Nile Basin Initiative

Eastern Nile Subsidiary Action Program (ENSAP)

Eastern Nile Technical Regional Office (ENTRO)

Watershed Management Project

Field Report

International Training/study tour on Rainwater Harvesting to Gansu, China

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Table of Contents

1. Background:

1.1 The Eastern Nile Watershed Project

The EN countries, comprising of Egypt, Ethiopia, South Sudan & Sudan are pursuing cooperative development at the sub-basin level through the investment oriented Eastern Nile Subsidiary Action Program (ENSAP). Towards this end, the EN countries have identified their first joint project, the Integrated Development of the Eastern Nile (IDEN), which consists of a series of sub-projects addressing issues related to flood preparedness and early warning, power development and interconnection, irrigation and drainage, watershed management, multi-purpose water resources development, and modeling in the Eastern Nile. The Eastern Nile Technical Regional Office (ENTRO) is an institution established by the three EN countries to advance the implementation of ENSAP projects.

The Eastern Nile Watershed Project is one of the seven areas of cooperation agreed by the Eastern Nile countries. Its immediate objective is to establish a sustainable framework for the management of selected watersheds in the sub-basin in order to improve the living conditions of the people, enhance agricultural productivity, protect the environment, and reduce sediment transport and siltation. Towards meeting its objective, the Watershed project undertook two sets of activities in parallel between 2004 -2008: preparation of investment ready projects for national implementation (fast track projects) and a Regional Cooperative Assessment (CRA) study. Both sets of activities were successfully completed. Currently implementation of eight pilot projects is initiated at national level.

The need for capacity building across a wide range of disciplines and subjects at all levels has been identified in the trans-boundary analysis of the CRA as a key pre-requisite for effective trans-boundary watershed management data collection, multi-disciplinary watershed management research and monitoring and evaluation of watershed management activities. To address this gap, a regional capacity building component is formulated with the objective to strengthen the knowledge base and human resource capacity for cooperative action on watershed management in the Eastern Nile Basin. Thus, organizing training and experience exchange visits is a key activity of the regional capacity building component.

1.2. Rationale and Objective of the proposed training workshop:

From the outset, ENTRO and member countries have recognized the importance of organizing study tours/training workshops both within & outside the region in order to learn from experiences of other countries and adapt and incorporate good land management practices in to the regional watershed program. To this effect a number of regional and international study tours were organized in the last three years of the project life (India, Ethiopia, Rwanda, Tanzania). In the context of the Eastern Nile countries, the experiences from these visits were very much relevant. The experience also illustrates that flexibility and diversity of simple technologies tailored to local conditions are viable approaches to Eastern Nile countries.

Building on the experience and based on the request of member countries, the focus of the current International training/study tour is on Rain Water harvesting and Watershed development. The importance of this theme is a reflection of the situation in the region. In the upper stream of the Eastern Nile basin (highlands of Ethiopia) where agriculture is exclusively rain fed, rainfall variability (spatial and temporal) has historically been a major cause of food insecurity although the total volume of rain water is relatively large. Inter-annual and seasonal rainfall variability in this part of the basin is high and agricultural yield declines resulting from such frequent inconsistencies. Due to large spatial and temporal variations in rainfall and lack of water storage facility to capture excess water for use during period ofr scarcity, there is no enough water for most farmers to produce more than one crop per year. Irregular dry spells and droughts exacerbate the incidence of crop failure and hence food insecurity and poverty. On the other hand the rainfall during the wet seasons is eroding fertile agricultural soils thus leaving behind degraded lands and gullies. Given the water available, the promotion of water storage related technologies, especially rainwater / runoff harvesting, at household and community level is crucial.

Water scarcity in the lower part of the basin is very critical with annual rainfall received in these areas is as low as 75 mm per year. The main concern among the stakeholders in this part of the basin is the poor access to water for domestic and agricultural purposes since there is limited structure in place to capture and store from the short flooding period. Access to clean water for household and livestock is poor. There is limited infrastructure in place to capture and store water from the short flooding period. Water availability to sustain biodiversity and agricultural production is a problem since the river is no longer flowing all year around. Efficient use of available water is another concern and there is scope for large improvements in irrigation efficiency. Minimization of evaporation losses is important not only due to the currently high temperatures but also the anticipated increase due to the impacts of climate change.

If rainwater harvesting is successfully implemented, significantly larger volumes of cereals, vegetables and other cash crops will be produced to ensure food security, to increase incomes and improve nutrition, and the burden on women and children in collecting water will be reduced. This can enable women to participate in other economic activities, girls will be freed from carrying water to attend school, and adult women can engage in more productive work. A virtuous cycle is then possible to increase food security, enhance incomes, reduce poverty and improve the environment as well.

The main purpose of organizing this training/study tour is to document experiences in Rainwater Harvesting in China and draw lessons which will be useful and applicable to the development of integrated watershed management interventions in the Eastern Nile context. In addition, it will provide a forum to discuss on project implementation modalities and contribute to multi-disciplinary perspectives on approaches and thereby ensure performance of project implementation and sustainability of outputs. Such exchange of knowledge will also serve as a forum for capacity and confidence building by enabling interaction among professionals of the basin. Knowledge and experience exchange tour will enhance the technical capacity of institutions involved in watershed management to undertake effective planning, monitoring & evaluation of watershed management interventions and thereby strengthen the role and capacity of national institutions in the development of pro-poor investments and services to promote productive and environmentally sound livelihoods with local community participation.

In line with the overall purpose, the international training/study tour on Rain Water Harvesting and watershed development is designed to strengthen the capacity of participants on improved approach on rainwater harvesting through classroom sessions and field visits, particularly to improve the capacity on planning, design and implementation of rainwater harvesting system.

1.3. The training/study tour Participants:

The International training/study tour was intended to complement the various capacity building activities being organized at regional and national levels. A total of 18 participants who are drawn from the four Eastern Nile countries and ENTRO attended the training/study tour which was held from 15 June to 04 July 2013 in Gansu, China. The training/study tour was facilitated by the Gansu Research Institute for Water Conservancy (GRIWC).

1.4. Organization of the training/study tour:

This international training/study tour was jointly organized by the Eastern Nile Technical Regional Office (ENTRO) and the Gansu Research Institute for Water Conservancy, Peoples Republic of China. The Ministry of Science and Technology (MOST), People's Republic of China and ENTRO jointly sponsored the training/study tour. EN National Coordinators for watershed project were actively engaged in the identification and selection of participants. The Gansu Research Institute for Water Conservancy was organizing and conducting the training/study tour, including logistic arrangement.

2. Overview of China's experience in Rain Water Harvesting & Utilization:

The Challenge:

Despite huge total water resource (total annual precipitation of 619 bm^3) and annual renewable water resource, composed of river runoff and groundwater of about 280 bm^3, China is faced with a serious water shortage. Uneven distribution both spatially and temporally is a major reason for the shortage. While water resource per capita in the South West of the country reaches more than 30,000 m^3, in some of the North and North West regions is as low as 200-300 m^3. Furthermore, the available water resource is concentrated in the rainy season which causes serious flooding while draught occurs in the dry season. For example, 60-70% of the yearly total river runoff in North China occurs from June to September. However, from May to June, it is only 20-25%, when crops need water and this hardly meets the crops' water demand, causing frequent draught and reduction in crop yield.

It was estimated that due to the shortage of rain, the country lost around 25 billion USD from industrial production and 25 billion tons of grain production resulting in food insecurity in many areas. It was also estimated that 400 of the 668 cities in the country suffered from serious water shortage.

The regions that suffered most include semi-arid loess plateau in Gansu; Nimgxi, Qinghai, and Inner Mongolia. About 29 million people residing in these regions were inaccessible to safe drinking water.

Water scarcity in the loess Plateau of Gansu province: Gansu province (located in the inner land of Northwest China) is one of the driest provinces with annual precipitation of around 300mm while the potential evaporation could reach between 1500-2500mm. The situation is much worse in the central and eastern part of the province which is characterized by a widely distributed loess plateau and hills crisscrossed by numerous gullies and ravines. The loess soil, being highly permeable and deep, absorbs most of the precipitation (runoff coefficient being 0.05). The distribution of precipitation is also uneven (60-70% falling between June and September while it is only 20-25% during the crop growing period). As a result, the area suffered from repeated draught. Out of the past 40 years, 26 were hit by draught which reduced production by 30-50% compared to the normal years. The other consequence of water scarcity in the region was the practice of mono cropping agricultural system as the available water was insufficient to cultivate cash crops, which require more water. This has resulted in low annual income per capita.

Soil erosion was also a serious challenge in the province. It was as high as 5,000-10,000 tons/km^2. This has forced farmers to encroach in to steep lands to compensate for the decline in land productivity, which further aggravated land degradation, environmental deterioration as well as intensifying soil and water losses.

Efforts to address the problem of water scarcity – example from Loess plateau of Gansu province:

In the past 40 years, efforts were made both by technical people and local community to improve the situation. The initial efforts were focused on finding solutions to the problem with the adoption of traditional dry farming practices. These include:

- ✓ Reforming the landscape in order to retain more rainfall (terracing and contour farming),
- ✓ Improve cultivation measures to protect soil moisture from evaporation through deep plowing, mulching, etc.
- ✓ Improve crop resistance to crop water stress through breeding drought resistant varieties, etc.)
- ✓ Taking measures to harvest water (mini-catchments, spate irrigation, flood harvesting)

Though these efforts were useful in enhancing productivity during normal years, the effectiveness of the interventions was limited for the drier periods. This is because the storage capacity of soil was not enough to mitigate the observed water shortage. It was concluded that complementing improved traditional dry farming techniques with artificial water supply can only enable a high level of crop yield in rain-fed agriculture at all times.

The conventional method of artificial water supply is through diverting water from rivers. However, this has its own shortcomings owing to high input and O&M cost and environmental problems associated with large projects. Thus, the only potential and easy to use water resource identified in the area was rainwater. Since the end of 1980's, RWH has been proved to be a more sustainable approach for integrated development of society and rural economy. In some areas (mountainous) it is the only source available.

The use of rainwater by local community dates back to thousands of years. Local people used to store runoff using underground tanks (known locally as Shuijiao). But the rainwater utilization efficiency was low and the collected water was not even sufficient for domestic use. It was thus found necessary to increase water collection efficiency through the increase of concentration area. To achieve this goal, experimentation, demonstration and extension project was launched with the support of Gansu Provincial Government and Water Resources Bureau. The project was aiming to study rainfall-runoff relation under different rainfall conditions on different rainwater harvesting fields to find out appropriate rainwater use pattern and formulate design procedures. Based on the research conducted from 1988 to 1990, relationship between Rainfall Collection Efficiency (RCE) and rainfall amount and intensity, under different catchment materials was established.

On the basis of research findings, demonstration and extension was launched since 1990. The household RWH system for daily water use includes 80-150 m^2 of tiled roof and concrete paved courtyard, one water-cellar (15-20 m^3) and a hand pump. Some RWH systems for irrigation purpose were set up with the construction of greenhouses. By the end of 1994, 2.4 million m^2 of collection field and 22,280 water-cellars with improved design were built. This improved the RCE by about 70%. Progress has also been made in rainwater irrigation scheme.

In 1995, a serious draught was occurred in Northwest China. Learning from the success stories of the research, demonstration, and extension project that was operational from 1988 to 1994, the provincial Government launched a project called **"1-2-1"** that aimed at solving the water shortage problem in the area. The project was financed by the government. The project involves building one rainwater collection field, two underground water tanks, and one piece of land close to the household to be irrigated with stored water. In a period of two years, the project met its pre-set goal of reaching 1.31 million people. Irrigation water was also applied to 1.33 thousand ha of land and helped farmers to generate income.

Following the successful implementation of "1-2-1" project, the government launched the RWH Irrigation project in 1996. This project further opened the way for farmers to develop the economy and improve their livelihood.

The practice of RWH in Gansu province was significant in rural development. Through RWH, rural communities benefited from reliable, clean, and cheap water resources. It also relieved the farmers, especially women and children from travelling long distances to fetch water. The tiling of roof and concrete courtyard raised the quality of life of rural community. The RWH for irrigation has enabled farmers to mitigate drought and increase crop yield by about 40% on average. RWH has also a significant impact in promoting ecological and environmental conservation. With increase in productivity, farmers gave up encroaching hill slopes. The hill slopes were converted into planting trees and grasses, promoting fruit tree plantation and intensifying animal husbandry. Now, it becomes a national policy to convert land above 25 degree to tree and grass plantation to stop soil erosion and reconstruct the ecosystem. As an incentive, the government subsidizes farmers with 50 RBM/Yuan and 100 kg of grain for planting trees and grasses on one Mu (15 Mu is equal to 1 ha) of originally cultivated land for a period of five years.

The recent progress of the RWH project in China:

The State government has paid serious attention to the rural water supply and the irrigation & drainage to promote the agriculture development and the "New Village Construction Program". Regarding to the rural water supply, most villages were linked with the centralized piping system. However, in the remote mountainous area and the area where surface and ground water source is inadequate to build the centralized system, RWH is still the feasible way for rural water supply. Apart from the future development of irrigation with the conventional water source (reservoir, canal, well, pumping, etc), the RWH irrigation will still play a key role for enhancing the rain-fed agriculture, especially in the remote and/or mountainous areas with water shortage.

Evaluation for RWH project:

The economic evaluation made for RWH project concludes that the RWH project in Gansu is economically feasible both for domestic and irrigation supply. In terms of social impact, the RWH project for domestic water supply avoids the hard labor of women and children for fetching water. Now, children have time to go to school and women can participate in the public and household activities. On top of that, it is also environment friendly project.

3. Description & highlight of the training/study tour:

The training/study tour was a mix of class room sessions (presentation and discussion) and field visits. Participants also made presentations focusing on the water resource development challenges of their respective countries to share their experiences and provide some lessons learned emerging from similar initiatives in their own countries. The field visit enabled the participants to observe closely some useful experiences that could be replicated in their own countries.

3.1 Highlight of Classroom Sessions:

The class room sessions were organized with the purpose of providing broader understanding of the challenges related to water resources development and their relation to sustainable development, conceptual basis for rainwater harvesting and integrated water resource planning and management to address the challenges, step by step planning and design procedures based on China's experience over the last 20 years and presentation of case studies. The classroom sessions were supported by visual aids and were very interactive.

The classroom sessions focused on two major thematic areas: *Rainwater Harvesting system and River Basin Planning for Water Resources development.* Below the content of each of the thematic areas is briefly described:

3.1.1 Rainwater Harvesting:

Global experience on Rainwater Harvesting:

Under this sub-topic, general information on global water resources, the challenges in water resources development to meet the increasing demand for water and global responses to address the challenges were highlighted. Globally two approaches were pursued as a response to the challenges: optimizing use of the limited resources, and finding alternative or additional water source.

Rainwater harvesting, a technology used for collecting (from rooftops, land surfaces or rock catchments), storing (by using simple techniques such as jars and pots as well as engineered techniques) rainwater for domestic and agricultural use, was highlighted as a viable option to augment fresh water for rural communities. The technology as such is not new and has been practiced for more than 4,000 years as important water source in many areas with fair rainfall but lacking of conventional, centralized water supply system. Driving forces to promote Rainwater Harvesting are: the global water crisis, global population-more than doubled since 1950 and reached 7 billion in Nov, 2011, natural resources- already being exploited beyond their limits in some regions, and urbanization-since 1950 (the number of people living in urban areas has jumped from 750 million to more than 2.5 billion).

Introduction to Rain Water Harvesting in China:

Under this sub-topic, definition of Rainwater Harvesting (RWH) and Rainwater Utilization (RWU) is provided. RWU denotes the utilization of rain drop at its primitive form (by the crop) or use of rainwater when it transforms to other types of water (surface and soil water and groundwater) at the very beginning stage. RWH is a mini-size water resource project, which collects, stores rainwater through structural measures and use rainwater in an efficient way. According to the definition, rain-fed agriculture is rainwater utilization (RWU) for agriculture production. The essentials of rain-fed agriculture is to enhance the rainwater use efficiency as high as possible by: preventing runoff of the land, preventing soil moisture loss from evaporation and deep percolation and enhancing productivity of rainwater use.

As part of the introduction, a brief description of RWH projects in Gansu was provided. The projects include **Research, Demonstration and Extension Project on RWH** implemented by the Gansu Research Institute for Water Conservancy (GRIWAC) from 1988 to 1992; and **the "1-**

2-1"Rainwater Catchment Project Launched by the Provincial government. The objectives of the research, demonstration and extension project were: study the rainfall-runoff relationship under different rainfall condition and on different rainwater collection surface; find out the appropriate rainwater utilization pattern; formulate the design of RWH procedure for the RWH system; and to justify the technical and economical feasibility of RWH.

The purpose of "1-2-1" Rainwater Catchment Project was in response to a serious drought that occurred in Northwest China in 1995. The Provincial Government made a decision to carry out the "1-2-1" Rainwater Catchment Project to support each family in the area to build the domestic RWH system to solve the water supply problem. The government supported the family in the area where the surface and subsurface water is unavailable and the only water source is rain to build:

- ***One*** catchment area with tiled roof and/or concrete lined courtyard. The total area is 100-150m^2,
- ***Two*** water cellars with capacity of 15-20 m^3 each, one for domestic supply and another for irrigation,
- ***One*** piece of land to be irrigated with stored rainwater for developing courtyard economy.

By the end of 1996, beneficiaries of the project reached 1.31 million populations in 264,000 families of 2018 villages in 27 counties. 0.977 M animals get drinking water.These households updated their roof and paved the courtyard with concrete slabs for collecting rainwater. The total area of these two kinds of catchment amounts to 37.16 million m^2. 286,000 newly designed water cellars were built. Irrigation water was applied to about 1330 ha of land for developing courtyard economy, helping farmers generate their income.

Types of rainwater collection surface:

- *Surface of existing structure:* including roof, paved highway, courtyard, country road, threshing yard, sport ground and roof of greenhouse, etc. Its advantages: 1) Relatively higher RCE; 2) Very low input; 3) Better quality of water collected from these kinds of catchment.
- *Natural slope:* Earthen slope, mainly used in humid area where soil is moist and infiltration rate is low. In semi-area, the natural soil is to be compacted as catchment. Rocky slope: has relatively high RCE
- *Purpose built catchment:*

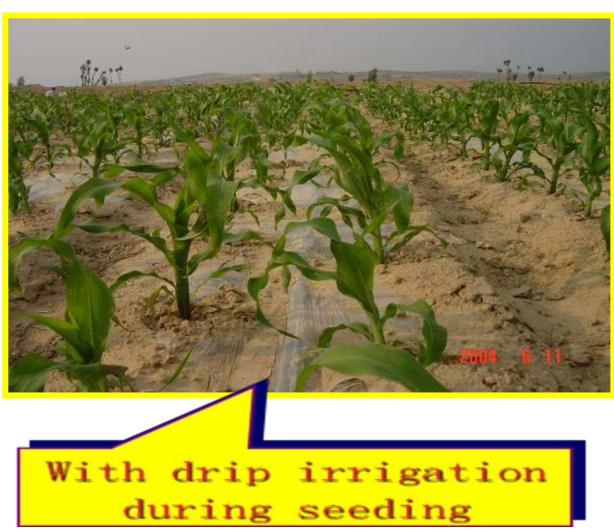
Dimensioning RWH System:

Dimensioning RWH system is a critical component of overall design of RWH system. During this session it was emphasized the importance to consider domestic water demand, supplemental irrigation water use, animal husbandry water use, and other water uses in order to calculate water demand. The following parameters are used to determine dimensioning of RWH system:

1. **1.** Design rainfall
2. **2.** Water supply reliability
3. **3.** Hydrological frequency and its calculation

The two necessary conditions to determine the capacity of the RWH system to meet the demand of water supply (quantity and reliability) are catchment area and storage capacity. The yearly inflow of the RWH system should be large enough to meet the demand (including the water use and reliability). This is guaranteed by determining a proper catchment area with certain Rainwater Collection Efficiency (RCE). Since the inflow of the RWH system is generated by the natural rainfall it may not meet the water demand in all the time. A storage with certain volume to store the runoff when it exceeds the water demand and supply water to the user when the runoff is less than water need is needed.

RWH based irrigation in China and Gansu: The experience of using stored rainwater for irrigation over the last 20 years was discussed in this session. The RWH irrigation methods in China are divided into two groups: Indigenously innovated water-saving methods, and the modern micro irrigation methods. All these methods have two features: High efficiency- Evaporation and seepage losses are reduced to minimum, and water is only applied at the crop root zone, conforming to the principle of modern partial irrigation. **Indigenously innovated water-saving methods include** irrigation during seeding, irrigation on the plastic film, furrow irrigation under the plastic film, injection irrigation, and bunch irrigation. **The modern mini-irrigation technique** is adopted in the RWH project in China with commonly used method of Drip system. Besides, the micro-spray is used for vegetables, mostly in the greenhouse and bubble irrigation is used for orchard. Advantages of mini-irrigation technique are: 1) high irrigation efficiency; 2) water saving; 3) uniform water application; 4) low energy consumption; 5) water and chemical applied in one operation; and 6) labor saving. The disadvantages of mini-irrigation are: 1) higher input; 2) clogging of the system is easy to happen; and 3) complicated technique in operation and maintenance.



It was mentioned that a special kind of water saving technique **–Low Rate Irrigation (LORI) –** has been developed. The technique stipulates applying irrigation water to crops only in critical periods of its growth, usually one application during seeding and one to two applications in the growth period. For each application, a total of 340-670m^3 per ha of water is provided, this is only 10-15% of the crop water requirement. To ensure efficient water use and high output, appropriate agricultural practices have to be followed. By the end of 2004, 2.08 million new storage tanks with a capacity of 81.12 million m^3 of water were built for the purpose of RWH irrigation. This can provide supplemental irrigation water for 80,550 ha of land.

Based on demonstration results, LORI can increase yield by 30-75%. Test results have also shown that in the rain-fed areas, Water Use Efficiency (WUE) is about 0.5 kg/m^3 while WUE with water supply from RWH system ranges between 0.6 to 2 kg/m^3 in average and in some cases, reaches to 5.7 kg/m^3. It indicates that RWH is much more effective in rainwater use than in the conventional dry farming. It would be reasonable to assume that the low rate water supply in the critical period is just to help crop to tide over the serious water stress to avoid the crop from fatal damage. Then in the rainy season the crop could use the rain efficiently.

Part II

RWH Irrigation methods in China

❖ Modern irrigation:

— drip

— micro-sprinkler

— bubble irrigation

Principles of RWH Irrigation:

a) WUE and the WSE should be maximum. This means RWH irrigation should get the maximum profit (in the form of production or cash) with certain amount of rainwater.

b) RWH irrigation is based on the principle of deficit irrigation (limited irrigation). The crop water demand is not fully met at every stage but only at some critical periods of growth. Critical periods are periods during the crop growing season where if crop is subjected to serious water stress, the damage to the crop would be unrecoverable even with water supply or natural rain in the later stage.

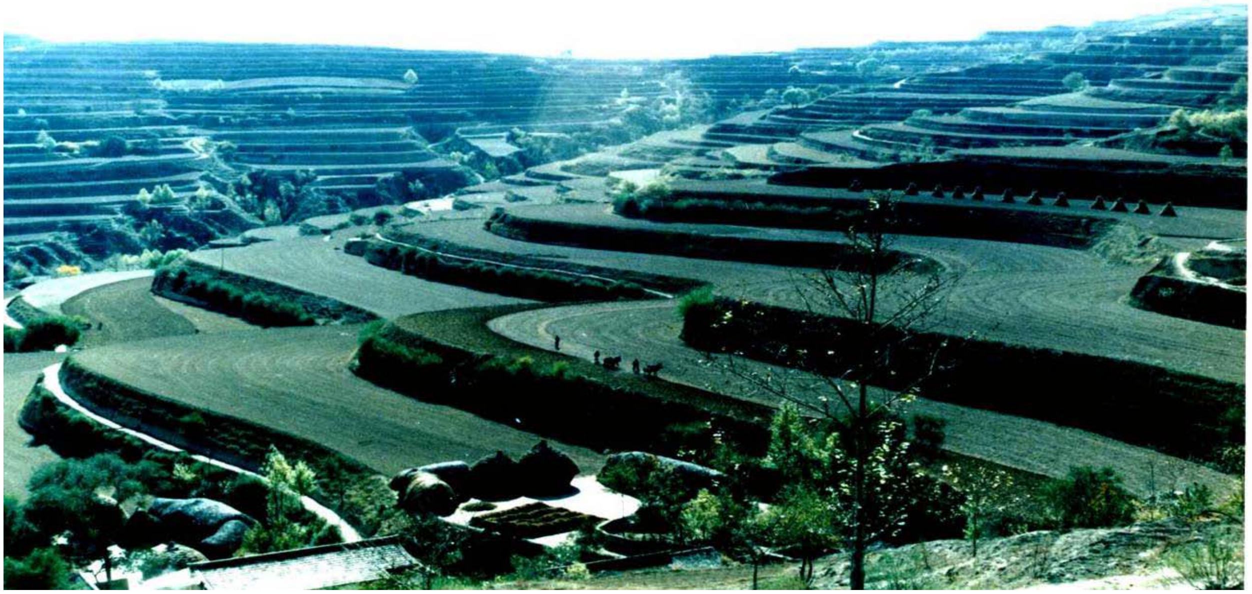
c) The water application takes place at the root zone of the crop. This will minimize soil evaporation.

d) The irrigation efficiency (ratio of valid water supply to the total supply) should be as high as possible. Water loss during irrigation process should be avoided as much as possible.

Integrated Agricultural Approach towards conservation of Rainwater:

One successful approach tested in the Gansu province towards poverty alleviation and ecosystem management is the integrated approach to conservation of rainwater. There are two ways to conserve rainwater: collecting and storing in structures such as tanks; collecting and storing in the soil.

Storing rainwater in the soil is done through application of terracing and mulching. Application of terracing which involves integration of terracing with mulching, RWH and crop adaptation has been supported by the provincial government. It was reported that around 80% of the sloppy arable land has been terraced by the end of 2012. Terracing is applied for slopes up to 25 degree. For slopes above 25 degree, other interventions such as deep pits for rainwater concentration, plastic mulches for high Rain Collection Efficiency (RCE), and fish scale pits for steep slopes along gullies to plant trees were found to be suitable to catch rainwater. The application of terracing has dramatically increased crop yield (see table below).



The terraced land in high mountains in China.

Average yields of main crops growing on terraced lands and non-terraced slope lands.

Crops	Yields from terraced lands (kg/hm^2)	Yields from non-terraced slope lands (kg/hm^2)	Yield increases %
Spring wheat	2187.5	1125.3	94.3
Pea	1947.5	1131.5	72.1
Flax	917.3	547.7	67.5
Potato	3317.4	2141.6	54.9
Buckwheat	2286.0	1199.5	90.5
Millet	4219.5	2971.0	42.0

The results were obtained by a five-year observation in Gaoquan Watershed (long-term mean annual rainfall 415 mm) of the Loess Plateau in mid-Gansu between 1996 and 2000.

Application of mulching involves the use of stubble and plastic mulches to conserve soil moisture. *Stubble mulch* has positive effect on improving water condition. It has also the function of restraining weeds and eliminating diseases and insects. It uses suitable materials which are cheap, locally available, easy to transport and apply. Cereal straw and stalks including maize straw are the most common in use for farmland mulching. *Plastic mulch* reduces evaporation, conserve soil moisture, prevent weed growth, reduce soil erosion, and boost crop root development, increase nutrient up-taking. It was observed that plastic mulching in mountainous areas increase yield by up to three fold.

Table The effects of mulching on the soil water content (mm) in depth of 0～200cm

Treatments	Winter wheat	Spring corn
	Soil water content in depth 0-200cm	Soil water content in depth 0-200cm
Stubble mulch	153.4	207.0
Non-mulched	105.6	137.7
Differences	47.8	69.3

Rainwater harvesting in the small watershed management: RWH has become integral part of small watershed management with the following benefits. It plays big role in enhancing survival rate of young trees by providing irrigation water; can make more efficient use of land and water resources by further enhancing the crop yield and providing irrigation water to orchards and greenhouses for high profitable agriculture; provides clean, cheap and reliable water source for domestic supply, and stores runoff on the catchment thus reducing soil erosion and water runoff. Rainwater harvesting is an innovative approach for rainwater management. In some areas, it is even an irreplaceable measure for human survival and development.

Comprehensive harnessing of small watershed

3.1.2 River Basin Water Resources Planning:

Integrated Water Resources Management (IWRM): IRWM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

A river basin water resources planning involves the following tasks (World Bank):

- Understanding the condition of the basin,
- Identifying the national, regional, and sub-national goals and objectives for water and related resources (e.g. land) development,
- Developing specific water and natural resource policies, procedures, goals, and strategies consistent with the national and regional goals, to guide how and when the resources can be utilized within the agreed stress or impact limits,
- Analyzing the various water sector requirements and the development of a broad basin-wide water and related resources framework that best meets the overall basin needs. The framework should be comprehensive, considering conjunctive use of surface water and groundwater, transferable water rights, reuse, and conventional supply management options, as well as demand management instrument,
- Undertaking bottom up planning at the sub-basin or catchment level, often called land and water management planning (or sub-basin planning, micro-planning, village development planning, or water user association planning, depending on the level and community institution involved). This will involve significant community participation,
- Obtaining broad input from relevant groups and people in the basin as to the appropriateness of both the higher-level framework plan and the lower-level land and water management plans,
- Incorporating the best portfolio of proposals that balance economic, environmental, and social issues at both higher and lower levels into the first basin development plan. Parts of the plan will likely change as more data become available and more planning occurs at the lower levels. It is common for the initial plan mainly to include major projects and broad management improvements from the top-down management, as the lower-level planning often takes longer to complete,
- Developing investment plans on both a sub-basin and whole-basin basis to fund and implement the basin water plan,
- Developing and implementing a monitoring plan to ensure that the contents and approaches expressed in the basin plan are being followed.

The integrated river basin planning is an overall arrangement for the development, utilization, conservation and protection of water resources based on the social, economic development and the present state of water resources development.

Methodology for Water Resources Planning:

- Data collection and evaluation of present state of water resources system
- General of river basin water resources planning
- Water requirement and water conservation plan
- Water resources protection
- Water supply planning
- Water resources development plan
- Overall arrangement of water resources system and implementation plan

Water reallocation plan for Shiyanghe River Basin (a case study): The main objective of Shiyanghe River Basin harnessing is to reallocate water between upper stream and downstream and between production and ecosystem use and to stop overdraft of groundwater. Ecosystem (tree and shrub) can survive only when groundwater table is higher than 3-5m. The plan includes increasing inflow into the Minqin Basin to raise water table by stopping overdraft of groundwater and increase recharge to the groundwater. Meanwhile, the water use should also be restricted to an acceptable level.

Measures to realize the River Basin harnessing plan:

a) *Negotiation with water users:* After negotiation with government at different level and the water users in the basin, the water allocation plan has been officially published. The plan stipulates water distribution to various counties and different water users.

b) *Establish a water conservation society:* The water use amount distributed to various counties is controlled by the Shiyanghe River Basin Authority. All the reservoirs and canal intakes are in the charge of the Authority. All the wells have to get license for pumping certain amount of water and are installed with water meter to monitor the water draft. Newly built well should get approval from the Authority. The participation approach is adopted to improve awareness and capacity building. The water user association and farmer water use association are set up.

c) Harnessing measures:

- Modify industry structure which includes ensuring water use for key industry development, reduce total irrigated area and restructure irrigation water use, reduce proportion of food crop and increase that of the cash crop thus the overall agriculture benefit is increased and environment conserved, and improve economic condition of households by encouraging farmers to find temporal job in the cities and support famers to improve agriculture facilities.
- Upgrading irrigation system including: canal retrofitting and seepage control, subsidy farmers to adopt water saving irrigation methods: pipe irrigation, drip and lessen area of irrigation boarder, and demonstrating greenhouse.

d) *Ecosystem restoration and conservation to: p*reserve vegetation in the mountainous zone for water source protection, build/improve shelter and windbreak belt in the cultivated field, build ecosystem (desert plant) in buffer zone between desert/dune and oasis, and demonstrate immigration for ecosystem conservation.

e) *Water resources protection to:* control waste water and pollution discharge, to ensure quality demand of different water functional zones being met, and build new waste water treatment plants.

f) *Institutional Measures:* The Gansu Provincial Government is responsible for Shiyanghe River Basin harnessing work. The state government agencies provide necessary instruction and support. The Administrative Committee for Shiayanghe River Basin was set up and headed by the Provincial Governor. The Gansu Bureau of Water Resources is in charge of the Shiyanghe River Basin Authority that is responsible to manage, allocate and monitor implementation of the Water Resources Plan of the Basin. To this end, a series of regulations have been approved and issued by the Government agencies. The local government is asked to pay respect to the farmers' right of information, participation and monitoring; promote awareness of the public and democratic procedure, etc.

Results of River Basin Water Resources Planning and implementation: According to the monitoring data, groundwater table of Minqin County has been raised by 6mm in the year 2011. Water table around Qingtuhu Lake raised by 42cm. Based on the State-wide investigation analysis of desertification, the forest coverage in Minqin increased from 7.8% to 11.8% in the period of 2006 to 2010.

3.2 Brief description of the Field Visit:

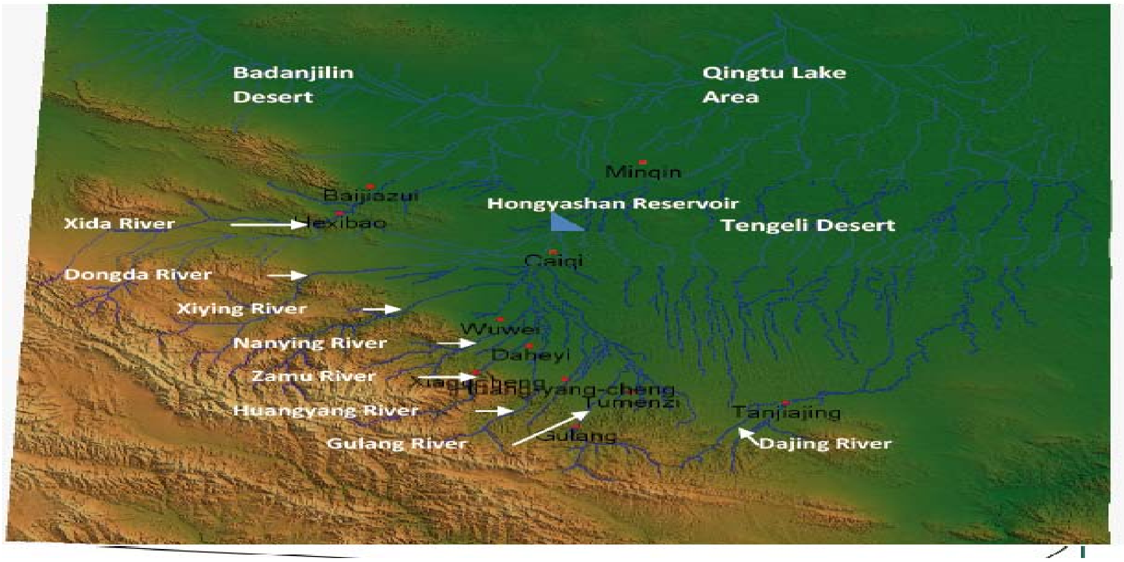
3.2.1 Xiying Reservoir and Head Works:

Due to excessive water use and mismanagement in the upper catchment, the level of water and its potential to provide different services decreased from time to time. The scale of water use has exceeded the carrying capacity of the water resources system. Each year an amount of 416 Mm^3 of water resources was over exploited, resulting in deteriorated ecosystem, desertification, water table descending. The water resources crisis threatens the oasis stability: the desert in the West and East are invading the oasis and eventually will join together. In addition, the water shortage causes water use conflicts between upper and downstream residents. Also, the accelerated overdraft of groundwater water table descending causes dozen thousand hectares of forests that have been survived by abstracting groundwater withered and died.

To curb this critical challenge, the government of China initiated Integrated Water Resources Management Program in consultation with key stakeholders. Its objective was to guarantee water supply for domestic use and basic need of the ecosystem, meet the demand of industry, modify the agriculture structure and enhance efficiency and benefit of irrigation, improve people's living and promote sustainable social and economy development. In particular, it was aiming to reallocate water between upstream and downstream and between production and ecosystem use and to stop overdraft of groundwater.

Construction of a reservoir was part of the implementation of the water resource management project with the following multipurpose objectives; hydropower generation, irrigation development, downstream recovery of environmental services, and flood control.

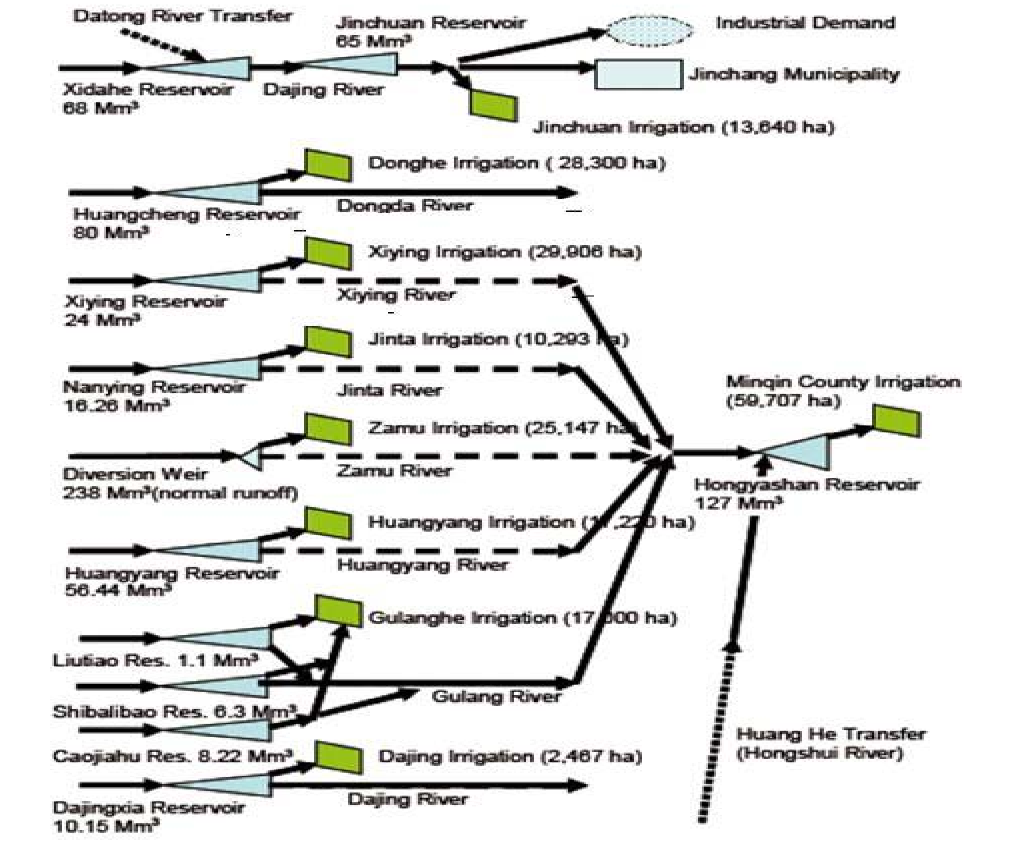
Xiying River is one of the eight tributary rivers of Shiyang River with a length of 170 km, its flow is 370 Mm^3/yr and covers 4035 km^2 catchment area .The source of water for Xiying River is from snow and rain, no ground water contribution to the river.



The Shiyang River Basin and Xiying River as one of its tributaries

Xiying Reservoir situated at Sigouzui of Xiying River, 40 Km distance far from southwest of Lianfzhou district in Wuwei city. The total storage is 23,500,000 m^3, with the designed and effective irrigated areas of 384,600 Mu (15 Mu = 1 ha) and 378,300 Mu, respectively. The construction of the reservoir was started in 1970, and completed and started storage in 1973. The reservoir pivot consists of main dam, auxiliary dam, water conveyance tunnel, and flood discharging tunnel. The maximum flood discharge is up to 430 m3/s.

The reservoir is providing irrigation services to 110,000 rural people in the downstream and its power station generating 12000 kw/h of electric power. The Water Resources Authority is responsible for the overall water resource management. At local level, the Water Users Association plays the leading role to distribute water for the farmers and different water user groups for irrigation and different purposes. In order to create ownership and sustain the project, water users pay nearly 0.14 Yuan per cubic meter).



Schematic of the reservoirs and surface water irrigation system

The focus has been given to the upper catchment development through increasing water use efficiencies of the upper catchment. One of the measures adopted was the introduction of efficient use of irrigation technologies and water harvesting technologies, which is also applicable for downstream communities. To cope with the water shortage, the downstream community/farmers changed their agricultural system. They cultivated crop varieties which are drought resistant. They also made use of irrigation technology like drip irrigation to curb the challenge of water shortage.

Concerning the environmental services of the reservoir, among others, it contributed to the dawn stream ground water increase, the recovery of dried out lake and grass species in the lake, prevention of desertification, restoration of biodiversity. The storage of excessive water in the reservoir from the upper catchment reduced the possible flood damage to dawn stream communities. To protect the dam from sedimentation, various integrated watershed management interventions were implemented such as plantation, terracing and construction of retaining walls. In general, the project saves the downstream community from displacement and the ecology to desertification.

3.2.2 Fengdousha Irrigation Equipment Factory:

Fengdousha irrigation device factory is a privately managed enterprise, it was established in 2001, it is a high-tech enterprise group with pipe production, equipment sales, project construction services, and technology development and consulting services. It mainly produces different kind of pipes, valves, water treatment equipments and facilities, multi-channel adjusted water devises as well as water saving irrigation series products, such as drip and sprinkler.

A collection of factory products includes bends, valves, and sprinklers

PVC pipes produced by the factory

The plastic company is a commercial project located in agricultural technical garden in Huining County, and covered 30Mu irrigation product line. The products have been widely applied into different fields in North-Western China, such as civil water supply and drainage, water conservancy, municipal engineering, special liquid delivery, agriculture and forestry spray irrigation. The plastic factory is intended for the supply of different fittings and pipes for supply of water for domestic and irrigation purposes. The purpose of the production is to supply the materials to the farmers with reasonable price and it also plays an important role to transfer technologies on water harvesting in the watershed management program.

3.2.3 Rainwater Harvesting Pilot Project at HH level and Government employees' support to families:

Roof Rainwater harvesting pilot project at house hold level: The Zhangchegpu village, with 123 households, is located in the East of the Anding district. There is neither Groundwater nor surface water in the village. The average annual rainfall is 380 mm while evaporation reaches to 150 mm. The local people were seriously suffered from lack of safe drinking water. They were drinking unsafe water from the gullies for survival.

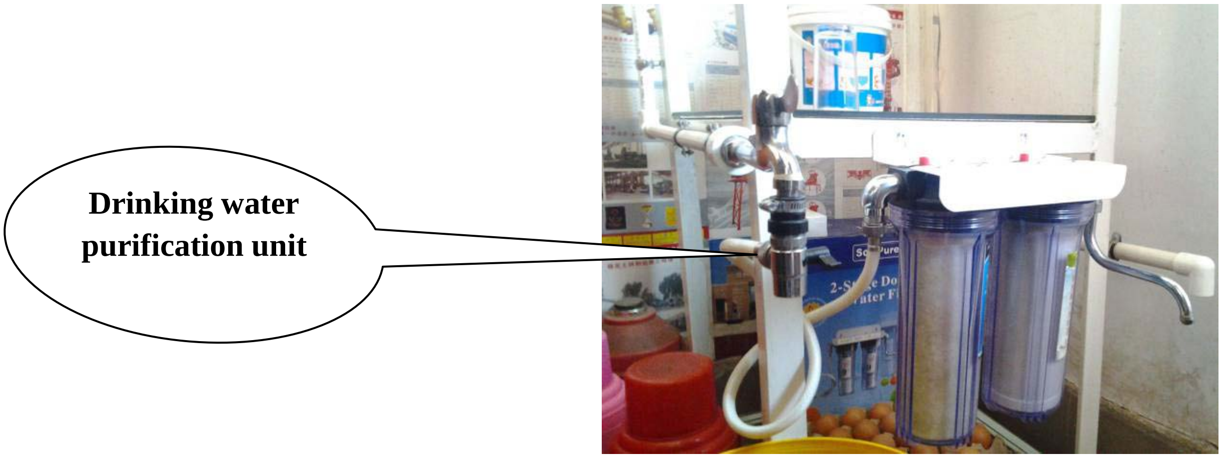
The village is one of project areas for the Well-off village demonstration program in the Anding district. Roof Rainwater Harvesting was one of the projects implemented at house hold level to improve the water shortage in the village. The roof and the courtyard are the catchment areas to collect rain water. Cement mortar thin wall cellar was constructed for each house hold to store rainwater in the compound. The water has been used for potable water supply after purification. Electric pump is installed in the storage well to pump out the water to the storage tank in the house. To purify the water, chemical is included in the water tank in addition to the filtering devices which are installed at the bottom of the water tank for the same purpose. After the storage well is full, the rain water will get out from the compound through the spill out hall placed in the fence of the compound. So far, 560 cellars has been built, equipped with water intake facilities and purification devices, which provide clean and hygienic water for domestic use, and utilize the cellar's water to develop courtyard economy; supplemental irrigation for open-farm and feeds livestock, which contributed to increase the farmers' income.

The roof of house as collecting field

Water cellar for storing rainwater

The courtyard as collecting field

Drinking water tank



Government Employees' Support to Families: In addition to the RWH support, government initiated family support by government employees to improve the lives of the rural people. Each Gov't organization supports one village to improve their lives. The support can be technical, financial and/or thru sharing ideas/best practices. Each staff of the government organization is responsible for a given family in the village. The number of families is determined based on his/her position or income level in the organization (For example- The director of Gansu Water resources Conservancy Institute supports four families). His/her support to the assigned family/ies can be from his pocket and or from his organization. Each employee is tasked to create a link between the family/ies and the organization and to monitor the familiy's progress periodically. If any problem is encountered which is beyond the family's capacity, they communicate with the assigned employee. The employee will help them to resolve the challenge himself and/or consulting with his organization and the family/ies per se. This is one of the poverty alleviation interventions in China.

3.2.4 Taibaishan Ecology Conservation Project:

It is located at the loess plateau area at the upper catchment of yellow river. It is a water shortage area with annual rainfall of about 360 mm, no surface and ground water. This project has been initiated by the Chinese government to conserve the environment and ensure a better life in the Taibaishan region. It consists of 204 watersheds, among which 157 have been treated. The total area served by the project amounts to 3638 km^2 which was suffering from severe water shortage. In this area, 3306 km^2 representing 91% of the area was seriously suffering from soil erosion. The erosion rate was reached 5640 ton per square km.

The project undertook several soil and water conservation interventions of different types depending on the local conditions starting from the upper catchment going down to the lower catchment. For the mountain tops of extreme slopes, a total of 850,000 trees were planted, in addition to grasses for slope stabilization. For lower areas with more gentle slopes (less than 21^o) terraces were constructed. These interventions have led to several benefits. In terms of water conservation, the terraces retained water for crop production such that farmers able to cultivate crops like corn which was not grown in the area before the treatment. Before the project, only potato was produced in the area. To further conserve water, plastic mulching was applied to the cultivated fields. Another benefit was a considerable reduction in soil erosion from steep slopes which dropped from 5640 to 1700 ton per km^2 /yr (70% reduction). At the bottom of the slope, 122 check dams were constructed for better water management. So far, 81% of the total area has been treated in 122 different sizes of catchments.

A sample catchment of 59 km^2 was visited by the team. Judie River, one of the tributaries of yellow river, crosses the catchment. This catchment has been recently treated and is now under cultivation. It consists of 6 different villages housing 6100 people. Each house hold has o.4 hectares of land. The treatment of this area took only 6 months. The government supported the project through provision of machinery, technical design, and supervision support. A total of 179 bulldozers were deployed in this project for those areas which are difficult for manual work. On the other hand, local farmers contributed for labor works. 240 ha have been planted by grass and trees (very steep slopes) and 670 ha have been shaped into terraces.

The project catchment treated with various soil and water conservation measures

3.2.5 Dingxi City, ANDing District Soil and Water Conservation (SWC) Museum:

Dingxi city is located in the loess plateau area. It is in the North Western part of China. Out of the 470,000 total populations, 370,000 are engaged in agricultural practices. It was a very poor area in terms of soil and water conservation. The amount of annual rainfall is very much limited, 380 mm. After the visit of top Chinese officials to this area, government support was initiated to undertake integrated watershed management interventions. Soil and water conservation has been started in 1976 and progressing significantly since then. The district organizes soil and water conservation exhibition every year in order to share best practices/success stories of the best performed watershed management projects. Besides, SWC Museum was established in the city. About 149 watershed projects have been implemented in the district. The establishment of SWC Museum and the organization of SWC exhibition clearly indicates the commitment of the government to curb the critical challenges of environmental degradation in the district.

Several images representing the history of construction are displayed in the Museum. The images include visits by government leaders to the project sites. They also include photos of electronic motors and equipment used during construction, photos showing the situation before and after the projects, images of received certificates and photos of exemplary workers. A guided tour was provided to participants which shed further light on developments in the area. It was indicated that 477,000 populations have been served by the project. The area is now characterized as a model potato production zone.

Rainwater Harvesting Demonstration Model: In order to record achievements of the above project (ecology conservation project), during the period 1981 to 1998, a RWH demonstration model has been developed and placed in the Museum. The demonstration model includes a three-dimensional view of the developed area.

3.2.6 RWH through Greenhouse and Plastic Mulching:

Due to scarce water resources, since the 1980's, many efforts have been exerted to introduce water saving agricultural practices in Gansu province. In the field visit, the team was able to see different types of these practices such as plastic mulching and greenhouse agriculture. Farmers produce various vegetable products thru greenhouse RWH method to improve their lives. The implementation of RWH through greenhouse method has increased vegetable productivity by fivefold as compared to without the GH. In addition, farmers harvest their production 3 times per year as compared to one time harvest without the GH.

Greenhouses have been introduced to the farmers to prolong the growing season such that they are able to cultivate in the extreme cold winter of the region which reaches temperatures of -20 degrees. Furthermore, the greenhouses serve as a means for RWH where the plastic sheet collects rainwater which directed through a ditch into the underground reservoir which is located inside the greenhouse to prevent freezing during winter. The water collected from the greenhouse roof is sufficient to sustain the agriculture during the dry season. Other benefits of greenhouse agriculture include increase in productivity and timing of crop production, such that higher prices can be obtained for agricultural produces. Even small trees such as peaches are now grown under greenhouses to produce fruits earlier than open field production and thus get a higher selling price for the products. Integrated pest management is also practiced inside the greenhouse to produce a healthy and high quality product.

Another means of water saving is the use of plastic mulch. The mulch is spread over the soil and water is applied either through drip lines extended beneath the mulch or through surface application. The benefits of mulching include water saving (30% or more), eliminating the need for weeding which results in a reduction in production costs and retains the nutrients supplied for the grown crop.

3.2.7 International Circular Economy Expo Jinchang City, Gansu China (2013):

"Make Limited Resources, Unlimited Circulation the top priority agenda!"

Jinchang City is located in the Eastern part of Hexi corridor and North of Qilian Mountains, administered by the Gansu province. The City covers about 9,600km^2 with 500,000 people (64.1 % are urban dwellers). Jinchang city boast abundant mineral resources, especially nonferrous metals such as Nickel mine reserves, Copper, Platinum group metals and Cobalt. The city is also one of the bases of comprehensive utilization of resources. Jinchang Development Zone was renamed as a state Economic and Technological development zone by the State council, and in addition Gansu Circular Economy pilot City of promoting integration in development between urban and rural set up.

The general concept of the Circular Economy is to maximize efficiency of resource utilization and minimizing wastage by make use of the waste of one production unit as an input resource for another unit. It promotes cooperation and partnership in development in a Small, Middle and Large scale Economy. The low value industrial waste such as waste water is treated to reclaim desert areas into Agricultural land. The proper utilization of limited natural resources in turn creates environmental friendly circular economy. Industrial circular Economy includes: Waste heat recycling, Waste Gas recycling, Waste Residue recycling, Logistical recycling, and reliance on renewable energy sources to reduce carbon footprint.

Among others, the following are the main benefits of Circular economy: Reclamation of desert area by the use of treated waste water into agricultural land, which increases food production; improves limited resources utilization for unlimited circulation; protection of the environment with the use of environmental friendly technological innovations; production of sufficient energy from limited resources; and through improving the environmental conditions, public health and quality of life in general.

Circular Economy provides a solution for the world, especially for regions which are faced with limited resources and unlimited demand through maximizing resources utilization efficiency and conserving scarce resources. This experience has utmost importance for the Nile Basin countries which are in the process of developing production models in order to maximize benefits from a limited resource, The Nile Water.

3.2.8 Qingtu Lake Reclamation:

Qingtu Lake was the biggest one in Minqin County with more than 4000km^2 blue water. In 1959 the lake dry out because of the high level consumption of the Singue River, source of water for the lake, by the upstream beneficiary community related to agricultural uses. The ground water table was also declined because of overuse beyond its carrying capacity.

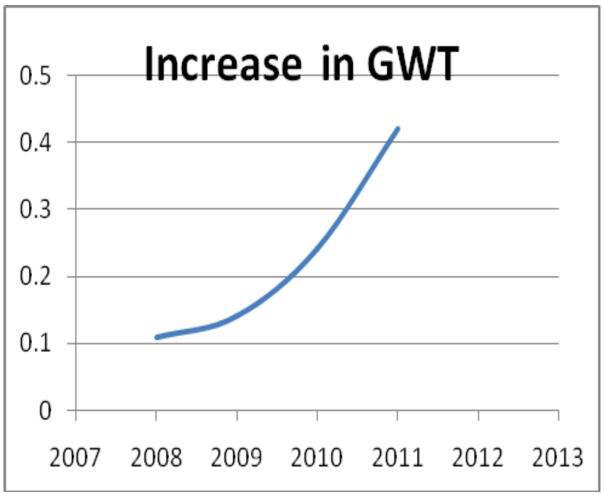
Qingtu Lake

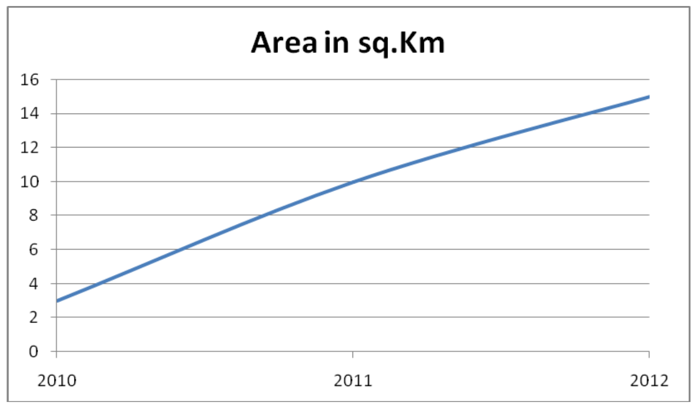
As a result, the two deserts met together. The lake had been buried by yellow sand since 1990, became part of Badain Jaran desert. The wildlife which was living in the lake migrated to other places searching for water. The depth of sand reached up to 3 to 6 m with 13 km of sand line, and moved at the speed of 8 to 10 m towards the oasis each year. The situation seriously threatens human inhabitant, industry and agricultural

Recovered Qingtu Lake

production and traffic in neighborhood of township, led to unexpected loss for local people.

In order to curb the challenge, integrated water resources management project was initiated in 2007. The objective of the project was to increase the annual water supply and recover the lake to the extent of the previous amount. The lake has been recovered within a time of 15 years using various corrective measures. Among others, the measures taken to bring the lake back were thru adopting agricultural practices which use less water/ efficient water use, controlling the overuse of the ground water, using integrated environmental protection interventions, and building reservoir to collect and store runoff during rainy season for balanced release of the available water.





Increase in Qingtu Lake area

Water Table Measurement: A water table measurement well was installed with the required measurement devices/tools to measure the daily water table level. The device takes the water table measurement every hour and stores in the database. Data has been taken from the data base every day at 2:00 AM. The baseline water table measurement taken in 2003 was 0.3 meter, at the beginning of the intervention year for the integrated water resources management project. It was planned to increase the water level of the project area to 3 meter. Currently, following the integrated WR management project, the water level has been increased to 3.41 meter. The project has achieved its objectives.

Minqin Trial Station: The research station has been established in the basin with the area of farmers land size 1.4ha including meteorological station. It was aiming to measure the efficiency of various irrigation methods (Drip, Furrow, etc) with plastic mulching on plots of small farms cultivated with different crops (sunflower, onion, tomato, maize, etc…).The meteorological station is so advanced that the soil moisture, temperature, rainfall, humidity, evaporation, wind speed and other parameters can be accessed even from the web.

Hongyashan Reservoir: The reservoir has been built on the Shiyanghe River, in the Tengger and Badain Jaran desert surrounded by two deserts, 30 km south of the Minqin City. This is the biggest dam in Asia with 25km^2 area coverage, built in 1958. The height of the dam is 16.5m, 8060 m long dam, with a total storage capacity of 127 million m^3. The reservoir has two parts, East dam with 1360 m long and West dam with 6700 m long. The objective of the reservoir is mainly to supply reliable water for potable water supply, irrigation, fishing, flood control, eco-tourism and environmental protection.

Lake of Hongyashan Reservoir

4. Challenges and Mitigation Measures:

4.1 Challenges:

Though an impressive achievement was made with regard to promoting RWH and invaluable success was achieved in terms of transforming the rural economy through the promotion of RWH, the project still faces some challenges that require attention. Some of the challenges identified include the following:

- *Inadequate capacity of RWH system to meet the criteria of safe rural water supply:* To meet water supply quota of 30L/person/day for a family of 4 members, yearly water harvested should be around 45-60 m^3. For annual rainfall of 300-400 mm, the catchment area composed of roof and concrete lined courtyard should be 200-340 m^2 and the storage capacity should be 120-200 m^3. The capacity of most of the RWH system in Gansu is not enough.
- *Problem of quality management:* Fund is not enough to improve the system such as to install the gutter, separate storage of roof and ground runoff, install the filtration equipment, etc. The awareness building and health education is also weak. The farmers do not accept some quality management measures with no or little cost. Besides, there is lack of quality monitoring.
- *Challenges of RWH irrigation project:* A large part of the RWH irrigation systems have not been brought to full play. Some have not been used. The awareness and capacity building on using rainwater for irrigation is still poor in many of the farmers. Lack of appropriate irrigation facility is another reason that the RWH irrigation system cannot be brought into full play. The land equipped with the modern drip or sprinkler system only accounts for 16.5% of

the total irrigated land. The capacity of the catchment is inadequate to match the storage capacity. It is estimated that water collected from the catchment can only feed 40% of the storage.

4.2 Mitigation Measures:

- Quality management has to be improved,
- Awareness and capacity building on the RWH irrigation has to be strengthened,
- Fund support from the government is to be further increased,
- For the area with annual precipitation less than 400mm, either the integrated water resources utilization has to be taken or the catchment (roof and courtyard) and storage capacity is to be enlarged,
- Extension service to the user has to be improved. The market for complete set of RWH equipment is to be developed.

5. Sustainability of the project gains:

Chinese experience shows that Rainwater harvesting is a sustainable approach for the integrated rural development in the mountainous areas with water scarcity. It is a strategic measure for integrated rural development. It has the features of: Being decentralized; use indigenous resources; adopt appropriate and acceptable technology; low input and O&M fees; household/community ownership of RWH project enables wide participation and high motivation; environment friendly; Thus, it is not a temporary measure only to fight drought but a strategy for sustainable development.

6. Key Lessons Learned:

- **Rainwater harvesting is a strategic measure for integrated rural development**: RWH has the features of: Being decentralized; use indigenous resources; adopt appropriate and acceptable technology; low input and O&M fees; household/community ownership of RWH project enables wide participation and high motivation; environment friendly; and it is not a temporary measure only to fight drought but a strategy for sustainable development.
- **Promotion of the ecological and environmental conservation:** RWH as an integral part of watershed management which plays vital role in making efficient use of land and water resources by enhancing crop yield and providing irrigation water to orchards and greenhouses for high profitable agriculture; provides clean, cheap and reliable water source for domestic supply, and stores runoff on the catchment thus reducing soil erosion and water runoff; and in enhancing survival rate of young trees by providing irrigation water. Sustainable land management through integrated watershed management and use of land according to its suitability for maximizing production, arresting soil erosion and conserving moisture in-situ was found to be beneficial. Reclamation of degraded ecology while at the same time enhancing production and productivity through application of IWRM principles, including adequate provision of environmental flow was achieved through integrated watershed management. RWH has also a significant impact in promoting ecological and environmental conservation. With increase in productivity, farmers gave up encroaching hill slopes. The hill slopes were converted in to planting tree crops and grasses, promoting fruit tree plantation and intensifying animal husbandry. It has now become a national policy to

convert land above 25 degree to tree and grass plantation to stop soil erosion and reconstruct the ecosystem. As an incentive, the government subsidize farmers with 50 RBM and 100 kg of grain for farmers for planting trees and grasses on one Mu (15 Mu is equal to 1 ha) of originally cultivated land for a period of five years.

- **Effective way for ensuring access to domestic water supply:** It enabled rural communities to have improved access to reliable and clean water resource. It also improves labor productivity by reducing time spent by women & children for fetching water from considerable distances. This enabled children to have time to go to school. Women can have more opportunities to actively participate in domestic and public affairs.

- **Enhancing the level and productivity of rain-fed agriculture:** RWH irrigation effectively mitigates drought by supplying water to crops at critical periods and help improve yield (increase crop yield by around 40% on average). Green house technology and plastic mulching further enhance rain water use efficiency by minimizing evaporation loss, enabling application of optimal quantity of water, and serving as media for rainwater collection. The affordability of these innovative approaches give hope for wide application of the system in water stress areas.

- **Significance of political support:** The political will and unreserved support provided by government at all levels played an important role for the successful implementation of RWH systems and there by sustainably develop and manage the water resources. Even though, both political and technical supports are important, the role of political champion is key for its effectiveness and sustainability. Technical issues are relatively less complex to address and resolve as far the government's commitment is ensured. The launching of "1-2-1" project by the provincial Government with the aim of solving the water shortage problem in the area is an example of the political will and unreserved support by government. The project was financed by the government. The project involves building one rainwater collection field, two underground water tanks, and one piece of land close to the household to be irrigated with stored water. In a period of two years, the project met its pre-set goal of reaching 1.31 million people. Irrigation water was also applied to 1.33 thousand ha of land and helped farmers generate income. Following the successful implementation of "1-2-1" project, the government launched the RWH Irrigation project in 1996. This project further opened the way for farmers to develop the economy and improve their livelihood. An effective model of government support and public participation has been demonstrated.

- **Application of IWRM principles and RWH system:** It is central to a win-win solution under a transboundary context. IWRM application is an efficient and effective system for rehabilitation of ecosystem while at the same time boost production and productivity.

- **Research, demonstration, and extension:** Though the use of rainwater by local community dates back to thousands of years, rainwater utilization efficiency was low and the collected water was not even sufficient for domestic use. It was thus found necessary to increase water collection efficiency through increase of concentration area. To achieve this goal, experimentation, demonstration and extension project was launched with the support of Gansu Provincial Government and Water Resources Bureau with the aim to study rainfall-runoff relation under different rainfall conditions and on different rainwater harvesting fields and to find out appropriate rainwater use pattern and formulate design procedures. Based on research done from 1988 to 1990, relationship between Rainfall Collection Efficiency (RCE) and rainfall amount and intensity under different catchment materials was established. The rainwater use pattern was set up based on traditional practices. The accompaniment of Rainwater Harvesting interventions with Research and technological support has accelerated the journey of China to poverty reduction.

- **The promotion of circular economy:** Limited Resources, Unlimited Circulation become one of the values of Chinese government. The general concept of the Circular Economy is to maximize efficiency of resource utilization and minimizing wastage by make use of the waste of one production unit as an input resource for another unit. It promotes cooperation and partnership in development in a Small, Middle and Large scale Economy. It is one of the good lessons to be taken by EN countries for efficient utilization of limited resources in the region.

7. Significance of RWH training/study tour and suggestion on the way forward:

Benefits from the training/study tour:

- It enhanced the participants' knowledge of RWH in terms of diversity use of rain water, strategy of collecting/harvesting rain water, and available types of structures for storing, distribution, and utilization.
- It gave us more insight on the positive impact of RWH on social, economic and ecological aspects.
- IWRM application is an efficient and effective system for rehabilitation of ecosystem while at the same time boost production and productivity.
- Experience sharing with other fellow participants was invaluable.

Applicability:

The china experience in RWH can be adopted easily in our region and will enhance the current challenges we are facing. However, to implement those best practices on the ground, political commitment and capable institution should be there to lead the process. One feature of the China experience is political will and commitment as well as the various incentive mechanisms used in promoting RWH. This requires buy-in by the respective governments. Capacity (technical as well as financial) could also be a constraint. Promotion and innovation of RWH in China is spearheaded by high level academic and research institute like Gansu. Thus, it is important to create such capacity in the EN for effective implementation of best practices.

Follow-up action and future cooperation:

- Conduct similar training on RWH within our region including establishing a demonstration sites to promote RWH (for example using existing WS pilot sites),
- Organize a short field visit to decision makers from the riparian countries and relevant institutions at national and regional level (ENTRO) to show the implementation of the

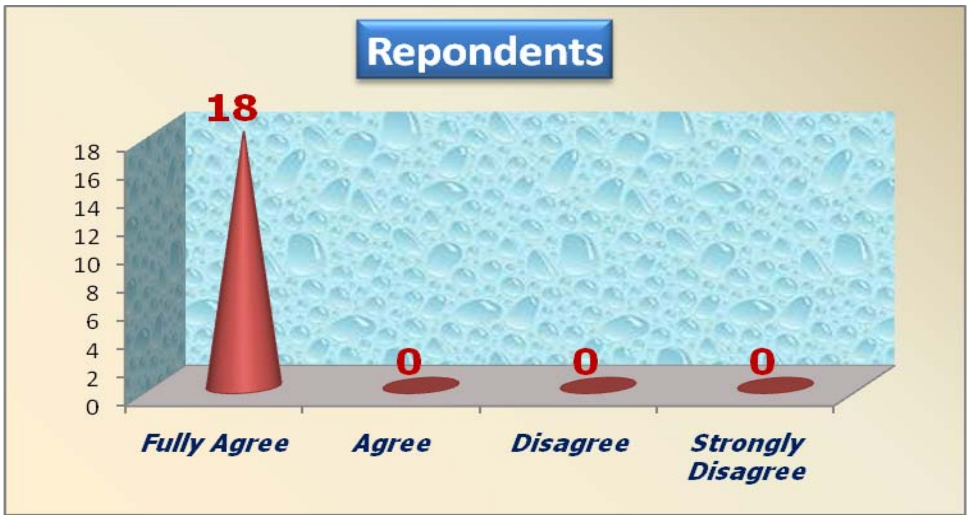
program, the scope of its applicability and witness the social, economic and environmental impact it has brought about in a relatively short period. This will help to secure the needed support at the highest level of decision making for projects to be implemented in our region,

- Undertake a joint research and demonstration project and pilot RWH system (eg. ENTRO with GRIWC),
- Establish an internet group (to be coordinated by GRIWC) of trainees and other interested professionals to share information on field activities, research results, challenges in application, etc.

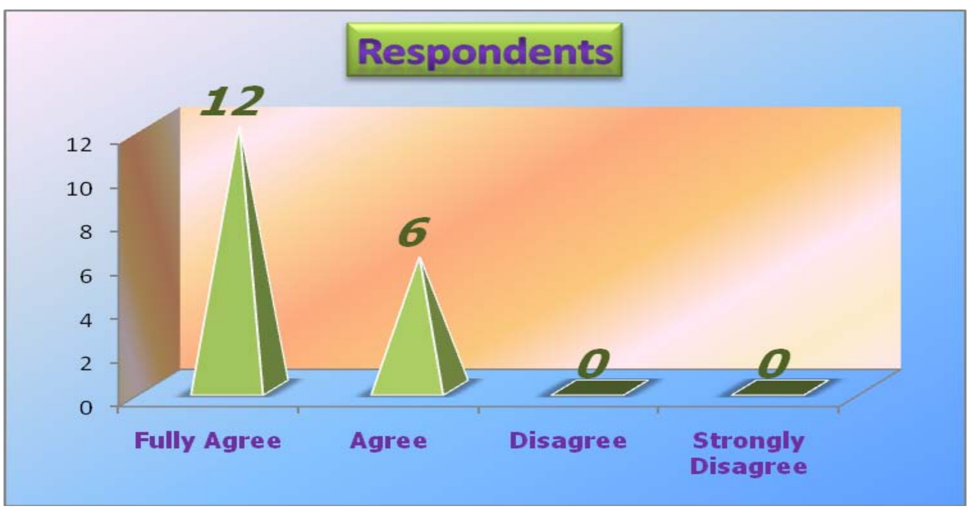
Annexes:

1. End of Training/study tour Evaluation Results:

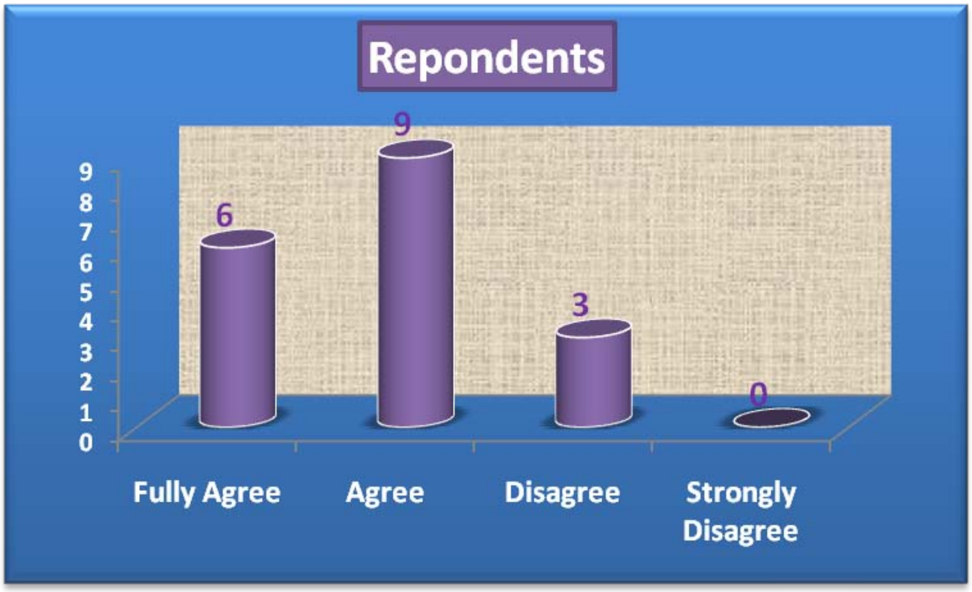
Q1 The training workshop has achieved its objectives.



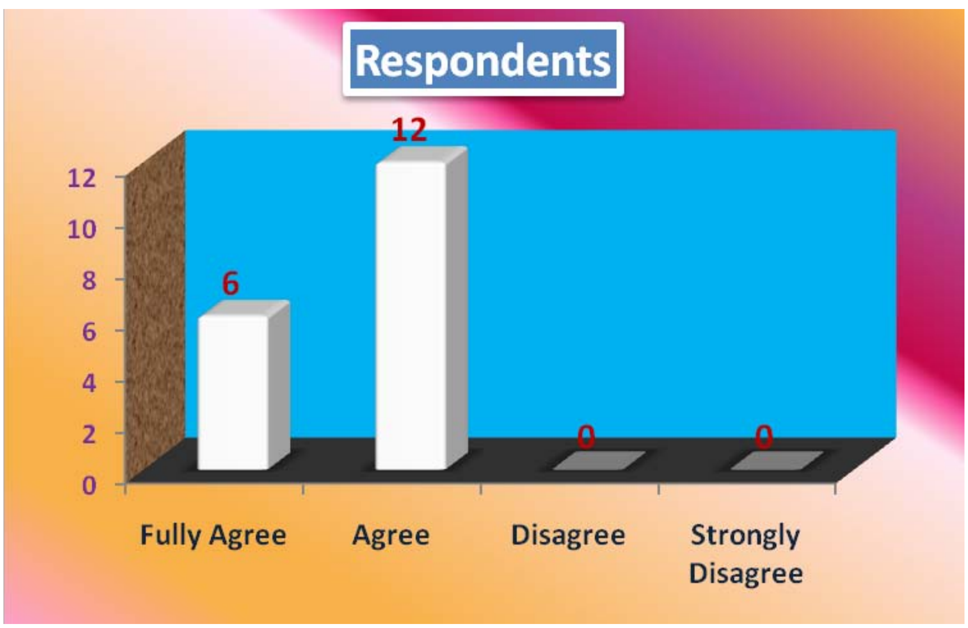
Q2 The training workshop has met my expectations.



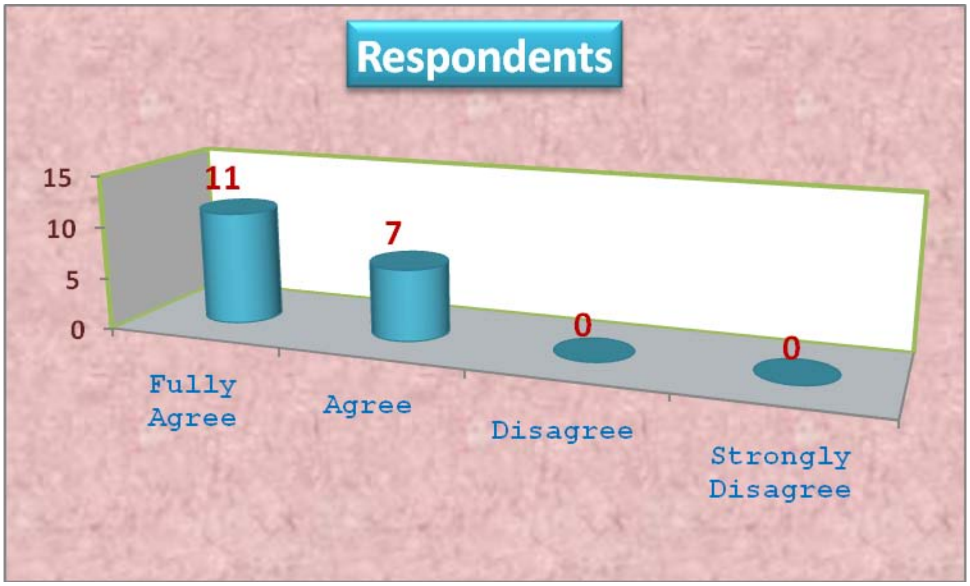
Q3 The RWH technologies are appropriate and possible to adopt in our context.



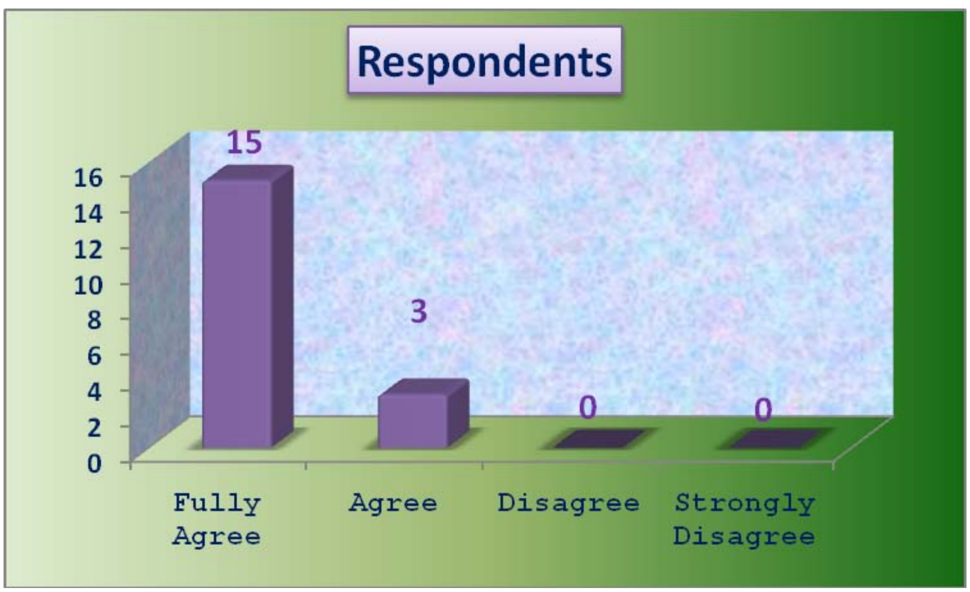
Q4 Time allocated for presentation and field visit was adequate and balanced.



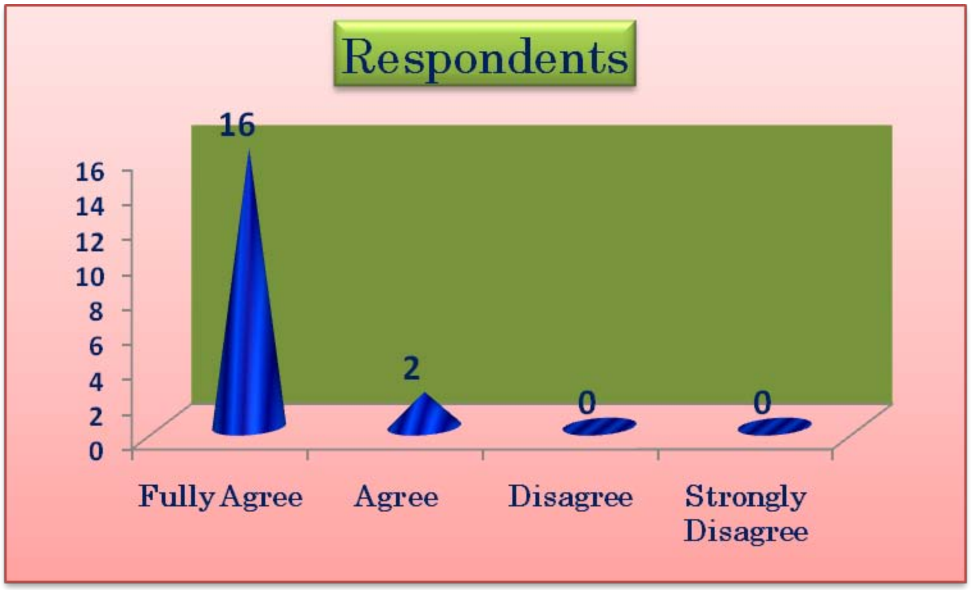
Q5 Resource persons were experienced to transfer the required knowledge and skill.



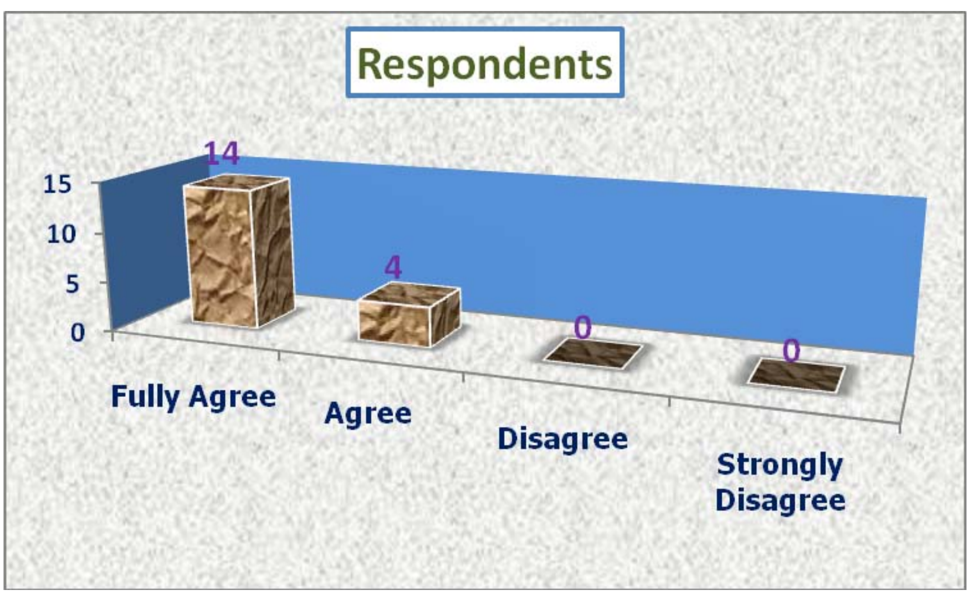
Q6 Training materials (Books & slide presentations) are helpful for further reference.



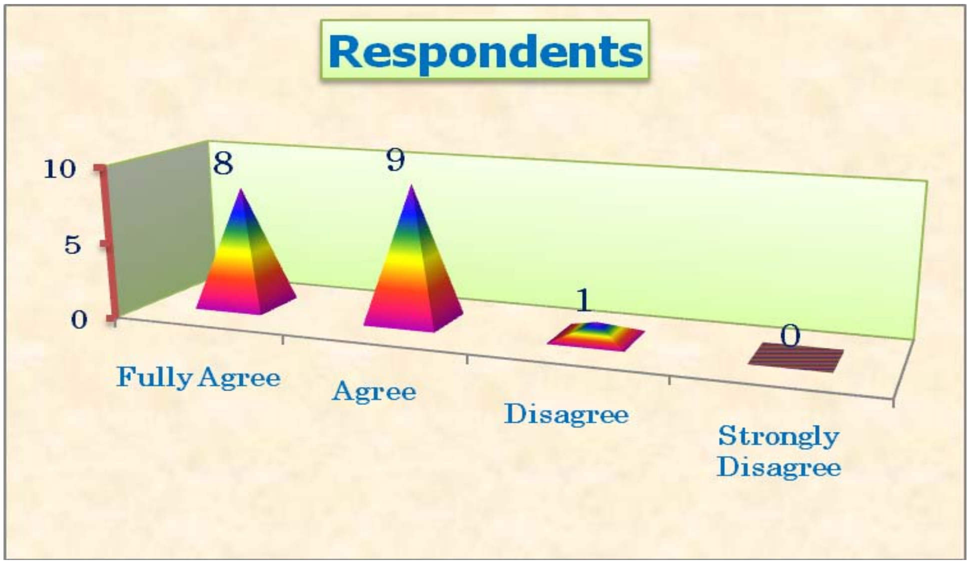
Q7 I recommend similar training workshop for EN experts engaged in Watershed Management/Rain Water Harvesting projects.



Q8 The general administration and management of the training workshop was well coordinated.



Q9 Accommodation service at Long Nan Hotel was very good.



The objective of end of the training/study tour evaluation was to collect feedback from participants for further improvement in the future. The above survey result indicates both strengths and areas for improvement.

Strengths: All respondents (100%) have reflected their agreement on the seven points of evaluation out of the total nine (Question number 1, 2, 4, 5, 6, 7 and 8). This will be maintained or strengthened further for similar arrangements in the future.

Areas of Improvement: For 16.6% of respondents (3 out of 18) the RWH technologies which have been adopted in China are inappropriate and impossible to adopt in their country's context, for 5.5% of respondents (1 out of 18) the accommodation service at Long Nan Hotel was inadequate. These are the lessons learnt for improvement while organizing similar trainings/study tours in the future, in addition to the points listed under Q10 below.

By and large, the training/study tour was successful in meeting its objectives and achieving the expectation of participants.

Q 10 Any additional comment on the training workshop/study tour and/or suggestions for prospect improvement:

1. RWH may not be applicable in Egypt due to lack of rain.

2. It was more important to present the countries experiences in RWH at the beginning of the training (before the class lecture and field visit). This approach helps the facilitators to focus more on RWH techniques which is not practiced in each country in order to minimize their gaps in RWH.

3. The duration of the training should not be less than a month, since the training course is comprehensive and very important.

4. It was better to involve beneficiary farmers during the field visit since they can explain exactly the benefits of each intervention more than anyone else.

2. List of Participants:

S. N.	Name	Country/Organization
1	Solomon Abate Eneyew	ENTRO
2	Awoke Kassa Alite	ENTRO
3	Aytenew Endeshaw Tatek	Ethiopia
4	Mitiku Kebede Mersha	Ethiopia
5	Kumsa Balcha Buse	Ethiopia
6	Assefa Gudina Muleta	Ethiopia
7	Belayneh Temesgen Beri	Ethiopia
8	Chut Isaac Chol Aleer	South Sudan
9	Nyika Charles Jacob Alimas	South Sudan
10	Doki Lako Busuk Loggalel	South Sudan
11	Badreldin Mohmoud Abdalla Mohamed	Sudan
12	Ibrahim Adam Ahmed Balia	Sudan
13	Nassreldin Saeed Mohamed Ahmed	Sudan
14	Yousuf Dafalla Ibrahim Dafalla	Sudan
15	Allaeldien Hassan Mohmed Saeeid	Sudan
16	Ashraf Hassan Mahib Ghanem	Egypt
17	Mohamed Attia Mohamed Abdelmeged	Egypt
18	Mohamed Gadelrab Hafiz Hassanein	Egypt

References:

Zhu,Q. Li, Y. (2007) Rainwater Harvesting

Zhu, Q. Li, Y. and John G. (2011) Every Last Drop- Rainwater Harvesting and Sustainable technologies in rural China