and outcomes of these planned investments will depend crucially on the capacity of OIDA to achieve a better performance than in the past.

3.3. Identification of Lacking Capacities

Although rainwater harvesting is a sustainable strategy for adaptation to climate change, its implementation is not as straightforward as it may seem to be. In a study conducted in the Amhara region of Ethiopia, Daniel (2007) identified the cause of failure of the much high speed implementation of the household or farm-level pond program. Implementation in Ethiopia is stressed by institutional problems like lack of well-organized coordination and communication between concerned body (Yohannes, 2004), fake participation of population in RWH program in Tigray (Daniel, 2007), and creation of practically entangled intervention (Segers et al., 2008).

Another explanation to the failures of RWH development intervention is the inappropriateness of the choices from the 'menu' of RWH structures for particular locations and situations. Different types or methods of rainwater harvesting are suitable for particular places and situations. Some of such findings and recommendations were given by Sisay (2009), Ahmed and Shyam (2005) and Birhanu (2012). Unfortunately, RWH technologies that are meant for reducing vulnerability may also increase it. This is a case of mal-adaptation where increased malaria infestation takes away the benefits of rainwater harvesting (Mokennen and Mitiku, 2010; Fistum et al., 2013).

The literature which focuses on Ethiopia clearly revealed the lack of links between development planning and research on RWH. Engaging in prescriptive research and future scenario building, rather than only evaluative research, could have saved resource from wastage and the intended beneficiaries from a permanent erosion of confidence on the technology (Yohannes, 2014). It is claimed that virtually no feasibility studies were done by most of the agencies constructing the schemes except those of OIDA [meaning of the acronyms], because most of the NGOs were not skilled in this. According to our surveys of the Regional Bureau staff, NGO projects are generally more expensive than OIDA projects, due to longer periods of construction and higher budgets than OIDA projects. In general, it is claimed that projects implemented based on the will and expectations of the beneficiary communities are the ones that succeed. On the other hand, those that are not in line with the peoples' expectation failed.

3.4. Capacity and Training Needs

The identified capacity needs of RWH for SSI are:

- Capacity in policy issues
- Institutional capacity
- Capacity in Socioeconomic and marketing activities
- Capacity in enhancing yields using irrigation
- Capacities in using water technologies

According to the respondents, the training needs in rainwater harvesting at Regional and/or Federal levels are:

- Policy and strategy drafting
- Technology related training
- Water management related training
- Operations and maintenance related training
- Marketing related training
- Gender related trainings on aspects of RWH
- Technicians and development agents (DAs) training
- Farmers and community level training
- Planning, monitoring and evaluation of schemes

The three most important in priority are:

a) Technology related
b) Policy and strategy drafting
c) Operation and maintenance related

According to the respondents, the training needs in small scale irrigation, which exist at Regional and/or Federal levels, are:

- Policy and strategy formulation
- Technology related training
- Water management related training
- Operations and maintenance related training
- Post-harvest technology related training
- Marketing related training
- Gender related training in relation to SSI
- Technicians and development agents (DAs) training
- Farmers and community level training
- Planning, monitoring and evaluation of schemes

The three most pressing needs in order of importance are:

a) Marketing related
b) water management related
c) post-harvesting related

Technicians and DAs training should provide more time and proportions of the training to practical skills than theoretical education.

3.4. Conclusions and/or Recommendations

The document analysis of the existing capacity of Ethiopia shows that there are 25 Agricultural Technical, Vocational Education and Training (ATVET) colleges; 6 Water Technical, Vocational Education and Training (WTVET) colleges; thousands of Farmers Training Centers (FTCs); and 16 small-scale irrigation schemes only under Oromia Irrigation Development Authority (OIDA). Availability of indigenous rainwater-harvesting techniques and practices is promising potentials to address water shortage problems. There are lack of well-organized coordination and communication between concerning bodies; inappropriateness choices of technologies; and lack of trained man power. There are capacity needs on issues of policy, institution, ssocioeconomic and marketing activities, in enhancing yields using irrigation, and in using water technologies.

There are also training needs in rainwater harvesting at Regional and/or Federal levels on policy and strategy drafting; technology related training; water management related training; operations and maintenance related training; marketing related training; gender related trainings on aspects of RWH for SSI; technicians and development agents (DAs) training; farmers and community level training; and planning, monitoring and evaluation of schemes.

The training needs in small scale irrigation, which exist at Regional and/or Federal levels, are policy and strategy formulation; technology related training; water management related training; operations and maintenance related training; post-harvest technology related training; marketing related training; gender related training in relation to SSI; technicians and development agents (DAs) training; farmers and community level training; an planning, monitoring and evaluation of schemes. Technicians and DAs training should provide more time and proportions of the training to practical skills than theoretical education.

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Chapter 4

Analysis of Technology-Transfer and Market-Oriented Needs of RWHI

4.1. Introduction

Technology transfer, also called transfer of technology (TOT), is the process of transferring skills, knowledge, technologies, methods of manufacturing, samples of manufacturing and facilities among governments or universities and other institutions to ensure that scientific and technological developments are accessible to a wider range of users who can then further develop and exploit the technology into new products, processes, applications, materials or services. It is closely related to knowledge transfer. Horizontal transfer is the movement of technologies from one area to another. At present transfer of technology (TOT) is primarily horizontal. Vertical transfer occurs when technologies are moved from applied research centres to research and development departments. Market orientation is an organization culture that most effectively and efficiently creates the necessary behaviours for the creation of superior value for buyers and, thus, continuous superior performance for the business. It is considered to be an organizational culture consisting of three behavioural components, namely, i) customer orientation, ii) competitor orientation and iii) inter-functional coordination. The marketing concept is a business philosophy, whereas the term market orientation refers to the actual implementation of the marketing concept.

Technology transfer must be recognized as a broad and complex process if it is to avoid creating and maintaining the dependency of the recipient, and if it is to contribute to sustained and equitable development. The end result for the recipient must be the ability to use, replicate, improve and, possibly, re-sell the technology. Transfer of technology is more than just the moving of high-tech equipment from the developed to the developing world, or within the developing world. Moreover, it encompasses far than equipment and other so-called “hard” technologies, for it also includes total systems and their component parts, including know-how, goods and services, equipment, and organizational and managerial procedures. Thus technology transfer is the suite of processes encompassing all dimensions of the origins, flows and uptake of know-how, experience and equipment amongst, across and within countries, stakeholder organizations and institutions.

If the transfer of inadequate, unsustainable, or unsafe technologies is to be avoided, technology recipients should be able to identify and select technologies that are appropriate to their actual needs, circumstances and capacities. Therefore, a key element of this wider view of technology transfer is choice. There is no single strategy for successful transfer that is appropriate to all situations. Desirably a technology recipient will choose a technology which at least meets the definition of being “environmentally sound". Environmentally sound technologies (ESTs) are technologies that have the potential for significantly improved environmental performance, relative to other technologies. Such technologies contribute to the three pillars of sustainable development.

For the environmentally sound technology transfer and uptake the issues of context, challenges, choice, certainty, communication, capacity and commitment should be well-addressed. Technology transfer does not take place in a vacuum. It is highly desirable that the technology is also found to be economically viable and socially acceptable, and hence sustainable. The technology recipients and users must be able to identify and procure the most appropriate technology for a given application in a given locale. A lack of certainty, and the consequential high levels of risk, both real and perceived, are recognized as major impediments to the successful establishment and ongoing operation of functional markets for ESTs. The technology transfer chain is often long, in terms of both distance and time. Effective communication is thus another essential ingredient in the recipe for successful technology transfer. Efficient and effective two-way communication and cooperation between key stakeholders will do much to remove barriers. Information management systems, knowledge management tools and formal and informal networks, both centralized and dispersed, can all make important contributions. Enhancing the transfer of technologies that support sustainable development is largely about creating favourable circumstances for technology transfer – ensuring all stakeholders have the ability (potential and realized) to fulfil their roles and meet their responsibilities, expeditiously. Generally speaking, government is the principal player in creating an enabling environment for technology transfer, but financial and insurance institutions and international organizations can also be influential. We must make a commitment to overcoming the challenges, providing technology users with the choice they deserve and desire, increase certainty, thereby reducing risks, enhancing communication between technology transfer stakeholders and building and strengthening the enabling environment and thus the capacity for technology transfer.

4.2. Identification of What Has Been Achieved in Terms of Technology Transfer and Market-Oriented Products

RAIN (Rainwater Harvesting Implementation Network) Foundation was established in the Netherlands in 2004, motivated to address appeals for action to achieve effective water supply solutions as raised during the World Summit on Sustainable Development in South Africa in September 2002. RAIN implements rainwater harvesting projects in close partnership with other non-governmental organizations (NGOs).In 2005, RAIN established Rainwater Harvesting Capacity Centre (RHCC) in Ethiopia within an existing organization called ERHA (Ethiopian

Rainwater Harvesting Association) and started implementation with four partner organizations, which constructed 11 tanks with a total storage capacity of 445,000 litres to supply water to more than 3,000 people. The collected rainwater is currently used at schools and health centres, mainly for drinking and hygiene purposes. Borana, one of RAIN's working areas, is a semi-arid region in southern Ethiopia with two annual dry seasons. During these periods, most people walk between 6 and 8 hours to fetch water. People depend largely on open water sources such as rivers and ponds, which tend to dry up quickly after the rainy season, providing unreliable water quality and quantity. In large areas, groundwater is not accessible or contains arsenic or high salt levels making it unsuitable for drinking. RAIN's work in Borana began in 2007 with the key aim to improve access to safe drinking water for remote communities, a programme funded by the Dutch Government.

A combination of water harvesting techniques (surface water runoff with below-ground tanks and sand dams) provided a reliable solution to the availability of drinking water for the community. Subsequently 15 local implementing organizations were trained in sand dam technology and are constructing sand dams within their interventions areas. The sand dams were designed so that runoff water is infiltrated in the sand behind a small dam traversing the riverbed, serving as an artificial aquifer. In this way, evaporation losses are limited, the quality of water remains high and water can be extracted from the sand in the dry season using shallow wells. The dams contribute to groundwater recharge and reduce the risk of erosion and flooding (van Steenbergen and Tuinhof, 2009). The dams protected the livelihoods of the people of Borana from the foreseeable effects of climate change.

In Amhara and Tigray a total of approximately 70,000 ponds and tanks were constructed last fiscal year alone. A few hundred thousand more are to follow with the aim to reduce poverty and increase food security on a massive scale by making water available to irrigate and produce higher value crops and provide water for livestock. Implementers on all levels struggle with a range of problems, many of which originate from the speed and scale on which the water-harvesting program is being implemented. Flaws in the design of the structures, insufficient building experience, and lack of skilled personnel and shortage of materials are some of the problems. In Amhara and Tigray, experts and farmers are also experimenting with low-cost water harvesting systems that are not presently in the mainstream of the government promoted water-harvesting approaches. Some of these are natural systems (e.g. gully rehabilitation with grasses, reed, trees and shrubs as the German GTZ is developing in Debre Tabor and some places in Tigray). Others include simple structures without industrial or commercial input like cement, steel bars, etc., which help collecting water and recharge to the ground water table to be tapped by wells. Even if the ongoing water-harvesting program has its problems and weaknesses – if done flexible and in a variety of ways – it could be an important technology that can help to improve the lives of many in the long run.

The Amhara Regional target in 2003 was the construction of 95,000 water schemes, of which 42,000 were completed. Most of the structures were planned and built in the 52 food insecure woredas and partly paid through food for work (FFW). In a few food secure woredas, ponds as well as river diversions and hand-dug wells were constructed also. Amhara has a total of 106 woredas. The schemes were all built according to a manual produced by a committee of experts in irrigation agronomy and soil and water conservation of the regional Bureau of Agriculture (BoA) in Bahar Dar. The manual is based on the designs from the Federal MoA and the designs had not been tested in Amhara itself according to the BoA experts in Bahar Dar. Therefore, Amhara's very ambitious water-harvesting program July 2002 – June 2003 turned out to be an experiment on a gigantic scale.

In 1995, the regional government of Tigray embarked on its first ambitious water harvesting plan: 500 micro dams to be constructed within 10 years, intended mainly for irrigation agriculture. But the program was initiated without initial assessment, and stopped in 2001, achieving less than 10% of the target. An evaluation study in 1998 showed that the initial assumptions of potential water resources available were overly optimistic: the cost was significantly higher than estimated and technical skills, human capacity and equipment were lacking. In the end, 46 micro dams were constructed of which 37 are still operational. Some have sedimentation problems or are seeping, others were never filled because rainfall and catchment capacity were overestimated.

Self-supply and market-based solutions are interdependent development concepts. The one describes the principle of households investing their own resources to improve their water supply while the other provides the means to do so through the commercial offer of appropriate and affordable products or services. In fact, it is responding to self-supply consumer demand for suitable products that fundamentally drives the development of market-based solutions. Conversely, self-supply aspirants are precisely the client base on which successful market-based development solutions depend. Consequently, the services and products created through market-based development are best defined by the needs of the self-supply community: responsiveness to consumer demands; affordability; and availability.

The implementation of RWH technology is expected to have a positive impact on the amount of agricultural yield harvested and/or the household's level of income and thereby welfare of the household. Using RWH technology, a farm household could increase its agricultural yield, by improving the availability of water during the dry spell period at times, where rainfall stops earlier than the usual rainy season period (Rockstrom, 2000) as cited in Nigigi (2003), and/or increasing the moisture of the soil and there by the productivity of the land indirectly by increasing the use of inputs (Pender and Gebremedhin Birhanu, 2004). This increment in level of yield will in turn lead to higher level of income and well-being of the household.

A competitive and open market encourages ongoing, replicable technology transfers through the use of market-based incentives. Due to the essential role of the private sector in the long-term transfer of technology there is a need to foster engagement of the business and financial communities in technology transfer. The private sector requires dependable risk assessments, strong returns on investment, consistent and transparent rules from government, and a high potential for replication of the business opportunity. Properly functioning markets for technologies generally require:

- Access to reliable and relevant information
- Technology alternatives, all of which are consistent with documented needs and the operating environment
- Levels of risk commensurate with anticipated returns on investment
- Key players who are appropriately skilled
- A system of property designation and protection
- Quality assurance systems
- Systems that minimize contractual and other legal risks
- Institutions that provide attractive financing arrangements and oversight of transactions
- Stable political, legal and fiscal regimes
- Decision-making autonomy for buyers and sellers

4.3. Identification of what else could be promoted

Macroeconomic conditions that favour technology transfer include those which will deliver low inflation, stable and realistic exchange and interest rates, pricing that reflects the true (marginal and fully internalized) costs of material, energy, labour and other inputs, deregulation, free movement of capital, operation of competitive markets, open trade policies and transparent foreign investment policies. Fiscal policies should allow for the provision of direct financial support through appropriate loan arrangements, and economic incentives that facilitate the uptake and operation of ESTs at community to national level, and discourage the continued use of environmentally unsound technologies. At present banks and other lending institutions are somewhat reluctant to finance the transfer and uptake of ESTs. This issue can be addressed through the promotion of institutions, arrangements and mechanisms that can provide innovative financing, including micro-financing, green finance, secured loans, leasing arrangements and public-private partnerships. Under such arrangements technology transfer can proliferate without government intervention.

There is evidence that most modern irrigation development in Ethiopia, has largely been a supply driven, technically focused approach, which has tended to ignore various factors that are relevant for making smallholder irrigation farming sufficiently rewarding to justify investment costs, and to achieve significant food security and poverty reduction impacts. Besides ignoring other important production-enhancing factors, irrigation water development in the country has not been conceived in ways that reflect the reality of multiple water uses in rural settings, taking domestic needs and diversified livelihood strategies into account. Although hardly incorporated into planning, the actual use of small-scale irrigation water use for crop production in Ethiopia is usually in tandem with livestock farming, vegetable gardening, backyard production, along with various kinds of domestic water uses.

In the Amhara Region, irrigation infrastructure has been increasing year after year, which may suggest experiences with SSI in the region have been positive. However, these positive experiences were largely evident on traditional small-scale schemes. Farmers, who have used traditional small-scale irrigation, which are mainly diversion schemes, for a long time seem to have good experiences. Their local know-how and indigenous knowledge perhaps enables them to take good advantage of emerging opportunities associated with interventions. This draws attention to the relevance of including local knowledge and know-how in small-scale irrigation development and planning. There is a general consensus that irrigation investment will achieve broader food security and poverty reduction impacts, if efforts are geared towards revitalizing and up-grading existing traditional small-scale irrigation schemes, with support to enhance access to input supply, output marketing and extension to facilitate access to information and innovations.

Given the diversity and often unfavourable production environments of agricultural areas in Ethiopia, there are many difficulties that this country must resolve. The productive and profitable crop varieties and production practices must be developed for Ethiopian farmers who are mostly engaged in farming in unfavourable production environments.

According to the respondents, the rate of farmers' adoption of introduced RWHI for agricultural activities in Ethiopia since the 1990s is increasing steadily. The major bottlenecks often mentioned for rapid adoption of RWH for agricultural purpose in the country are:

- High cost of construction of structures compared to income accrued as a result of the adoption of the technology
- Lack of trust (awareness) on the contribution of the technology
- Incompatibility of the technology with local farming system
- Lack of appropriate training how to construct, use and maintain structures
- Improper planning, implementation and promotion of the technology by DAs/experts
- Lack of commitment to promote the technology compared with other agricultural extension activities

The major bottlenecks often mentioned for rapid adoption of SSI in the agricultural activities in the country are:

- High cost of construction compared to income accrued as a result of the adoption of the technology
- Lack of trust (awareness) on the contribution of the technology
- Incompatibility of the technology with local farming system
- Lack of appropriate training how to construct, use and maintain structures
- Improper planning, implementation and promotion of the technology by DAs/experts
- Lack of commitment to promote the technology compared with other agricultural extension activities
- Absence of enough and appropriate equipment and materials
- Uncertainty of tenure of the structures constructed close to farm
- Absence of clear regulation on water use among different users

According to the respondents, the future prospects of RWH practices in Ethiopia are:

- Adoption will increase to adapt the problem of rain fall variability
- Adoption will increase with better awareness, training and participatory planning

The future prospect of SSI in Ethiopia is that:

- Adoption rate will increase

4.4. Conclusions and/or Recommendations

The major identified bottlenecks for rapid adoption of RWH for agricultural purpose in the country are high cost of construction of structures compared to income accrued as a result of the adoption of the technology; lack of trust (awareness) on the contribution of the technology; incompatibility of the technology with local farming system; lack of appropriate training how to construct, use and maintain structures; improper planning, implementation and promotion of the technology by DAs/experts; and lack of commitment to promote the technology compared with other agricultural extension activities. The major bottlenecks often mentioned for rapid adoption of SSI in the agricultural activities in the country are high cost of construction compared to income accrued as a result of the adoption of the technology; lack of trust (awareness) on the contribution of the technology; incompatibility of the technology with local farming system; lack of appropriate training how to construct, use and maintain structures; improper planning, implementation and promotion of the technology by DAs/experts; lack of commitment to promote the technology compared with other agricultural extension activities; absence of enough and appropriate equipment and materials; uncertainty of tenure of the structures constructed close to farm; and absence of clear regulation on water use among different users.

The key actions that will foster technology transfer include needs assessments, including identification of shortcomings in the enabling environment, with relevant organizations and agencies helping to address these; evaluation and strengthening of policies that influence the enabling environment; greater communication and interaction between key parts of government; political support for programs and institutions that foster technology transfer; capacity enhancement for major stakeholders; ensuring that technology transfer initiatives are compatible with national sustainable development agendas; and increase communication among technology transfer bodies

The following main steps in technology transfer are recommended:

- Establishment of cooperative and collaborative partnerships between key stake-holders, with the common purpose of enhancing technology transfer
- Implementation of technology needs assessments
- participation in the processes of technology creation, development and adaptation
- Design and implementation of technology transfer plans and specific actions;
- Evaluation and refinement of the actions and plans
- Dissemination of technology information.

Encouraging the adoption and use of environmentally sound and, desirably, fully sustainable technologies thus requires both voluntary approaches and a regulatory framework that nurtures innovation and economic, social and environmental accountability. Enacting policies that lower costs and stimulate a demand for sustainable technologies is necessary in order to achieve the environmental and other benefits that might not otherwise be realized. Furthermore, there needs to be greater clarification of existing environmental rules and regulations, as well as better coordination and harmonization with international standards.

Improved technologies should be transferred to Ethiopia from elsewhere after strong research capacity has been established. Based on these considerations, the following recommendations are proposed to boost RWH for SSI in Ethiopia:

- Closer collaboration with CIMMYT and IRRI must be established
- Capacity of the national agricultural research and extension systems must be strengthened so as to facilitate the transfer of appropriate technologies from abroad
- Investments in infrastructures, such as irrigation and road network, must be accelerated, in order to fully realize the potential of improved technologies

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Chapter 5

Analysis of Available Practices and Technologies, Technical Capacity, Socio-economic and Climatic Conditions

5.1. Introduction

Modern RWHI practices in the country have recent history (Getachew, 1999; Awulachew et al.,., 2005), which was started in mid 1970s as response to the then catastrophic drought. In fact, modern irrigation began in the 1950s with the advent of sugar estate in the Middle Awash (GOE, 2011a). No matter how their introduction is recent, it is quite possible to draw lessons from those practices. Lessons that can be drawn from those practices are of both identification of best practices, challenges and opportunities. The best practices include practices related to the available technologies, policies and institutions, socio-economic imperatives for the application of the RWHI and related issues. Opportunities also include the general socio-economic milieu the country is looking forward and the policies and institutions, readiness in several forms, and related issues. The major challenges also briefly described with the aim to pinpoint the available gap in implementing RWHI. Such analysis is believed help to better plan and get prepared for better application in the future towards achieving food security, on the one hand and to enhance the livelihood of the community through market integration of the production.

The term best practices could be used and defined differently by different field of specializations. Amongst the definitions the frequently cited one is the following. "An approach or method of carrying out a function or process to achieve a specified output that is recognised as being superior to that used in other organizations or businesses. Such an approach or method lends itself to replication by others who wish to gain the benefits provided by the best practice model" (Anderson and Burton, 2009). This report also follows this definition. In fact, it must be understood that best practices could be analysed at different scales, namely: at specific technology or approach level, at specific site level where certain technology and approach implemented and at levels beyond specific site scale. For the sake of this report best practice of RWHI appraised at general level (national level) and as deemed necessary at specific technology level.

Methods employed to identify best practices and assess the available potential

Two data sources were used to assess the available best practices and potentials for RWHI in Ethiopia. The first source was questionnaire survey. Those who filled the questionnaire were professionals in the area of rain water harvesting and irrigation and had field-work experience in the regions with farmers for many years. The objective of conducting questionnaire survey with professionals was to acquire "experts' opinion/view". Their opinions believed indicate types and under what circumstances do these technologies are disseminated. In fact, in order to get first-hand information and data it is absolutely necessary to make detailed empirical and experimental investigation. Hence, we presumed that the analysis that we making here is an indicative one. The second major source of data was literature review on the field which includes grey literature of different institutions, proceeding papers regarding the RWHI undertakings in the country and from scholarly papers published regarding the experiences of RWHI. Major problems, challenges and opportunities identified by those researchers are reviewed and included in this report.

In brief this report attempted to answer the following questions:

- How big is the application of RWH/SSI practices in Ethiopia to enhance food security for small holder farmers and what trend is observed?
- What is the perception of experts towards the adoption of RWH/SSI in Ethiopia?
- Which policy and institutional frameworks exist to support RWHI?
- Which technologies are widely practiced for RWHI in the country?

5.2. RWHI Potential by Practices and Technologies

5.2.1 Natural resource base/ potential for RWHI

Climate variability

The country is endowed with huge potential for rain water harvesting and for irrigable land. By virtue of its location and altitudinal gradient, Ethiopia experiences different climatic regime. Following Köppen's climatic classification system, eleven climatic zones identified (see details NMSA, 1996). They generally come under dry climates, tropical rainy climates and temperate type of climates. Rainfall pattern is the major climate element used to define the climatic condition of Ethiopia. In this regard a long-term monthly rainfall analysis by National Meteorological Agency scientists (NMSA, 1996) reveal that Ethiopia is represented by three major rainfall regimes; namely: mono-modal, bimodal type I and bimodal Type II rainfall regimes. Very brief account of each of them described as below.

- Mono-modal Rainfall Regime: it is a pattern of rainfall in a year where there are single maximum. The western and north-western highlands and associated lowland parts of the country are dominated by this type of rainfall pattern. The wet periods, however, decreases generally northwards. In this regime three parts are discerned based on length of wet months: areas experiencing around nine months from February/March to October/November; around seven months from

April/May to October/November and areas enjoying three months of rainfall from June/July to August/September.

- Bimodal Type I: this is a rainfall pattern characterized by quasi-double maxima with small peak in April and maximum peak in August. This type is dominantly found in North Eastern Escarpments and Rift Valley parts of the country.
- Bimodal type II: it is characterized by double maxima with peaks during April and October. It is dominantly found in the Eastern and Southern highlands and lowlands of Ethiopia

Furthermore the rainfall pattern of the country is characterized by high rainfall variability. This variability coupled with the current climate change poses great challenge to rain fed agriculture. Taking 30% coefficient of variation (CV) as dividing line, analysis of the rainfall data of 221 stations shows, except the Central highlands, south western highlands and some part of the eastern highlands, the inter-annual variability is very high in most parts of the country (where CV is over 30%) (NMSA, 1996). Alebachew and Woldeamlack (2011) quoting NMSA (2006) explain that the country experienced 10 wet years and 11 dry years over 55 years analysed. Generally the country experiences both spatial and temporal variability of rainfall, Several detailed case studies reveal that seasonal rainfall pattern is much more variable in almost all parts of the country with the exception of few pockets of south western highlands.

Physiography

Ethiopia occupies very heterogeneous physiography (landscape). The altitudinal range is between 116 meters below sea level at Dallol to 4533 meters above sea level at Mt Ras Dejen. This altitudinal range coupled with several natural factors host large number of agro-ecological belts and agro-ecological zones. Awulachew et al., (2005) presented succinct account on this as follows.

> Ethiopia's topography can be broadly grouped into uplifted central highlands, tapering into peripheral lowlands that also include the Rift Valley. Most of the country consists of high plateaus and mountain ranges with precipitous edges dissected by numerous streams in the centre, and rolling plains all along the periphery…. The lowlands are relatively hot, with annual rainfall varying between less than 200 to 800 mm and average temperatures of 25° C. The climate in the highlands above 1800 m is mild and annual rainfall ranges from 800 to 2200 mm, with a mean annual temperature of 15° C. The highlands above 1500 m altitude constitute 43 percent of the country. The dry lands occupy about 70 percent of the total landmass and 45 percent of the arable land. They are characterized by a highly fragile natural resource base; soils are often coarse-textured, sandy, and inherently low in organic matter and water-holding capacity, making them easily susceptible to both wind and water erosion. Crops can suffer from moisture stress and drought even during normal rainfall seasons. Farm productivity has declined substantially and farmers find themselves sliding into poverty …. . The different altitudes and ranges of precipitation give Ethiopia six major agro-climates having distinctly different agricultural potential:
>
> i. Arid - 42.3 million hectares, used for pastoral grazing

ii. Semi-arid - 2.9 million ha, used for grazing and cultivation
iii. Dry sub-humid - 19 million ha, used for cultivation of annual crops
iv. Moist - 24.5 million ha, used for annual crops
v. Semi-humid - 16.5 million ha, annual/perennial crops
vi. Per-humid - 0.7 million ha, used for perennial crops (Awulachew et al., 2005:2)

Evaluating from RWHI perspective, except small pockets of the South Western Highlands, largest portion of the country (a) has clear seasonal differentiation into wet and dry months; (b) experiences strong inter-annual and seasonal variation of rainfall, (c) as all parts of the globe, it is suffering from climate change and (d) has heterogeneous landscape and experience huge relative relief which caused differences in rainfall and temperature pattern. In addition, the highlands and mountains are sources of water, often said "water towers" for the lowlands. The elevation difference is also important for runoff generation to be stored at foot slopes or to be conveyed by streams. This very brief account into the natural system is great potential for RWHI.

The government vision and strategy also show great potential for future RWHI undertakings. The following quote from the Irrigation Strategy Document of the government, testify the bright future for SSI which, in fact, demands a lot from scientists and researchers to make the vision of the government reality.

> The irrigation potential of the country is estimated to be about 3.7 million hectares. Of the total potential, until now only about 20 to 23% of this potential is put under irrigated agriculture up until now (both traditional and modern irrigation systems). Recent estimates indicate that the total irrigated area under small-scale irrigation in Ethiopia has reached to 853,000 ha during the last implementation period of PASDEP – 2009/10 and the plan set for development of small scale irrigation is 1,850,000 ha, which is planned to be achieved by the end of the five years GTP of 2015 (GOE, 2011b:).

The action plan of this strategy which spans from 2012 to 2025 also sets target, among others, to enable 80% of farmers to make use of irrigation for agriculture.

5.2.2 Experience of traditional and introduced RWHI as best practice

In many parts of Ethiopia traditional rain water harvesting and small scale irrigation have been practiced for centuries. Currently both traditional and introduced small scale irrigation technologies are expanding in many parts of the country in the face of rain fall variability, on the one hand and due to the favourable policy environment of the government, which encourages farmers to transform their agriculture from purely rain fed to irrigation based farming, on the other. Several other factors also drive the expansion of SSI (market availability, better implements and equipment for construction of water storage systems, improvement on farming system, better knowhow on the part of farmer operators, existence of agricultural extension activities, better credit facilities, better knowledge support from different organizations including government and non-government organizations, better social infrastructure, etc.). Hence, the interplay of these several factors seems to drive acceptance of the technology for better agricultural production.

However, the degree of acceptance and implementation of these technologies for food security enhancement varies from region to region (Fitsum et al.,., 2009). For example, a summary data presented by Awulachew et al., (2006) disclosed that in 2004 out of around 247, 470 ha under irrigation agriculture, 138, 339 ha of land (55.9%) was under traditional irrigation system and there was huge regional disparity. Out of the inventoried 138 339 ha of land under traditional irrigation Amhara (46.3%), Oromia (41.1%) and Somali (5.9%) regions constitute the largest share. In 2007/08 cropping year, the total area under irrigation, according to data collected from the regional states (Liuel, 2009) was 610,384 ha, of which 41.6% in Amhara Region, 44.8% in Oromia Region, 6.7% in Tigray Region and 6.9% in SNNP Region. Though such huge regional disparity existed, the available experience of traditional irrigation in the country could be considered as best practice which can serve as a spring board for expansion. In the recent years small scale irrigation activity by small holder farmers had expanded enormously owing to the fact that SSI is one major policy direction and major agricultural package that is practiced in almost all parts of the country in the endeavour to be food self-sufficient on the one hand and to produce industrial high value crops.

Hence, with appropriate technology, approach, financial and technical input, and policy and institutional setup small scale irrigation has great potential to enhance agricultural production in most parts of the country where a priori experiences already exist.

5.2.4 Experts' opinion on best practices and opportunities of RWH/SSI

The analytical framework we used to assess experts' opinion on best practices of RWHI was the framework suggested in Aderson and Burton (2009) (see Table 1). For the purpose we send questionnaire for 50 experts to get their perception and opinions on several aspects of RWH/SSI and particularly requested to evaluate implementation of them from the framework of best practice measurement perspective. Sample respondent experts were selected using snowball sampling method since we lack the complete registry of experts dwelling on issues of water resource management. The intention was to get an impression what the field practitioners have in the last few decades. Large number of experts returned the questionnaire and it is based on this that we tentatively analysis the impression they have (please note that we are expecting some more questionnaires to be returned and want to extend the survey in regions and hope we will have a deeper analysis on the issue latter using large sample size). The general framework for identification and understanding of best practice of RWHI covering the five domains in the work of Anderson and Burton (2009: 37) was used. These domains are: technical, economic, social, environmental and institutional/ policy. Each domain has several indicators.

Table 1: Framework for best practices assessment (adapted from Anderson and Burton, 2009)

Domain	Sub-criteria
Technical	(i) Adequate experiences , (ii) Functioning system, (iii) Variety of designs that can suit specific situations, (iv) Technically equipped and trained manpower, (v) unsophisticated and easy to implement technologies (vi) Others, mention
Social	(i) Cohesiveness, (ii) Work together, (iii) Help each other, (iv) Limited conflict, (v) Others, mention
Economic	(i) Communities can and are meeting management, (ii) operation and maintenance (MOM) costs, (iii) available demand for agricultural production, (iv) Accessible markets (at reasonable cost), (v) Good prices for agricultural produce, (vi) Availability of adequate raw materials necessary for construction of RWH & SSI structures, (vii) Others, mention
Institution/policy	(i) Adequate legislation (Water law, WUA law, water rights, Environment law, standards of water quality, standards of structures, upstream – downstream link, others, mention), (ii) Political support for improved conservation measures in agriculture, (iii) Political support for water harvesting, (iv) Functioning systems of governance (government agencies, WUAs, etc.), (v) Functioning educational systems (primary through tertiary education), (vi) Functioning, knowledgeable and adequately resourced extension service, (vii) Functioning, knowledgeable and adequately resourced WH support agency (staffed, trained, skilled in MOM), (viii) Others, mention
Environmental	(i) Favourable physical environment (soils, water resources, climate, topography, etc.), (ii) combating natural resource degradation (erosion, over-abstraction of surface or groundwater, etc.), (iii) Limited runoff and pollution of land and water resources from agriculture, (iv) Favourable health environment (in relation to waterborne disease), (v) Others, mention

The stem question we posed to experts for each domain was stated as "which technical/economic/social/institutional best practices and/or opportunities of RWH/SSI exist in Ethiopia?" for each domain several alternatives were provided in which respondents requested to indicate their choice/s they think appropriate. At this point one has to be very clear that assessments of best practices would be more meaningful when assessments are undertaken to each specific technology of RWHI on the given specific site. In this latter case detailed data both quantitative (such as on cost of construction, management and maintenance of structures, benefits obtained from the use of the structures mainly sales of products, etc.) and qualitative data (such as acceptability of technologies, norms and values attached to water resource management, traditional institutional set up vis-à-vis the introduced formal institutions, etc.) pertaining to RWHI have to be analysed in detail. In this report, however the intention was to get the general reflection on RWHI practices at national scale as perceived by experts of the field.

Table 2 and 3 indicates the perception/views of experts on the domain of best practices regarding the general practice of RWHI activities implemented in Ethiopia over the last few decades.

Identified perceived best practices and opportunities regarding to RWH

Table 2 indicates perceived best practices observed in the last few decades while implementing RWH for agricultural activities. Those specific indicators scoped by experts from each domain are: 'availability of unsophisticated and easy to implement technologies' from technical domain; the behaviour of the community towards 'working together' and 'helping each other' from social domain; existence of 'demand' and 'good price' for agricultural products from economic domain; 'political support for agriculture sector and RWH' from institution/policy domain; and existence of 'conducive natural environment for RWH' and current 'natural resource conservation' activities from environment domain suggested by majority of experts as best practices to expand the RWH activities further in the future. On the other hand, several elements in each domain considered yet unmet which throw light to address those issues.

Case studies conducted at different parts of the country (e.g., Nijhof et al.,., 20010; Gezahegn and Betre, 2009; Liuel, 2009; Woldeamlack, 2009; Regassa, 2006; Yoseph, 2010; Awulachew, Fitsum and 2008; Mitku and Sorsa, 2002) showed mixed results on the success, acceptability, effectiveness and efficiency of RWH that aimed towards enhancing food security of small holder farmers. Diverse challenges and drivers were mentioned for such diverse responses.

Gezahegn and Betre (2009), for example conclude the following after their several review of cases.

> "The impacts of water harvesting campaign have been variable. There are localities where water harvesting has resulted in achieving food security and become commercial farmers. There are also localities where farmers become so discouraged by the loss they incurred on construction of water harvesting structures. From the outset successful areas are in those where high value crops are grown and well marketed. Lack of skill for proper selection and implementation of the structures, high cost of construction and market have caused poor performance in many localities across the nation. This implies in depth understanding of biophysical and socio-economic factors that govern prioritization of geographic areas for intervention and selection of appropriate

water harvesting systems for each of those geographic areas. In addition targeting of agro-ecologies and socio-economic conditions would improve to maximize effectiveness of water harvesting interventions".

Table 2: Experts' perceived best practices of RWH in Ethiopia (N=28)

Domain of Best Practices	Sub-indicators of major domains	Response (N=28)	
		Number	%age
Which technical best practices and/or potentials exist on RWH?	adequate experiences since the 1970s	6	21.4
	functioning system	9	32.1
	variety of designs	8	28.6
	technically equipped & trained human power	6	21.4
	unsophisticated and easy to implement technologies	14	50.0
	others/	2	7.1
Which social best practices and/or potentials exist on RWH?	Cohesiveness	3	10.7
	work together	16	57.1
	help each other	6	21.4
	limited conflict	9	32.1
	Others	0	0.0
Which economic best practices and/or potentials exist on RWH?	communities can and are meeting MOM costs	5	17.9
	available demand for agricultural production	16	57.1
	accessible market at reasonable cost	4	14.3
	good price for produce	10	35.7
	availability of raw material for construction	10	35.7
	Others	1	3.6
Which institutional best practices and/or potentials exist on RWH?	adequate legislation *		
	political support for conservation agricultural	18	64.3
	political support for RWH	13	46.4
	functioning system of governance	8	28.6
	functioning system of education	2	7.1
	functioning knowledgeable & extension system	4	14.3
	skilled Management, Operation & Maintenance	3	10.7
	Others	2	7.1
Which environmental best practices and/or potentials exist on RWH?	favourable physical environment	17	60.7
	combating natural resource degradation	17	60.7
	limited runoff and pollution of land, water for agriculture	5	17.9
	favourable health environment	4	14.3
	Others	0	0.0

**this item included Water law, WUA law, water rights, Environment law, standards of water quality, standards of structures, upstream – downstream link -Respondents perceived that only partial aspects of legislation are enacted. Many of the respondents even didn't know major policy instruments existed at national level as well at regions.*

Identified best practices and opportunities in relation to small scale irrigation

Table 3 describes the reply of expert's opinion on the different aspects of best practices as regards small scale irrigation in Ethiopia.

1. Technical best practices: existence of varied and already tested designs of small scale irrigation technologies that could serve at different agro-ecology is mentioned as the best practice, again the accumulated experience since its introduction in 1970s is also considered an asset that can be best utilized in the future. The experiences are not only success but also failures. The latter is equally important with the success stories in the area of implementation of SSI to draw lesson not to repeat the previous mistakes.
2. Social best practices: "working together" and "helping each other" are the two practices regarded as best from the social criteria in which 46% and 36% of respondents expressed the view. One thing these percentage values are small and the other several other virtues of the community are not mentioned. In any case the experts seem frustrated in the field experience that they haven't seen the previous social values of the people. This has an implication to the policy maker that such important societal values shouldn't be eroded fast without any substitution.
3. Economic best practices: available 'demand for agricultural products' is the major best practice and opportunity exists for wide application of SSI. Other factors such as the management, operation and maintenance (MOM) capabilities of agricultural communities are quite fine particularly for the traditional schemes. With proper bylaws the community scale introduced SSI can be handled by the community. This, however, needs empowerment of the community.
4. Institutional/policy best practices: Item 'political support for agriculture' is identified as best institutional criteria.
5. Environmental best practices: favourable environmental situations and the current widespread activities to combat land degradation are important environmental best practices identified by the experts.

Table 3: Experts' perceived best practices of SSI in Ethiopia (N=28)

Domains of Best Practices	Sub-indicators of major domains	Response	
		Number	%age
Which technical best practices and/or potentials exist on SSI?	adequate experiences since the 1970s	8	28.6
	functioning system	7	25.0
	variety of designs	13	46.4
	technically equipped & trained human power	2	7.1
	unsophisticated and easy to implement technologies	9	32.1
	Others	1	3.6
Which social best practices and/or potentials exist on SSI?	Cohesiveness	6	21.4
	work together	13	46.4
	help each other	10	35.7
	limited conflict	8	28.6
	Others	2	7.1
Which economic best practices and/or potentials exist on SSI?	communities can and are meeting Management, Operation & Maintenance costs	8	28.6
	available demand for agricultural production	20	71.4
	accessible market at reasonable cost	3	10.7
	good price for produce	8	28.6
	availability of raw material for construction	2	7.1
	Others	1	3.6
Which institutional best practices and/or potentials exist on SSI?	adequate legislation*		
	political support for conservation agricultural	13	46.4
	political support for RWH	10	35.7
	functioning system of governance	7	25.0
	functioning system of education	4	14.3
	functioning knowledgeable & resourced extension system	6	21.4
	Skilled in MOM	1	3.6
	Others	1	3.6
Which environmental best practices and/or potentials exist on SSI?	favourable physical environment	15	53.6
	combating natural resource degradation	12	42.9
	limited runoff and pollution of land, water for agriculture	8	28.6
	favourable health environment	3	10.7
	Others	0	0.0

**this item included Water law, WUA law, water rights, Environment law, standards of water quality, standards of structures, upstream – downstream link -Respondents perceived that only* *partial aspects of legislation are enacted. Many of the respondents even didn't know major policy instruments existed at national level as well at regions.*

In conclusion, experts' opinion reveals some best practices and pessimism in many of the issues. The pessimism view of experts' is not unfounded. The major reasons are lie on poor performance constructed RWH structures owing due to hasty planning and implementation of technologies in a kind of campaign approach in the period between 2002 and 2005. Many of the implementations were not supported by research and demonstration. These pessimistic views of experts are conforming to several case study findings and field assessment reports (Girma & Kiros, 2011; Liuel, 2010; Woldeamlak, 2009; Awulachhew 2006; Melaku. 2006; Awulachew et al.,., 2005; Yacob Rämi, 2003; Yohannes, 2002). These studies reveal several challenges and constrains. The challenges ranges from policy related issues to design of specific technology. The following is the summary of those identified challenges and constraints often mentioned.: lack of or inadequacy of baseline studies for proper planning and decision making, lack of data and information on potentials of different areas for the development of water resources; poor technology choice; low yields of completed systems; unclear property rights of the facilities; too small landholdings for bringing impact on the livelihood; conflicts in water use and use rights; marketing, market access and market linkages; dependency syndrome of the some sections of the community in case where structures are constructed by NGOs; institutional arrangements and instability that manages RWHI activities at different administrative tier of the country; lack of training to handle technologies; lack of extension services; lack of start-up capital or access to credit to initiate venture; poor linkage between research and extension in the area of irrigation water management.

Regarding knowledge gaps researchers identified the following constraints: faulty design; lack of knowledge on use of modern irrigation technology; poor water management; poor land management; poor input utilization; poor management capacity; lack of information and database and lack of post-harvest technology and management. In addition, the following are mentioned in several occasions: poor awareness of the technology; poor implementation procedures (use of only standard design which lacks flexibility according to the conditions; problems related to site selection; poor construction management; shortage of water to be harvested and stored; water lifting problems; shallow depth of irrigation water application; poor crop selection and cropping pattern problems with time and method of irrigation and limited experience in irrigation extension; maintenance related (tearing of plastic sheets, silt up of structures, etc.); environmental related: (where some storages become breeding ground for malaria, hazard to human & animals, stinging water, etc.).

With the above large list of constraint and challenges, still bright spots and opportunities are there for future expansion of these technologies. Few examples of RWH technologies for SSI are presented below.

5.2.3.2 Example 2: Groundwater dams

"Sand dams are constructed across dry sandy riverbeds in arid and semi-arid lands. The function of a subsurface dam is to block the downstream underground movement of water downstream, and to raise the water level in the sand to within 0.30 m of the surface of the riverbed. Subsurface dams can be built from a variety of materials including clay, rocks and clay, rubble masonry or concrete, provided that the materials used create an impermeable subsurface barrier to flow" (Anderson and Burton, 2009: 128). In Ethiopia sand dams are fond semi-arid and arid areas, particularly in Borena Zone of Oromia Region, Somali Regional State and Dir Dawa Administration. Historically ground water damming in Ethiopia was practiced since 1974 whereby sand and subsurface dams have been built in Eastern Ethiopia: Dire Dawa (Adada, Ejaneni, Melka Belina, Gende Bira, Melka Jeldu etc.) & Gursum area.

Regarding the Natural potential, there is great potential for sand dams in arid and semi-arid part of the country in which streams plentiful intermittent streams are found. Since the 1970s experience in the Ministry of Agriculture and NGOs are already created which actually need to be boosted for fuller utilization of both the technology and the water resource generated during the upslope of the rainy periods (fig 2).

Fig 2: Sand dams constructed along intermittent stream in Yabello, Borana Zone of Oromia Regional State (Photo: Amare, 2011)

5.2.3.3. Example 3: Pond

Ponds of different size and shape are among the most frequently constructed water storages that collected runoff from ground catchments. In Ethiopia the household level ponds have an average capacity of $60m^3$ of water. It is often constructed at back yard for vegetable cultivation. It is also used for crop production for supplemental irrigation when constructed close to the farm plot. Community scale ponds are also used to be constructed mainly by the support of different NGOs (e.g. see figures below).

5.3 Available Infrastructure and Technical Capacity

5.3.1. General description of the RWHI

Large number of RWHI technologies already introduced in the country. Their efficiency, effectiveness, acceptance and impacts on the livelihood, however, vary considerably from place to place. There are different ways of classifying RWH. Based on the area of harvesting they classified as in-situ and ex-situ RWH systems. Based on types of catchments for water collection the main ones are roof top harvesting, runoff harvesting, and flood harvesting. Based on types of storage the major ones are tank above ground, excavated cistern, small dams, and ground dams. The storages have also different shapes and sizes. There is also different rainwater harvesting techniques: namely, roof catchment, ground catchment, small earth dams, rock catchment dam, subsurface dam and pond.

The following excerpts are the state of RWH experiences and practices at different regions.

Case I: Situation in Amhara Region in 2004

Large number of HH water harvesting and SSI schemes developed. The 2004 inventory showed the following finding: "A total of 14,976 HHWHS were counted, 13,028 (87%) of which were based on run-off harvesting and 1,948 (13%) hand dug wells. 82% of the schemes were constructed in 2003 while only 1.2% before this period. 22 % of the structures were found to be functional, 70% not functional and the rest were destroyed. Harvested water has been used for different purposes: 35.6 % for irrigation only, 31.4 %

for other purposes (water supply, cleaning and construction) and 33 % for both purposes. The total area irrigated using the functional structures in the dry and wet season was found to be only 51.4 and 25.9 ha, respectively. Water from these functional structures were used to provide supplementary irrigation to an average area of only 216 m2 in the dry season and/or 290m2 in the wet season. A total number 6,219 SSIs were counted, of which 311 (5%) were modern and 5908 (95%) were traditional. A total of 8063 ha was irrigated by the modern schemes during the dry season, which put the modern irrigation at a rate of 80% of the planned area. This was only about 1.4 % of the potential irrigable area of Amhara Region. Irrigated area of most of the beneficiaries ranged between 0.125- 0.25ha, benefiting more than 330,000 households and 1.9 million people. Use of modern inputs was seldom and minimal, with fertilizer rate of not more than 0.013 q/ha. Flooding and furrow were the most common methods of irrigation used. Irrigation intervals were dangerously too long and hardly met.
Lessons learnt from HHWHS and SSI schemes in the region includes that these schemes have problems encompassing technical, social and environmental issues. The major problems with HHWH schemes were design, construction and operation related whereas with SSI schemes operation was the most important problem. As a result, crop yield and income were low. It is important that the whole process of planning and management of these schemes are based on full participation of the communities so that the schemes are eventually owned and sustainably managed by the farmers and operated at their full potential providing maximum benefits to the farmers" (Yacob Wondimkun and Melaku Tefera. 2006:11).

Case 2: situation in Tigray Regional State (Successful vegetable and cash crop production with plastic-lined ponds)

"Dangolo Tabia is a model village in Wukro Woreda. It boasts 30 ponds, mainly clay and plastic-lined serving a total of 80 households. Small gardens with peppers, tomatoes, maize and root crops, which were planted during the rainy season, and freshly planted fruit and coffee trees, were found around most of the ponds. While all of the ponds remained full during the rainy season, only the plastic-lined ponds contained water, remaining about one-half full since the cessation of the rains three weeks earlier. There was sufficient water for irrigation until crop maturation. Most clay-lined ponds though were seeping heavily and almost empty. According to experts from REST, the clay layer was not compacted well enough but the ponds could be repaired. Nearby a community livestock-watering-pond constructed two decades ago was still almost full, proof that clay ponds if properly constructed can work and are sustainable if properly maintained. The old pond was sunk into thick clay ground, which was well compacted through the yearlong use by livestock and therefore did not leak nor seep" (Rämi, 2003:19)

5.3.1.1. RWHI Development (behaviour for the last 10 years)

A question was raised for experts to indicate the behaviour of RWHI adoption and/or adaptation by the small holder farmers in Ethiopia. The following tables show the perception (view) of experts.

Tale 4: Expert's opinion on Farmers' adoption of RWHI in since the 1990s (N=28)

Item	Alternatives (response)	No.
Perceived rate of farmer's adoption of RWH for agricultural activities since 1990s	increased steadily	13
	Decreasing	2
	neither increased nor decreased	3
	abandoning previously constructed structures	3
	no opinion	5
	those didn't indicate their choice	2
Perceived rate of farmer's adoption of SSI for agricultural activities since 1990s	increased steadily	19
	Decreasing	2
	neither increasing nor decreasing	0
	abandoning previously constructed structures	0
	no opinion	3
	those didn't indicate their choice	4

Regarding the RWH, experts seem uncertainty on the trend and continuity of it. It is only less than half of them that have the opinion on the issue. In the period 2000-2006, RWH, particularly ponds of different shape were constructed in almost all parts of the country in a campaign approach. As a result, several ten thousands of structures believed constructed. For example, in Amhara Region the plan for the year 2003/4 was more than 350, 000 ponds and in Tigray Region the plan was 500,000 pounds for five years (Rämi, 2003). Indeed, these plans were ambitious and the result was not encouraging. Several empirical studies (Girma and Kiros, 2011; Woldeamlack, 2009; Yacob and Tefera. 2006; Rämi, 2003) confirmed that RWH planning followed hasty approach and resulted big failure. In which large number of structure remained functional.

With regard to the future situation, experts indicate optimistic view has for both RWHI for agricultural purposes. Still they indicate emphasis on the necessity if enhanced awareness and better training on the application of those technologies. The optimistic view of experts is supported by the government strategy for the period 2012 to 2025, which it indicate the absolute necessity of promoting agriculture supported by irrigation.

Table 5: Expert's opinion on future adoption of RWHI in Ethiopia (N=28)

Item	Alternatives	No.
Perceived future prospect of RWH	adoption will increase due to RF variability	12
	adoption will increase with better awareness, training	20
	adoption will decrease with alternative livelihood strategy	2
	adoption will decrease because it is not the priority of government	1
	adoption will remain low due to inappropriate policy	7
	adoption will decline b/s of health & other risks	0
	Others	1
perceived future prospect of SSI	adoption rate will increase	23
	adoption will remain same	1
	adoption rate will decline	0
	Others	1

Table 6: Experts' view on bottlenecks of wider adoption for RWHI in Ethiopia (N=28)

Item	Alternatives	No.
bottlenecks for rapid adoption of RWH	high cost of construction compared to benefits	13
	lack of trust to the technology (lack of awareness)	9
	incompatibility of technology with local farming system	10
	lack of appropriate training on construction, maintenance	18
	improper planning, implementation, promotion	14
	lack of commitment to promote it compared to other agricultural extension activities	15
	absence of enough & appropriate equipment	7
	uncertainty of tenure of the structures	4
	Others	2
bottlenecks for rapid adoption of SSI	high cost of construction compared to benefits	12
	lack of trust to the technology (lack of awareness)	6
	incompatibility of technology with local farming system	3
	lack of appropriate training on construction, maintenance	16
	improper planning, implementation, promotion	10
	lack of commitment to promote it compared to other agricultural extension activities	14
	absence of enough & appropriate equipment	12

	uncertainty of tenure of the structures	7
	absence of clear regulation on water use among uses	11
	others (low level incentives to farmers - market)	5

5.3.1.2. Rainwater harvesting and/or small-scale irrigation systems

(Description of the systems – water and agricultural yield, costs, cost-efficiency, etc.)

Few studies conducted regarding the cost – benefit analysis of RWHI (Adinew, 2006; Fitsum et al.,., 2009; etc.). These studies have found mixed results. Many of them indicate the profitability while other the reverse. For example Adinew (2006) in his empirical study on the issue in Kobo-Girana irrigation project (North Wollo of Amhara Regional State) reached the following conclusion.

"Product Marketing and Income from the Systems Products are normally handled in an ordinary manner and sold to private traders, military camps and to Ambasel Trading House (in case of cotton & Haricot Bean). Marketing constitutes the major aspect of problems in irrigated agricultural production. From the potential point of view, the systems are not efficiently operating. As a result, income gained from the system by farmers is not to the expected level as compared to commercial farms. Even at the existing operational efficiency, however, the farmers significantly benefited from the system. The harvests showed that a net income of Birr 750012000 per hectare per season was gained depending the strength of the farm operators" (p: 19-20).

Regarding the impact of irrigation in reducing poverty level, Fitsum et al., (2009), from their empirical research, they concluded that irrigation contributes considerably to poverty reduction. Their words are "… there is significant reduction in poverty from AWMT. In fact, our calculations show that there is about 22% less poverty among users compared to non-users of AWMT. The magnitude of poverty reduction is technology specific. Accordingly, deep wells, river diversions and micro dams have led to 50, 32 and 25 percent reduction in poverty levels compared to the reference, i.e. rain fed system."

Nevertheless, many researchers pinpointed that the existence of week market integration, fluctuating (and even low) price for products manly during harvest period. Several problems also rose related to construction which makes the project unprofitable.

5.4. Growth Projections of RWHI

It is too difficult to get reliable time series region-wise disaggregated data on the number of RWH/SSI structures, storage capacity of those structures and corresponding area irrigated in each year. To use it as an indicative figure, Leul (2009) tried to collect data for the year 2000 and 2008. Comparison of the two figures indicates considerable increase on both number of structures and presumed land area irrigated by rain water harvest. Leul (2009) summarized the comparison of irrigated land size in 2008/2009 with the situation in 2002/2003 in four of major regions of the country and he found an increase by 138%, 113%, 291% and 224% in 208/2009 from the year 2002/2003 in Oromia, SNNPR, Amhara and Tigray Regional States respectively.

Government of Ethiopia developed a 15 years strategy for small scale irrigation in 2011. In this strategy document, it is emphatically declared that the Ethiopian Agriculture has to be transformed from rain fed to irrigation based and from subsistence level to commercial based. It is also clear that agriculture as the leading sector for the development of the country should propel the development of the country. With this understanding, SSI is given big attention. The objectives and major principles of the strategy are depicted here under (GoE, 2011: 10-11).

"…The overall objective of the SSI capacity building strategy is to lay down a road map that would ensure irrigation water availability and access to smallholder farmers for increased production and productivity of irrigated agriculture.

Specific objectives: The specific objectives of small-scale irrigation capacity building strategy are to:

- Improve the technical and institutional capacity, expand infrastructure for SSI and create appropriate institutions at all levels to deliver more effective and efficient services;
- Increase production and productivity of irrigated agriculture to ensure food security, supply adequate raw materials to domestic factories and industries and increase export earnings,
- Improve institutional linkages and sustain effective coordination between key stakeholders
- Strengthen the input supply schemes and market information systems in order to improve access for quality inputs and improve value chain to ensure profitability of irrigation subsector and
- Encourage the participation of private sector in the development and management of SSI.

GUIDING PRINCIPLES

The basic principles of SSI Capacity Building Strategy pertaining to the national water strategy are:

- Water is a natural endowment, commonly owned and its fair distribution shall be exercised;

- SSI development shall be based on participatory approach and integrated framework;
- The participation of all stakeholders particularly user communities and women's will be promoted in the relevant aspects of water resources management;
- Irrigation in general, should be integrated with maintaining environmental sustainability and
- Capacity building is a long-term process that builds on what has been achieved".

With these objectives and principles the targets set to arrive are also indicated in the strategic plan, among which percentage share of farmers adopted labour intensive technology is targeted to be 80% at the end of 2025.This implies the government is determined to vigorously work to realize the set objectives.

5.5. Conclusions and /or Recommendations

In Ethiopia unlike the traditional RWHI systems, modern RWHI re recently introduced in response to the 1970s deadly drought prevailed in the country. Since recurrence of drought is increasing and the rainfall pattern became more variable the government and several NGOs determined to implement RWHI more vigorously. Particularly, construction of household scale RWH structures reached climax in the period 2002-2005. This was basically due to government's direct involvement by taking this activity as one of the mainstream extension activity to boost agricultural production. However, the assessment made in 2006 and afterword's revealed that quite large number of those structures constructed in the period between 2002 and 2005 appeared malfunctioned. In appropriate technology choice, design, operation, maintenance and other socio-economic and institutional reasons identified causative factors for such large failure. In this regard experts' opinion clearly shows that the way these technologies planned and implemented in the previous years had several problems.

Although several failures are registered, equally there are brighter spots where farmers' production and livelihood are greatly improved. Those farmers worked relentlessly to make the technology productive.

Analysing factors of failures and success are believed to be very important to rectify failure on the one hand and to up-scale success. In this regard several scientific studies are found very important. In terms types, quite large number of RWH designs and types introduced in different parts of the country. However, which type is more appropriate, economical and acceptable by the community and which is appropriate from physical geographic criteria perspective detailed studies are needed.

Regarding the potential of RWHI, literature and previous studies confirmed that immense potential exists. The annual amount of rainfall in the largest portion of the country generates excess runoff in the rainy months that can be stored to be used during the dry months. The topographic gradient can be taken a potential for appropriate ground catchment that it makes conveyance construction relatively easy just to collect the water and store it in smaller and medium storage facilities.

Regarding the future prospect, the government is planning to expand SSI. This calls for researchers to develop site specific, cost effective, socially acceptable and robust structures and planning and implementation procedures. Doing things as usual cannot be taken as alternative. The policy framework should also be checked.

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Chapter 6

Mapping of Best Practice of Integration of RWHI

6.1. Introduction

Looking back few decades ago in Ethiopia and in many countries as well, development efforts and activities were sector based and were lacking integration. Natural resource management is no exception. Land rehabilitation activates in Ethiopia, for example, began in the late 1970s and there was huge campaign throughout the 1980s to reverse the observed excessive land degradation mainly in the northern, central and eastern highlands of the country. During those years huge emphases was given for SWC activities in the degraded hillsides without properly addressing the issue of integrated resources management and towards improving the livelihood of the people with due consideration of conservation of natural resources for sustained ecosystem services. Since a decade and half ago, there is a paradigm shift that advocates development activities to make shift from sector-based development to holistic and integrated development; from top-down planning approach to participatory approaches; from SWC alone to integrated watershed management approach. These shifts also necessitate considering water resource development from integrated use perspective. On this line the following pages trying to present case examples where attempts are being made towards integration of RWHI in Ethiopia.

6.2. Best-practice of integration of RWHI

6.2.1 Case study 1. Integrating in-situ water harvesting and conservation with SSI

In situ soil and water conservation in Ethiopia has more than four decades experience. Earlier experiences of SWC were basically intended to reduce the huge erosion happening in the degraded steep slopes. Over the years, the emphasis changed and shifted towards achieving multiple benefits and mainly towards enhancing agricultural yield. The recent shift is observed on two aspects: firstly, the previous SWC projects were emphasizing on already severely degraded areas where agricultural production was virtually reached a critical stage as a result huge soil loss due to water erosion and now the emphasis is to pro-actively to protect soil erosion in agriculturally high potential areas. Secondly, the emphasis is not only on SWC but on integrated watershed development including enhancing the livelihood of the community through agricultural yield enhancement and introduction of off-farm activities. In this line both in-situ and ex-situ water harvesting for agriculture is becoming popular and practiced in several parts of the country. To cite examples of projects very active in this direction are Managing Environmental Resources to Enable Transition for more Sustainable

Livelihood (MERET) (TANGO et al., 2011; Eco-Agriculture Partners, 2013; Tilahun et al.,., 2007), Sustainable Land Management Project (SLMP) (GOE, 2010, Lakew et al., 2005)), Learning Watersheds (WLRC, 2014) and others. MERET is a project supported by World Food Program and currently active over more than 400 micro watersheds and communities for integrated watershed management where water harvesting is a part. SLMP is supported by multiple donors and coordinated by the Ministry of Agriculture which is operating in six regional states. Learning Watersheds in Upper Abbay (Nile) Basin, currently six are run by Water and Land Resource Centre (a collaborative Centre of University of Bern and Addis Ababa University). Oromia and Amhara Bureaus of Agriculture are closely working with the Centre with major objective of developing demonstration and learning centres for different stakeholders. Financially they are supported by Swiss Development Cooperation. Major in-situ water harvesting activities and technologies applied in those projects are presented in Table….. See also some pictures next to the table. TANGO (2012:11) regarding the success of MERET has the following findings.

> MERET SWC activities have had a strong impact on agricultural production. Terraces, bunds, check dams and other flood control, erosion control and water harvesting activities are improving soil fertility, depth and moisture, and restoring ground and surface water sources. These in turn have significantly enhanced land productivity and crop productivity and yield over time. …. Overall, MERET households report more land cultivated, higher production levels, and higher value of sales than control site households, though the difference in production is statistically significant only for cereals and pulses and the difference in area cultivated is statistically significant only for cereals. These results may be attributed to a higher proportion of MERET sites being trained in improved agricultural practices compared to control sites. More than 80% of MERET households have been trained in one or more SWC activities; nearly 75% have been trained in one or more

Amen (2006), also precisely demonstrates how in-situ water harvesting practices becoming important in small scale irrigation in Tigray regional state.

Table 1: Different soil and water conservation practices used for in-situ water harvesting that enable undertake small scale irrigation agriculture in different parts of Ethiopia (mainly in Tigray, Amhara, Oromia and Southern Nations, Nationalities and Regional States).

No.	Name of SWC technologies used for water harvesting and SSI system	Advantage	Disadvantage
A. Managing water in the hillside			
A1	**Eyebrow basin (EB), half moon,**	• EB are larger circular and stone faced (occasionally sodded) structures for tree and other species planting • Based upon experience they are effective in low rainfall areas to grow trees and harvest moisture. • Can be constructed in slopes above 50% for spot planting. • Controls runoff and contribute to recharge of water tables.	• EBs are labour intensive. • Require maintenance if not well constructed and stabilized. • Need to avoid free grazing • Require skill • Commonly on communal lands which make regular maintenance difficult
A2	**semi-circle terrace on cultivated land**	• Effective soil conservation and water harvesting structures • Short –term benefits • Can render unproductive hillsides into intensively cultivated units with supplementary irrigation • Individual user rights can be applied • Can provide income for land less farmers	• Need to be protected from livestock and wild animals (Baboons, Porcupines, and Rodents) • Require skill, training • Labour Intensive • Require a nearby water source for optimum productivity (ponds, springs) • Establishment of individual user right in most cases causes user right disputes
A3	**Trenches on communal land**	• are large and deep pits constructed along the contours with the main purpose of collecting & storing rainfall water to support the growth of trees, shrubs, cash crops and grass or various combination of those species in moisture stressed areas (350-900 mm rainfall) • can have FLEXIBLE DESIGN, to accommodate the requirements of	• Labour intensive. Need some 50 cm of top soil to be applied. • Require maintenance if not well constructed and stabilized. • Need to avoid free grazing

		different tree species • protect cultivated fields located downstream from flood and erosion • Part of the water captured by the trenches reaches the underground aquifer	• Require skill • Commonly on communal lands which make regular maintenance difficult
B. Harvesting gully water			
B1	**Bio-physical gully treatment**	• Effective gully erosion control • Direct short-term benefit (forage biomass) • Effective ground water recharge • Drinking water supply • Small scale irrigation	• Labour intensive physical gully treatment • Requires reshaping of gully walls • Loss of arable land or pasture • Requires livestock exclusion • Necessity to establish clear cut user rights • Likely to cause user right disputes
B2	**Bio-physical gully treatment with serial ponds**	• Effective ground water recharge • Drinking water Supply • SSI from hand dug wells	• Labour intensive, costly pond construction work • Large ponds occupy land • Increased risk of Malaria
B3	**Sediment storage (SS) dams**	• Converts unproductive large and active gullies into productive areas (fertile cultivated or fodder producing areas, mixed plantations, and fruit tree orchards). • Stone-faced earth dams constructed across medium/large size gullies to trap sediments, collect water and divert excess runoff. • Accommodate the runoff generated by the catchment located above the gully. • Are often constructed in series along the gully which can contribute significantly to protect cultivated lands, arrest gully expansion and recharge water tables	• Labour intensive • Needs thorough follow-up – • Difficult in areas with limited expertise. • Not suitable in sandy and sodic soils • Need to avoid free grazing

C. Managing water in the farmland			
C1	**Soil bund: an ecological niche for development (multipurpose shrubs, sunflower, fruit trees, stimulants on bunds)**	• Can provide short-term benefits to farmers (Bee forage, oilseed) • Does not compete with arable production • Low labour input • Can provide an incentive to farmers to maintain soil bunds and trench bunds	• Most farmers are not familiar with sunflower • More awareness creation is needed • Weeding, thinning out is essential • Sunflower can be susceptible to pests
C2	**Fanya juu (FJ) (multipurpose shrubs, sunflower, fruit trees, stimulants on bunds)**	• The FJ reduces and stops the velocity of runoff and consequently reduces soil erosion and the steady decline of crop yields • They are impermeable structures intended to retain rainfall, and hence, increase soil moisture, water availability to plants, and increase the efficiency of fertilizer application if any.	• Fanya juus bench quicker than soil bunds but are not as efficient in moisture conservation and more prone to breakages/ overtopping • Labour intensive • Need to avoid free grazing
C3	**Trench bund**	• Effective combination of runoff water harvesting with supplementary irrigation (ponds, hand dug wells, springs) • Does not compete with arable production • Can increase household income and improve household nutrition within three years • Can provide an incentive to farmers to maintain trench bunds • No user right disputes on individual farmland	• Requires livestock exclusion on farmland • May require protection from rodents (Baskets) during the first two years • Requires supplementary irrigation (ponds, springs and hand dug wells) • Increases household labour input (supplementary irrigation, weeding, harvesting, marketing etc.)

Source: summarized from (Lakew et al.,., 2005; Amen, 2006; TANGO, 2012).

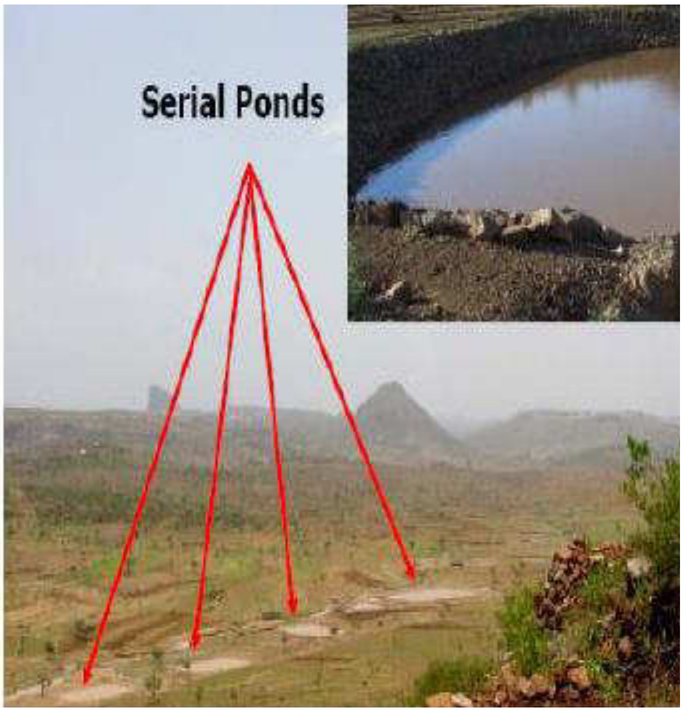

Fig 1a serial ponds constructed in a gully

Fig.1b. Sediment harvesting in a gully

Fig 1c: Multipurpose shrub on bunds, N. Wello (photo: Amare, 2005)

Fig 1d: Bench terrace on Cultivated fields (Betru, 2013)

Fig 1e: Trench on cultivated field (Tekeze Basin, Tigray region) (source: Asmamaw, 2014)

Fig 1f: rehabilitated gully in only less than three years (Tilahun et al.,., 2007)

6.2.1. Case study 2: Ponds for RWHI

RWH through construction of ponds that were initiated either by individual households/farmers or supported by NGOs and government was among major water harvesting technologies for irrigation of high value crops (e.g., vegetables and fruit trees) and/or for supplementary irrigation for annual crops in Ethiopia. This activity reached climax in the country in the years 2003 to 2005. Several thousands of ponds with different shapes (Trapezoidal, semi-hemispherical, spherical, circular, dome shape, and bottle shape, rectangular, square) were constructed. Some of them lined by concrete, while majority of them by geo-membrane plastic. Reports indicate big number of them failed. For example Leuel (2009) reported that from 2002 to 2005 more than 858,503 rain water harvesting structures (private ponds, community ponds, hand-dug wells, spring development) were constructed in Amhara, Oromia, Tigray and SNNP Regional states of which about 380,575 (44%) were functioning by 2006. Despite such huge failures, there are very successful farmers who improved their production and their livelihood. For example, one example of success form Amahara Region reports the following:

> *Mr. Abdul from Bati Woreda of Amhara National Regional State practices small scale irrigation using runoff harvesting. He constructed a pond by himself and he is now using it to grow papaya, mango, mandarin, tomato, chat and carrot as main crops. Moreover he has a plan to excavate another water harvesting pond in order to increase the size of his irrigation farm to two hectares. He said that he already prepared construction materials required for his anticipated water harvesting pond. Mr. Abdu reported that because of the water harvesting structures he managed to buy a pump for his irrigated field. He also mentioned that because of his success twelve households in his village are already organized to irrigate their farm using water harvesting. Mr. Abdu nevertheless indicated that the evaporation rate from his water harvesting pond is too much and it subsequently reduced the water available for irrigation use later and requested assistance in controlling and minimizing this loss. He also requested technical assistance as the technology is new and there is limited know-how in the area* (Abdul and Adinew, 2006: 22)

In the same way as above Leule (2009) from Tigray Region (Alemata Woreda, Kulu Gize Lemlem Kebele) documented the following farmer's narratives.

> *In this Kebele, a total of 64 plastic lined and many more unlined ponds (each 180 m^3 capacity) were constructed in 2003. Out of these, only eight plastic lined ponds are functional. One of them belongs to a farmer called Ato Abadi Asfaw who immediately planted seedlings of 3 orange, 1 mango and 2 lemon plants. These plants have already started bearing fruits as of 2007. The fruit was mainly consumed by his family and only a portion of it was sold (no data on the value of fruits sold). Besides, the farmer has also used the water from the pond for supplementary irrigation of maize planted on 0.25 ha in 2008 and to raise onion seedlings on 28 seed beds each year. The seedlings were sold at a rate of Birr 200 – 300 per seedbed or a total of about Birr 7000 per year (or equivalent to over 416,000 Birr/ha). Inspired by the income, he has planted more fruit tree seedlings and he has now a total of 20 orange, 20 mango, 2 lemon and 30 papaya plants in his backyard. (Shortcoming observed was that the spacing of the newly planted tree seedlings was smaller than the required). The owners of the other 7 plastic lined ponds use the stored water to produce seedlings of*

onion, tomato and pepper for sale and own use. A typical farmer of this group is Ato Zenebe Adhana who earned Birr 3200 in August 2007 by selling onion seedlings (Leul, 2009:49).

6.2.3. Case study 3: Borena Sand Dam by RAIN Foundation

Like other water harvesting technologies sand dam and underground water harvesting systems also have long history. Particularly in North Africa this technology is as old as 2000 years. In Ethiopia sand dam construction dated to 1974 in eastern part of the country. The specific places where it started are around Dire Dawa (Adada, Ejaneni, Melka Belina, Gende Bira, Melka Jeldu etc.) & Gursum area (Eskindir, 20014). These areas are semi-arid where pastoralism is the major economic activity. Although pastoralists have their own indigenous water harvesting and management systems water is a critical problem for their livestock and domestic use. It is with this intention that sand dam is considered an alternative technology for storing rainwater. In line with this and with rainwater harvesting activities in general, RAIN Foundation started its operation in Ethiopia in 2003. It has several engagements since then in cooperation with partner institutions, including government, NGOs and Civil Societies. The following is one successful example that Rain Foundation developed in Borna Zone of Oromia Region. See also Fig 2 showing the Borena Pastoralists watering their animals form one of the sand dams.

"Borana, one of RAIN's working areas, is a semi-arid region in southern Ethiopia with two annual dry seasons. During these periods, most people walk between 6 and 8 hours to fetch water. People depend largely on open water sources such as rivers and ponds, which tend to dry up quickly after the rainy season, providing unreliable water quality and quantity. In large areas, groundwater is not accessible or contains arsenic or high salt levels making it unsuitable for drinking. RAIN's work in Borana began in 2007 with the key aim to improve access to safe drinking water for remote communities, a programme funded by the Dutch Government. A combination of water harvesting techniques (surface water runoff with below-ground tanks and sand dams) provided a reliable solution to the availability of drinking water. Subsequently 15 local implementing organizations were trained in sand dam technology and are constructing sand dams within their interventions areas. The sand dams are designed so that runoff water is infiltrated in the sand behind a small dam traversing the riverbed, serving as an artificial aquifer. In this way, evaporation losses are limited, the quality of water remains high and water can be extracted from the sand in the dry season using shallow wells. The dams contribute to groundwater recharge and reduce the risk of erosion and flooding ..... If a sand dam is properly constructed, it requires little or no major maintenance. In time, the dams should protect the livelihoods of the people of Borana from the foreseeable effects of climate change". (Nijhof et al.,., 2010, *3-4*).

Fig 2: Borena castles served water from the constructed sand dam (photo Amare, 2011)

6.3. Conclusions and /or Recommendations

Soil and water conservation (SWC) practices in Ethiopia have more than four decade's history. They were introduced to reduce soil loss by water erosion in the most degraded highlands of the country. Later, SWC activities integrated with other activities such as rain water harvesting to enhance ecosystem services and livelihood of the people. In this regard the major change (shift) was to use SWC for in-situ water harvesting to use it for small scale irrigation. Along with this several rainwater harvesting technologies, particularly farm pond construction were promoted by the years from 2002 to 2005 several thousands of structures constructed. In fact, among large number of constructed ponds it was about 44% that found functional by the year 2006 which indicates large number of failures. Several factors accounted for the failure, which need ardent attention. In semi-arid areas where most of the months in a year are dry and have several dry river beds, construction of sand dams is an alternative to harvest/store enough water from peak runoff during rainy months and for multiple uses in dry months (domestic, livestock and crop cultivation). The latter technology should be encouraged as farm ponds, surface dams and river diversions are to the areas where enough rain is falling during the rainy season to collect water for dry months for both supplemental irrigation and for back yard gardening.

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