Water harvesting in northern Ethiopia: Environmental, health and socio-economic impacts

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Abstract

In northern Ethiopia, water scarcity is a key factor in food security. In some areas, the water is so precious that the principle of 'irrigating the crop and not the land' is adopted in an attempt to curb rural exodus. In other areas, considerable effort is put to introduce innovative water harvesting and management systems. The introduction of small-scale irrigation using micro-dams has become an excellent option considering the hydro-climatological conditions of the region.

In Tigray, over the last 10 years, about 50 micro-dams were constructed; consequently, considerable improvements were observed in the livelihood of the rural poor. Water security brought food security. Some negative impacts are being observed especially on soil salinity and erosion. Malaria has become a growing concern in micro-dam areas with altitude lower than 2000 metres above sea level (masl).

In general, the positive and negative impacts of micro-dam water harvesting systems need to be well understood before further up-scaling. Research should focus on system design, farm hydrology, socio-economic constraints and systems transferability.

Introduction

Although several definitions of water harvesting (WH) have been suggested, Siegert (1994) gave the most encompassing definition as: '...an umbrella term describing a range of methods of collecting and conserving various forms of water originating from ephemeral water flows produced during rainstorms'. The aim of water harvesting is to mitigate the effects of temporal shortages of rain, so-called dry spells, to cover both household needs and productive use. This involves storage component and various forms of storage exist such as: micro-dams, farm ponds, subsurface dams, tanks etc.

Water scarcity is a critical issue for many developing countries in general and for those in the arid to semi-arid areas of the world in particular. It has long been understood that intensive water resource development can have a decisive role in the economic and social development of a country and in alleviating drought. Alleviating food security related to

drought and famine through sustainable agriculture and environmental rehabilitation requires a short- and long-term planning of water resource development of an area.

In northern Ethiopia, in an effort to address the problems of recurrent drought, famine and food insecurity, attempts are being made to harvest runoff water in micro-dams for use both in households and small-scale irrigation schemes. It is recognised that the construction of micro-dams with proper irrigation and agronomic services will result in micro-climatic and environmental changes with positive impact on sustained productivity.

Notwithstanding the positive impacts on increased agricultural productivity and improved community welfare, the negative impacts of water resource development require constant assessment and monitoring on environmental changes.

Thus, the objectives of this paper are to present:

- the positive and negative impacts of water harvesting and
- the knowledge gap and research priorities in water harvesting.

The study area

General description

Tigray is the northernmost region of Ethiopia extending from 12°15' to 14°50'N latitude and from 36°27' to 39°59'E longitude. It is bound in the north by Eritrea, to the west by The Sudan and to the east and south by the Afar and Amhara regions of Ethiopia. It covers a little more than 80 thousand km^2, most of which are highlands between 1500 and 3900 metres above sea level (masl).

Tigray's economy, like the other parts of the country, is based on plow cultivation for predominantly cereal production. The level of subsistence, except for periods of good rains, has declined radically during the past decade, with almost everything produced being consumed at the farm household level.

Tigray's agriculture depends entirely on availability of rainfall; because of this, agricultural production is erratic, showing high temporal and spatial variability in yield. Agricultural production operates with very low modern external input, resulting in depletion of soil nutrients. Increasing loss of topsoil through erosion has exposed the region to serious environmental and ecological imbalances.

The agrarian system is pressed with a fast accelerating population growth and a high arable land to population density, which far exceeds the carrying capacity of the land. Recurrent drought, pest infestation and unfavourable climatic factors contribute to poor production performances. The inevitable result of these prevailing conditions has been a gradual and steady decline in soil and labour productivity.

A major means of rehabilitating and reconstructing the natural resource base is through water resource development. That water is the single most critical variable in Tigray's agricultural production has been long recognised.

Sustainable agricultural and environmental rehabilitation programme

Having realised the need to have a comprehensive rural development programme, the regional government, in 1994, decided to establish a sustainable agricultural and environmental rehabilitation programme. Through this programme, water harvesting was seen as an option and hence was planned to construct 500 earthen micro-dams over 10 years to supply 200 thousand tonnes of grain equivalent enough to feed 930 thousand people who, without the project, would almost surely depend on food aid.

Of the estimated 1.2 million hectares of arable land, 95% is under rainfed cultivation. Since 1995, through the massive irrigation development, about 50 micro-dams (each with a capacity to hold about 50,000–2,000,000 m^3 of water), and 11 diversion plants have been constructed in drought prone areas giving an increase of 2000 ha of irrigated land only.

Additional impacts anticipated from the environmental rehabilitation programme were: degraded areas show signs of recovery, while millions of seedlings planted as a means to biological soil conservation will result in forest products. Availability of forage for livestock will improve sustainability. With storage and utilisation of seasonal surface runoff water, many prevailing social and economic problems should be alleviated; decreased women's burdensome and time-consuming responsibilities for fetching water and thus improve women and children welfare. Furthermore, the introduction of fisheries could improve the diet of the community and serve as a supplementary source of income to families.

Water harvesting and irrigation management

In Tigray, a major means of rehabilitating and reconstructing the natural resource base is through comprehensive water harvesting development. Thus, water security through runoff harvesting has been chosen as a strategy to curb the acute water shortage in the region.

Farmers in Tigray have been producing different crops under traditional irrigation management for a long time. The diversion of perennial streams using temporary structures during the dry season is the major means of irrigation. In addition, flood spreading using runoff water from higher altitudes and upper catchment areas is also practised. Horticultural crops and maize are the main crops grown under these irrigation schemes.

Materials and methods

A study to document the effects of micro-dam water harvesting on the socio-economic, environmental and health aspects was undertaken by Mekelle University and Tigray Region Health Bureau.

For the impact on health, 7000 children living in villages near to dams (less than 2 km radius) and away from dams (more than 2 km radius) were monitored for the incidences of malaria and schistosomiasis over three years (Tedros et al. 1999).

For the environmental impact assessment, salinity of soil and irrigation water was monitored over four years (Mitiku and Sorsa 2002). A survey was also undertaken through semi-structured questionnaires to analyse the perception of farmers to land degradation (as a result of catchment erosion and subsequent sedimentation in reservoirs). In addition, studies reveal that a reservoir water quality is deteriorated following biological contaminants.

For the socio-economic impact assessment, a study was undertaken using semi-structured questionnaire to see the economic returns of water harvesting in small dams used for irrigation (Mintesinot 2002).

Results and discussion

Environmental impact assessment

Most dams were constructed without prior rehabilitation of the catchments. Thus, one serious environmental problem is erosion of catchments leading to increased sedimentation, which reduces the storage capacity of the reservoirs. In some dams, the situation is so severe that periodical excavation is becoming necessary. 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 Sorsa 2002).

Another serious environmental impact is the introduction of salinity to the irrigated schemes. With the current water management practice (furrow management without appropriate scheduling), the absence of well-designed drainage ditches and very high clay content, salinity hazard is imminent. The level of salinity in some schemes has reached a situation where serious impacts are being observed both on crops and soils.

The pattern of salt distribution was studied by taking a transect and results have shown that the salt content of irrigated fields nearer to the embankments were generally higher than fields either in the centre or at the tail end. This, according to Mitiku and Sorsa (2002), is attributed to the high seepage loss from the nearby embankments.

Although not as such wide spread incidence, there was also biological contamination observed in the reservoirs of some dams. The watercolour in the reservoirs changes from a normal blue green to deep red/brown. This change was so homogenous that a suspended powder pigment was observed. Water quality studies revealed that the incidence was a biological contamination caused by bacteria known as Myxobacteria, a Polyangiaceae genus.

The bacteria are mainly active cellulose decomposers that widely occur in soils and water. They are capable of forming fruiting bodies, which can survive for a long time under unfavourable conditions. The study has continued to identify the original sources but preliminary findings show that similar biological structures are found within livestock dung around the dams.

Health impact assessment

The impact of prolonged available surface water in newly developed irrigation areas is on water and vector-borne diseases. Areas that were periodically affected by malaria and schistosomiasis are exposed to continued year round attack. Peak transmission that coincides with seasonal onset of the big and small rains in the region will be prolonged to other months, which were relatively free of malaria. Mosquitoes and snails have an ideal environmental situation to breed.

Health studies (Tedros et al. 1999) revealed that villagers living near to dams that are built in altitudes lower than 2000 masl are faced with increased risk of malaria incidence. Incidence surveys conducted showed a seven-fold increased risk for children. Some of the documented risk factors were open caves, keeping animals in living houses and earthen roofs.

Identification of such local risk factors for malaria is important for the planning of malaria control (Tedros et al. 1999). To mitigate the risk of malaria, insecticide impregnated bed-nets were distributed to near micro-dams village under a cost-recovery scheme. Malaria incidence was then measured and the risk was reduced to less than two-fold.

Studies on the incidence of schistosomiasis revealed that the overall prevalence of infection was 39% for children and 48% for adults (Tedros et al. 1999). The effectiveness of *endod* (*phytolacca dodecandra*) in controlling snail is currently under investigation.

Socio-economic impacts

Irrigation development aims to bring about increased agricultural production and consequently to improve the economic and social well-being of the rural population. Studies on household income by irrigation (Mintesinot 2002) revealed that irrigation users, on average, have three-fold increase in income compared with those that solely depend on rainfed cultivation.

The same study indicated that irrigation compounded with rainfed cultivation ensures year-round food security, although, off-farm employment during part of the year is a common practice to obtain extra money.

Conclusion

With the growing demand for daily food and continued struggle to achieve long-term food security, there is a dire need to maximise the productivity of both land and water. Inputs to land may improve land productivity but inputs to water may not change the productive capacity of water. Improving the water security through increasing the water use efficiency (more crop per drop!) can however result in higher productivity.

The issue of water security in Tigray (northern Ethiopia) is addressed through the extensive water harvesting endeavours underway. The positive and negative impacts of this effort are, however, little understood.

Farmers living in the vicinity of micro-dams are aware of the problem of land degradation. They understand the effect of sedimentation on the reduced capacity of micro-dams to store water to be used for irrigation. Apparently, they are willing to invest in land management systems that are sustainable, productive and effective in reducing sediment load.

Health studies indicated that villagers living near micro-dams that are built in the lowlands (<2000 masl) are faced with the risk of increased incidences of malaria. Community participation in draining excess water that can be a breeding ground for mosquitoes coupled with the use of impregnated bednets has decreased the incidence of malaria. Credit schemes are important avenues to undertake this venture. The major point of departure is the benefit that is obtained from the use of the irrigation schemes. In the schemes where economic benefits are obtained the farmers are willing to pay for the extra cost of prevention of malaria (Lampietti et al. 1999)

Knowledge gaps and future avenues

Despite the vast knowledge and experiences accumulated in the field of water harvesting, there are still large gaps in research that need to be filled. Some of the reasons for the poor research in water resources could be attributed to:

- no institutional responsibility as such exists to take up research on sustainable water resource development
- limited and/or very scattered capacity (trained manpower) available to undertake interdisciplinary research
- very few institutions available to offer specialised training in water resource development.

Of the many research topics in micro-dam water harvesting, the following thematic areas are prioritised:

- hydrology at farm level
- upstream/downstream effects of water harvesting
- water productivity in agriculture
- water pricing
- co-operatives under smallholder irrigation managements
- soil–plant–water relationship.

To address the main causes for the limited attention in water resource research and capacity building:

1. there needs to be mandate sharing among the various institutions (governmental organisations and non-governmental organisations, NGO's) for research in water resources (basin-level, small-scale...)
2. higher learning institutions should play the needed role to meet the capacity building needs of water sciences.

What does Mekelle University have to offer?

There is a faculty of dryland agriculture that gives a degree level training in land resources management and environmental sciences. Through this programme, many courses are being offered in areas of water sciences. In addition, periodical short-term trainings are organised for stakeholders in areas of water harvesting, irrigation management and soil and water conservation.

Apart from this, multi-disciplinary research is being undertaken in areas of small dams: water productivity, socio-economics, and health aspects. In partnership with the International Water Management Institute (IWMI) and the Ministry of Water Resources (MoWR), a study has been launched to apply PODIUM (policy dialogue model) to develop various scenarios for future water needs (for food production, people and the environment) at both basin and national level. New studies are also being launched in areas of community water management (in collaboration with the International Livestock Research Institute (ILRI), the Ethiopian Agricultural Research Organization (EARO) and MoWR and on malaria in small dams (with IWMI). There is already a network available, but this needs to be strengthened.

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