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THE BENEFITS AND ENVIRONMENTAL EFFECT OF COMMUNITY BASED SMALL SCALE IRRIGATION DEVELOPMENT IN THE AWASH RIVER BASIN, ETHIOPIA: A CASE STUDY OF FOUR COMMUNITY BASED IRRIGATION SCHEMES

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ABSTRACT: This study aims to examine the environmental and socio economic impact of community based small-scale irrigation in the Upper Awash Basin. Its main objective is to assess the benefits and environmental effect of community based small-scale irrigation schemes in the selected study areas. Results are based on household survey and irrigation water samples analyzed. The findings highlights that development of smallholder irrigation schemes has resulted in high incomes for irrigator smallholder farmers compared with the non-irrigators. The average net farm incomes of irrigated farms in general are higher per ha than the non-irrigated farms. Employment creation, additional food availability and economic backward and forward linkages are other benefits created by irrigation development in all four irrigated schemes. The principal negative environmental effects identified in the study of the four small-scale irrigation schemes are inefficient use of water, soil fertility and quality maintenance problems, soil erosion, and water related diseases hazards while soil salinity is a major problem in Doni and Batu Dega irrigation schemes. These issues, which affect the sustainability of the schemes and environment, are considered to be the key issues that should be taken into account in making future investments.

Key words/phrases: Community based, environmental impact, Ethiopia, small-scale irrigation, water quality parameters

INTRODUCTION

Ethiopia's renewable surface and ground water amounts to 123 and 2.6 billion cubic meters per annum, respectively (CARE, 1998). Floods and drought, and lack of means to store water in times of plenty place Ethiopia at risk of drought and chronic food shortages (CARE, 1998). Excess runoff is also responsible for the soil erosion in the highlands. Recent studies show that the sediment yields in different rivers range between 180 and 900 t/year per km^2 (Rodecco, 2002). It is estimated that the Trans-boundary Rivers alone carry about 1.3 billion tones of sediment each year to neighbouring countries (MoWR, 1993).

The country has an estimated irrigable land of about 1.5–3.5 million ha of which only about 5% ha have been developed to date, with about 55% of the developed area being under traditional irrigation system (MoWR, 2001a). At the end of the 1990s, the area under small-scale irrigation was estimated at around 65 thousand ha while that of medium and large-scale were appraised at 112 thousand ha, of which 22 thousand ha were new small-scale irrigation schemes implemented since 1992 (WWDSE, 2001). The majority of existing traditional and modern irrigation schemes are micro level in size, serving households usually not more than 200 to 300 in number (Tahal, 1988). Many of these schemes are based on stream and river diversions but some may be dependent on small dams and perennial springs.

The increased dependence on irrigation has not been without its negative environmental effects. In sub-Saharan Africa more land is going out of irrigation each year than can be developed for irrigation because of the difficulty of planning and conducting sustainable schemes (Bruns, 2000). Inadequate attention to factors like land allocation, population pressure, input supply, market situation and health situation other than the technical engineering and projected economic implications of small-scale irrigation schemes in Ethiopia has led to great difficulties (CRS, 1999). Decisions to construct dams or upgrade traditional irrigation systems have often been made in the absence of sound objective assessments of their environmental and social implications (CRS, 1999).

This study attempts to find out the socio-economic and environmental impacts of small-scale irrigation schemes by comparative analyses of households in the four irrigation schemes using household survey and irrigation water sample analyses, thus contributing to a better understanding of community based small-scale irrigation subsector.

MATERIALS AND METHODS

The study area

The Awash Basin covers a total area of 110 000 Km^2 (MoWR, 2001a). The main river length is about 1200 km and emanates at an elevation of about 3000 m in the central Ethiopian Highlands, west of Addis Ababa, near Ginchi town and flows northeastwards along the Rift Valley into Afar where it terminates in Lake Abe at an elevation of 250 meters. The Awash Basin has been the most intensively studied river basin in Ethiopia and, because of its strategic location, good access facilities, available land and water resources, is currently the most developed river of Ethiopia in terms of its irrigated agriculture. The current irrigated area is approximately 69,000 ha (MoWR, 2001b).

The basin has an extensive resource potential in climate, land and water. The annual rainfall amounts range from about 200 to 800 mm, and the mean annual temperature ranges from 20.8°C to 29°C (NMSA, 1998). The total mean annual surface water resource of the basin is estimated to be 4900 Mm^3 of which 2250 Mm^3 is currently diverted for irrigation in the Upper, Middle and Lower Valley areas. There is a progressive increase in the salinity of the water from the Upper valley through the Middle Valley. The quality of the incoming water from the Uplands is generally good and deterioration occurs partly as a result of irrigation return flows, and partly from the contributions of the various relatively saline hot springs. In an attempt to contribute a better understanding of the community based irrigation sub-sector in the Awash River Basin, social benefits and environmental effect assessment was carried out on four selected smallholder irrigation schemes (Fig. 1).

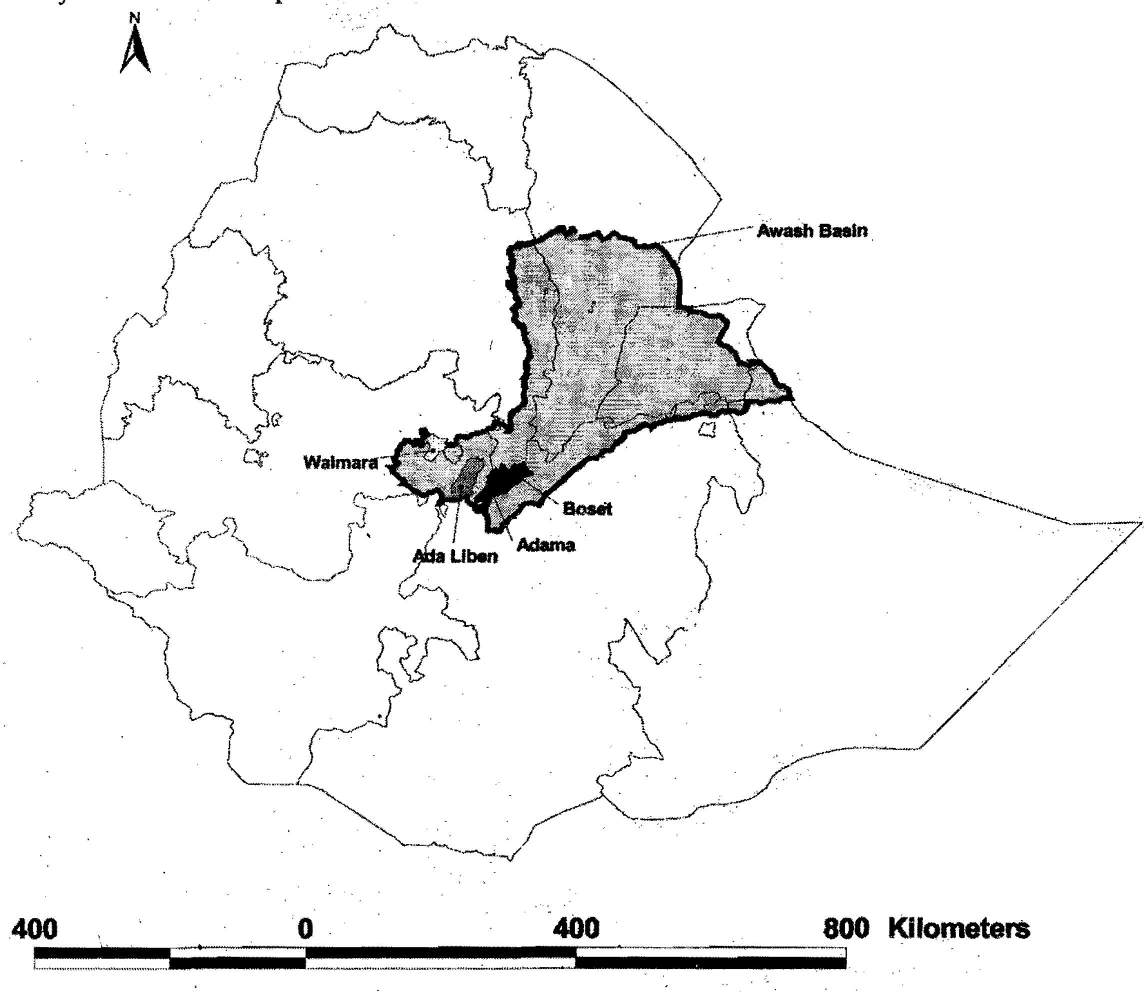

Fig. 1. Map of Awash River Basin and study Woredas

Household survey

Among the number of community based small-scale irrigation schemes in the Upper Awash River basin, four irrigation schemes from four woredas were selected for the study based on accessibility, experience and type of scheme. The study was conducted from February to May, 2004. Sample households from the four irrigation schemes and peasant associations were selected using random sampling techniques. Sample populations were classified into two groups: irrigators and non-irrigators. These were selected from the same peasant associations where irrigation schemes are found and the difference is limited only to access to irrigation water. The two farm categories were considered to use the similar cropping pattern and their annual income from farm lands was considered for comparison. 30 irrigators and 30 non-irrigating farmers were selected from each peasant association where the schemes are located. The total population of irrigators and non-irrigator farmers of the four-peasant associations are 627 and 3207, respectively.

The household survey was conducted using questionnaires which cover demographic characteristics, household socio-economic factors, plot characteristics, water management practices, cropping patterns, agricultural inputs and yields at plot level, marketing and conception of constraints and environmental effects. In addition, physical environmental effects of irrigation like impact of dams on flooding, siltation, erosion, gully formation; local sanitation facilities were assessed by direct observation of the farms and villages.

Water quality analyses

Irrigation water samples were collected from each site at different locations for water quality analyses. 12 water samples were collected from three different locations from each of the four schemes. The collection points were, at the junction where the diversion canal starts, at mid point in the irrigation system, and finally before the water joins the river. All samples were collected by grab method. Samples collected at specific location at given time at once and at only one particular point in the sample medium. Three samples were collected from each site in three plastic bottle thoroughly cleaned by detergent. The samples were then filtered using Whitman's no.42 filter paper, labeled, sealed, transported to the laboratory and stored under refrigeration at 4°C until analyses was carried out at the Geological Survey Agency (GSA) in Addis Ababa.

Water samples from the four schemes were collected from two different locations at each scheme for analyses of indicator micro-organisms (coliform bacteria) for possible contamination. The collection points were, at representative points where most farmers use the water for drinking in the irrigation system. Eight samples, two samples from each of the four sites were collected in eight thoroughly cleaned plastic bottles. Microbial analyses from 100 ml sample were conducted within 48 hours of sample collection at the International Livestock Research Institute (ILRI), Debre Zeit Research Station laboratory using Standard Methods for the Examination of Water and Wastewater of American Public Health Association APHA (1999). The filter paper was put on the lauryl sulphate agar plate. Precaution was taken not to trap air bubbles underneath the filter. The Petri dishes were incubated for 24 hrs at 37°C and all yellow colonies were counted. Then all yellow colonies were inoculated to a separate Brilliant Green Bile Broth 2% to examine for gas formation after 24 hrs at 37°C.

Statistical analyses

Comparative data analyses were carried out using the SPSS statistical software package. The purpose of the analyses was to show the flow of goods services and cash in a small farm system and to see the links between the farm and the household and between these two entities and the effect on the environment.

Scope and limitation of the study

This research was conducted to assess the socio-economic and environmental effects of community based small-scale irrigation in the Upper Awash River Basin. However, this study is subject to the following limitations.

- Time series information is difficult to collect from the farmers since they are not recording and remember only the most recent ones. It was not possible to take more than one-year data due to limited time and money given for the study.
- Pesticide residue and soil analyses, which are very important to see the environmental effect of irrigation, were not done because of fund and time shortage.

RESULTS AND DISCUSSION

Major existing positive environmental impacts

The long-term development in agriculture is based on the potential of smallholder agriculture. Raising the productivity and incomes of smallholder farmers is the most feasible strategy towards achieving agricultural growth in Ethiopia. The major constraints facing these smallholders are persistent drought and harsh climatic conditions in the areas they live. The high level of inputs applied in the studied irrigation schemes indicates that the farmers have developed an entrepreneurship. The other benefits that can accrue from irrigation development as shown by the study of the four schemes are as follows:

Incomes and food security

The development of smallholder irrigation schemes has resulted in high income for the smallholder irrigating farmers compared with the non-irrigators (Table 1). The cost of inputs like fertilizers, pesticides, herbicides and seeds were deducted from the gross farm income. The result revealed that the average net farm income of irrigation farms in general is higher per ha than the non-irrigated farms. Smallholder irrigation can lead to food security at the household level and for the surrounding community through increased productivity and increased income as shown by the analyses of the four irrigation schemes.

Table 1. Mean comparison of net farm income between farm types in 2002/2003 cropping season.

Dependent variable	Farm type		significance
	Irrigator	Non-irrigator	
Input cost (Birr/ha)	1428	605	**
Gross farm income (Birr/ha)	5181	1886	**
Net farm income (Birr/ha)	3754	1280	**

**=significant at p<0.01

Impact on employment

Irrigated farms are more labour intensive than non-irrigated farms (Table 2). The family labour supply is not enough for irrigated farming in most cases while non-irrigated farms have almost enough aggregate labour needed for the farm operation. As a result non-family labour has to be used by irrigator farmers. Labour is both exchanged and hired to overcome labour bottlenecks. Hired labour is most used during transplanting seedlings, weeding and harvesting time. For other activities all physically able members of the household assist in farm work. The total labour required in man-days for irrigated crops is significantly higher than non-irrigated crops assuming that no quality difference between the labour inputs of the different age and sex groups. Of this about 60% is supplied by the family and 40% by hired labour for irrigated plot while 88% supplied by the family and 12% by hired and exchange labour for non-irrigated plots.

Table 2. Mean comparison of labour requirement between farms.

Variable	Total labour input/ha		Significance
	Irrigator	Non-irrigator	
Family Labour			
Men	66	38	
Women	18	13	
Children	37	27	
Sub--total	121	78	**
Hired-Labour			
Men	63	31	
Women	45	18	
Children	60	21	
Sub-total	168	70	**
Total	289	148	**

**=significant at p<0.01

Backward and forward linkages

Irrigated farming has created economic backward and forward linkages. Crops that are grown under irrigation rely heavily on improved purchased agricultural inputs, which have encouraged the local merchants to supply the farms. This has also increased labour use in the marketing and distribution sectors. Forward linkages occurred since it contributed extra income to the farmers, which enable them to access food. These effects have been reflected in the analyses of the four schemes.

Major existing environmental constraints

Inefficient use of water

Inefficient use of water was observed in most of the schemes studied specially in Godino and Doni. Leakage from unlined canals through the earthen dam structure or from breakages of cemented canals system and faulty use of irrigation water were the major problems in the study area. Overusing water than is required for satisfactory crop production can lead to inefficient use of fertilizers and leaching of nutrients, increase favourable conditions for pests, and leaves the soils in a more degraded condition. This is becoming the point of conflict in the water user association in all the schemes. The other problem observed was use of flood irrigation in Godino which created over flow of water causing erosion on other farmers' fields.

Soil fertility and quality maintenance problems

Irrigation gives farmers the option for second and third season production. As a result of this intensification of agricultural production the quality and fertility of the soils of irrigated plots have been affected. This specifically was observed in Godino and Markos where the land has been cropped for more than 100 years. Nutrients are removed more rapidly than they are replaced. All crop residue and green by products from vegetable production are removed from the field for livestock feed, fuel, and house construction. The only source of nutrient is use of fertilizer. Few farmers who have livestock apply manure. It is believed that irrigated plots are more exposed to nutrient depletion than the non-irrigated plots given the other factors are similar in both cases. The indication for this phenomenon is gradual yield decrease and the study conducted by CRS (1999) also revealed a similar result. The use of large amount of chemicals like copper fungicides on irrigated plots is also another long-term environmental problem in irrigated farms.

Soil salinity

Salinity problem is minor in Markos and Godino (high altitude) while it is severe in Batu Degaga and Doni schemes, which are located in low altitude. Some plots are covered with white salt deposits on the soil surface especially at Doni. As a result some farmers have abandoned their fields because of low productivity and to the extent of no vegetative growth in salt affected plots. This was observed mainly along Awash River bank and was also reported in the Awash Basin study conducted by Halcrow (1989) that salinization of irrigated land is mainly a problem in most of the state farms in the Awash Basin.

To verify the problems observed, water samples were collected from each scheme for physical and chemical analyses of the irrigation water. Ethiopian Geological Survey Water Laboratory in Addis Ababa determined the physical characters, like pH, and electro-conductivity and concentration of cations, anions and CO_2. The results (Table 3) compared with the world standard and Ethiopian standard both for human and plant revealed that there is no significant risk of salts and nutrient toxicity problem at present. Electrical conductivity of the irrigation water (ECW) values of the four schemes in general is within the acceptable limit and is safe for irrigation. However, there are some pockets where salinity and sodicity problem are observed in Doni and Batu Degaga schemes. The calculated SAR (Sodium Adsorption Ratio) value is higher than the recommended rate (>9). It is assumed that the hot springs in the basin are dissolving rock salts and adding the concentration to the Awash River in the Rift Valley (Halcrow, 1989). This needs further study on the soil quality to verify the assumption in the schemes.

Table 3. Physical and chemical characteristics of irrigation water samples collected from the schemes. (concentrations for all parameters are in mg/l, except for pH, EC and SAR).

Parmeters	Scheme				
	Markos	Doni	Batu Degaga	Godino	Significant SD(n=8)
pH	7.7	8.0	7.6	7.6	0.001
Ecw (μs/cm)	248.7	401.3	443.3	362.0	0.000
SAR adj.	2.2[a*]	9.9[ab]	10.3[c]	2.8[cd]	0.000
Bicarbonate (HCO_3)	144.3	205.3	222.0	202.7	0.000
Chloride (Cl)	6.7	20.0	23.3	8.3	0.065
Sulphate(SO_4)l	0.9	13.0	12.0	0.9	0.000
Fluoride (F)	0.3	2.3	2.2	0.5	0.073
Nitrate (NO_3)	1.6	0.1	0.1	3.7	0.000
Sodium (Na)	9.5	45.7	48.7	13.8	0.348
Potassium (K)	3.1	7.8	10.7	14.0	0.002
Calcium (Ca)	26.0	34.3	36.3	38.7	0.030
Magnesium (Mg)	10.0	8.0	8.7	10.8	0.384
Boron (HBO_2)	0.2	0.2	0.6	1.3	0.163
Carbon Dioxide (CO_2)	6.0	4.0	10.0	12.0	0.055

NS=non-significant, *=significant at p<0.05; **=significant at p<0.01
* Means with the same letter in the raw are not different (p<0.05) from Duncan's Multiple Range Test.
SAR adj. = adjusted sodium adsorption ratio.

At Doni and Batu Degaga, sodium and boron are within the acceptable range while pH ranges from 7.30 to 8.08 in all the schemes, which is within the accepted range. Fluoride analyses showed that at Batu Degaga and Doni the values are in the higher range. This has no any immediate effect on human health; however, care should be taken in the long run. In general the irrigated water quality analyses showed that there is no immediate concern on the pollution level both for human and plant consumption. However, the soil should be analyzed and the interaction of soil and water in relation to plant growth needs to be further studied.

Soil erosion problem

Due to shortage of rainfall, dry condition is observed at Doni and Batu Degaga irrigation schemes. The heavy grazing from the pastoralist camels which migrate in the dry season to the area and the livestock owned causes considerable damage to the natural protective vegetation cover of the soil. Thus the soil is exposed to the action of strong wind, causing wind erosion forming rills and gullies.

In Godino and Markos, erosion caused by flood irrigation and furrow irrigation along the slope is common problem as observed during the study. Irrigated plots at Godino and Markos are excessively steep slope and practicing flood irrigation is causing sheet and gully erosion in the agricultural fields. At Doni and Batu Degaga erosion problem is very minimal since the plots are gentle slope. However some farmers are affected by flooding when Awash River overflows its banks.

Water related diseases hazards

Water-borne diseases account for a substantial part of the total incidence of diseases in the rural population. It is directly related to the water use system adapted by the farming community. The problem is more severe in irrigated agricultural system where irrigation water is used for human as well as animal consumption directly without any treatment. The greatest danger associated with drinking water is contamination by human and animal excrement. Human as well as animal faeces are left in the open system in the field and around homestead area in all the schemes. Rainfall and inefficient utilization of irrigation water takes coliform bacteria into water. The presence of faecal coliform in drinking water may cause concern because many diseases can be spread through faecal transmission.

To study the level of pollution of irrigated water, water samples were collected from the four sites and laboratory analyses on coliform count was done at International Livestock Research Institute (ILRI) Debre Zeit Research Station. The result (Table 4) shows that all the coliform counts were very high indicating the level of pollution compared with the standard (0.1 CFU/ 100 ml). It is clear that the colony count alone is of little value in detecting the presence of faecal pollution since organisms of all types will be counted. However an analysis of the presence of indicator organisms is a shortcut attempt to determine the microbiological quality and public health safety of waters.

Table 4. Total Coliform analyses.

Scheme	Temperature(°C)	pH	Coliform count CFU/100ml	Ethiopian Standard[1]		European standards (CFU/100ml)	International standards (CFU/100ml)
				Recommended limit (CFU/100ml)	Maximum allowable limit (CFU/100ml)		
Godino-1	21.5	7.8	150	0	0.1	Nil	Nil
Godino-2	232.0	7.6	170				
Markos-1	19.1	7.9	90				
Markos-2	17.0	7.6	20				
Donni-1	21.9	7.9	600				
Donni-2	21.0	7.6	2000				
Batu Degaga-1	21.5	8.5	90				
Batu Degaga-2	22.0	8.3	120				

[1]Source: Environmental Protection Authority (EPA) (2003)

The highest coliform count was found in Doni whereas the lowest was in Markos. This shows that Doni and Godino are highly contaminated than Markos and Batu Degaga. This may be due to the water passing through the small towns of Doni and Godino where human, animal excreta is left in the open and other wastes are dumped to the water. In general, in all the schemes, irrigation water is polluted considering the international standards, in particular the Ethiopian standards (Table 4). The coliform count standard is based on an organism that is not in itself pathogenic but merely as an indicator of possible contamination. Generally, disinfected supply should not show coliform organisms per 100 ml of distributed water. Again a one-time sample is only an indicator and is difficult to give conclusion without statistically tested result. A further time series data collection is necessary to see scheme differences.

It was also found out in the study that the design of irrigation systems, which was supposed to avoid stagnant water to prevent negative health impacts of irrigation, was not properly working. This was also aggravated by the inefficient use of water in most of the schemes. Water breaks furrows and ponds in depressions out side the farm. This was observed in Batu Degaga and Doni where the landscape is almost flat and the climate is arid. This has created favourable condition for vector and water borne diseases like Malaria, sischotosomiasis, and lungworms. In Godino and Markos the ditches pass through the villages and people and animal drink and clean themselves from the same irrigation water .One can imagine how intensely the population is exposed to vectors or infested water.

CONCLUSIONS AND RECOMMENDATIONS

The high yields obtained through irrigation and other benefits such as increased incomes, employment creation, food security, are an indication that irrigation can bring sustainable agriculture and economic development without severe effect on the environment. The study of the four small-scale irrigation schemes in the Awash River Basin has revealed some factors that are important for the successful implementation of small-scale irrigation schemes. Irrigation can be comparatively well designed and in a sound technical state but other issues related to, population pressure, input supply, market situation, health situation can affect the sustainability of irrigation schemes. The most important factor that came out as affecting the viability of the irrigation schemes is nutrient depletion, soil erosion and water related health hazards. The nutrient recycling system is disrupted by the agricultural practice followed by the farming community. The system of furrow irrigation, which is practiced in most of the schemes, has higher labour demands and some farmers practice flooding system. This will aggravate erosion especially in sloppy plots.

Good irrigation water management is a problem at schemes, if farmers do not pay for water costs. All the three schemes expect Markos doesn't use water efficiently. The water breaks canals and destroys other farmers' fields and the next farmer is also left without water. This has been a point of conflict in some schemes. Some farmers leave the water to flow out of their fields since they have nothing to pay for the water.

The study of the four schemes has also shown that in the future all smallholder irrigation development should take an integrated rural development approach covering irrigation infrastructure and associated communication and health facilities. Given the fact that irrigation development can be associated with water borne and vector diseases such as malaria, bilharzia and lungworm the need for health facilities and clean potable water should be complementary project of irrigation.

It was also observed that there is lack of technical knowledge among farmers on new technologies and management system. Most farmers are not aware of the interaction and inter linkages between crop rotation, pest management, introduction of new crops, water and vector borne diseases and the environment. Teaching farmers on new techniques and scientific findings should be considered along with provision of water for irrigation.

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