# CHAPTER 3

# MONITORING AND EVALUATION OF COMMUNITY-BASED IRRIGATION WATER MANAGEMENT AT THE GODINO SCHEME OF ETHIOPIA

## 3.1 Introduction

Irrigation is the provision of water to crops in the quantity and time controlled by farmers. In arid and semi-arid areas, where annual rainfall is not adequate for reasonable crop yields, irrigation can increase crop yield and farming profits. Even though irrigation is widely practised in arid and semi-arid climatic zones, supplementary irrigation is also becoming popular in sub-humid climates (Thorne & Peterson, 1950).

Irrigation was a well-known practice since the beginning of recorded history. In fact, many of the earliest civilisations developed in arid regions where irrigation was indispensable for human survival. These early cultures were so dependent on irrigation that historians referred to them as the hydraulic society (Thorne & Peterson, 1950). Since irrigation of any extent requires a highly organised society to build and maintain the water diversion and delivery systems, it may have catalysed the first community in which humankind evolved from the nomadic food-gathering society (Wynne, 1979).

At present, surface irrigation methods are dominantly being practised in developing countries due to their low energy requirement. This factor significantly influences the economic analysis required before a new irrigation supply can be set up and determines the water application method to be used (Stacy, 1999). Hence, due to their high energy costs, systems that are more modern have not replaced this irrigation method in most developing countries. Efficient surface irrigation management requires optimum knowledge of several variables: flow rate, cut-off time, watering intervals, depth of application, etc. Similarly, over-irrigation is one of the other extreme aspects of water management that promote water-logging, run-off and deep percolation, which all result in excessive nutrient loss and finally become unfriendly to the environment. Optimum irrigation water management is very important and, in fact, the base for irrigation system design, the saving of water resources, energy, and environmental protection (Samad & Vermillion, 1999). A quantitative determination of these variables explicitly leads to the details of crop water requirement and irrigation scheduling. Therefore, the determination of the amount of irrigation water to supply crops and the time interval required between applications could best prevent loss of water resources.

The objective of this study was to monitor and evaluate the traditional water management status of farmers at the Godino scheme to determine opportunities for potential further improvement.

## 3.2 Materials and methods

### Site background information

Godino is situated in the East Shewa zone of the Oromiya region, Ethiopia, about 55 km north east of Addis Ababa, and 12 km from the adjacent town of Bushoftu at a latitude of $8^o$ 48' N, and a longitude of $39^o$ E. The area has an undulating topography and an altitude of 1895 m.a.s.l. According to the long-term meteorological data collected from Bushoftu, the area receives an average annual rainfall of 866 mm and has an average annual temperature of 18.7°C. This area is also known to have an average reference evapotranspiration (ETo) of 1443 mm/year, with a monthly peak of 138 mm in April (OWMERDB, 1996).

Farmers of the Godino scheme practise two cropping systems, one under rain-fed conditions and the other using irrigation. The rainy season is from mid-May to mid-September, which is suitable for tef, maize, potatoes, peppers, beetroot, carrots, tomatoes, cabbage, pulses and other cereal crop production. However, irrigation is practised during the dry period, from October to the end of April, which is suitable for most vegetable crops like onions, cabbages, potatoes, peppers, tomatoes and others. In addition, citrus and sugarcane are also grown as perennial crops. The predominant soil is clay with a bulk density of 1.12 Mg $m^{-3}$, field capacity of 0.45 kg $kg^{-1}$ and permanent wilting point of 0.32 kg $kg^{-1}$, which gives a plant available water (PAW) of around 146 mm $m^{-1}$ (OWMERDB, 1996). The irrigation water for the scheme is abstracted from the Wadecha Dam. According to the National Soil Service laboratory, the quality of water for irrigation was found to be excellent and suitable for any crop production, with an electrical conductivity of 14.2 mS $m^{-1}$ and SAR of 0.31.

**The water users**

Societies sharing common water resources for irrigation need to have binding rules and regulations for equitable and efficient use of the resources. When the social aspect of a community sharing the same natural resource is overlooked, it is unlikely that an efficient utilisation of the communal water resource would be attained. Similarly, under community-based water management conditions, it is essential to assess the existing social structure and its functionalities before attempting to improve the water management in the scheme.

The existing social structure of water users in the project area was assessed through distributing questionnaires to about 15% (42 people) of the water user families. In addition, major constraints in the scheme, both social and technical, were included in the questionnaire. The farmers' responses on the existing agricultural constraints were summarised in three categories: none, some and severe. When a constraint was experienced by less than 10% of the total respondents, it was regarded as "none" or no constraint, from 10-40% as "some"; and above 40% as "severe" constraint.

**Irrigation water supply**

The main canal supplying Godino has no structure that enables the measurement of water supply to the scheme. Hence, a Parshall flume with a 9" (22.86 cm) throat width was installed on a concrete canal on 22 January 2004. Water delivery into the scheme was recorded three times a day, at 06:00, 12:00 and 18:00. This activity took place from the date of installation up to 15 April 2004 to estimate the average delivery of water into the scheme. Similarly, on-farm water application was measured using a 3" (7.62 cm) throat width Parshall flume for three major crops, namely onions, potatoes and tomatoes. This measurement provided information on the amount of water that a farmer typically applies to his crop. The soil water status was monitored before each irrigation, by collecting soil samples from 0-200 mm, 200-400 mm and 400-600 mm for the same crops. The soil samples were weighed and then oven-dried for 24 hrs at 105°C, whereafter they were weighed again to calculate the soil water content before the application of irrigation.

### 3.3 Results and discussion

**The water user's organisation**

Successful scheme irrigation water management not only requires knowledge, but also structural organisation of the society. Organised water users are bound to become increasingly concerned with balancing the farm budget and meeting the additional demands being placed upon them (Abernethy *et al.,* 2000). Hence, approaches to the development of water users' organisations and cost recovery need careful planning and implementation for a particular society and its conditions.

Strong community-based irrigation schemes consist of three-dimensional structural linkages, that is, research-extension-farmer linkages. These institutional linkages were observed to be missing at the Godino community scheme. In addition, this traditional irrigation scheme is not at all supported by improved management practices. The extension service department of the government organisation is linked to the water users' association without any improved technologies, mostly performing administrative and political-related activities. The Melka Werer Research Centre, the only centre dealing with water management research, is located far away from this scheme with the focus on the development of improved water management technologies for large-scale irrigated agriculture. Generally, the improved water management technologies developed under the Melka Werer climatic conditions could not be extrapolated to any other part of the country out of that area. So far, there is no committed organisation to develop improved water management technologies for traditional irrigation schemes in general and for Godino in particular.

At present, in the absence of a strong water users' organisation and improved water management technologies at the Godino traditional irrigation scheme, the situation is deteriorating and highly unsatisfactory. There is low irrigation efficiency, numerous inequalities in water distribution, complexity and lack of transparency among water users. In this context, the intervention of research in developing effective water management technologies that fully involve water users is decisive. This would help the society induce a collective rethinking on the management of water as a resource in the irrigation system and maintain economic feasibility and sustainability of irrigated agriculture.

A summary of the Godino irrigation scheme irrigation water-related constraints indicated that the required amount of water application and the irrigation interval were the major technical problems, as agreed upon by all the interviewed farmers (Fig. 3.1). In addition, about 80% of the farmers interviewed agreed that water distribution, water availability and irrigation methods were still important constraints on the scheme.

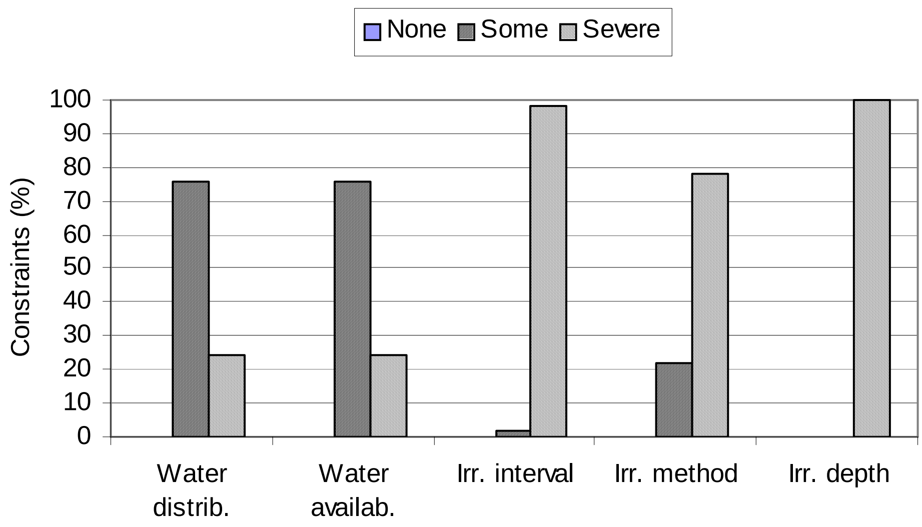


**Figure 3.1** Water management related constraints and their extent at the Godino traditional irrigation scheme

Figures 1 and 3.2 further illustrates that about 80% of the respondents considered the method of irrigation and lack of land levelling as severe problems. More than 80% of the respondents claimed to have some problems with drainage and improper design of the land.

Figure 3.2 indicates the views of farmers on soil, maintenance and operation, and drainage-related constraints. In this respect, farmers claimed that the soil might be deficient in major plant nutrients and that they applied the same amount of nitrogen and phosphorus to all crops in the scheme, as fertiliser rates were not established. Similarly, the scheme was not properly designed from the start and surface drainage prevails as land levelling was not practiced at all. Maintenance of the existing infrastructure was also not carried out regularly as a result of poor coordination services.

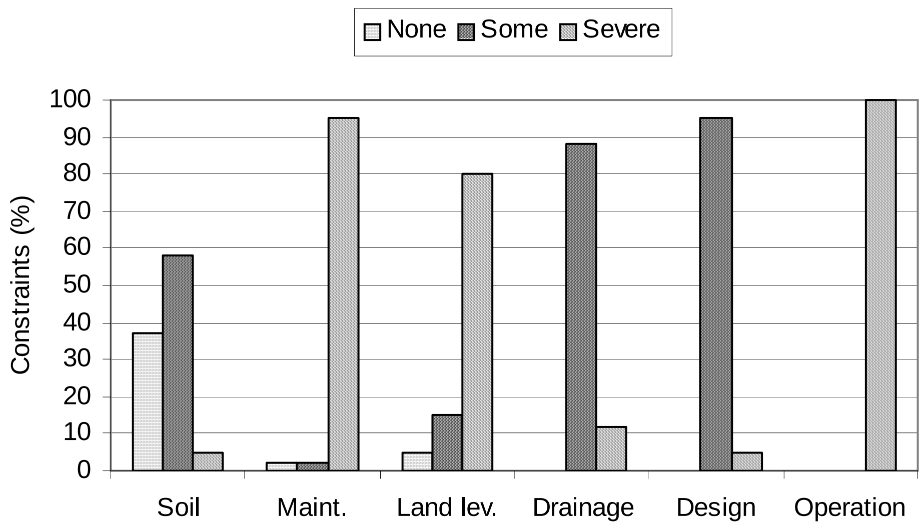


**Figure 3.2** Soil and farm infrastructure related constraints and their extent at the Godino traditional irrigation scheme

On the other hand, the majority of the farmers encountered severe problems with regard to low crop productivity, inaccessibility of the scheme and inadequate extension services (Fig. 3.3). Marketing problems, shortage of labour during activity overlaps and wildlife menace were also considered as severe constraints to most farmers. In general, the overall loose farmers' organisation and poor extension services were found to be the major courses of most associated agricultural constraints on the scheme.

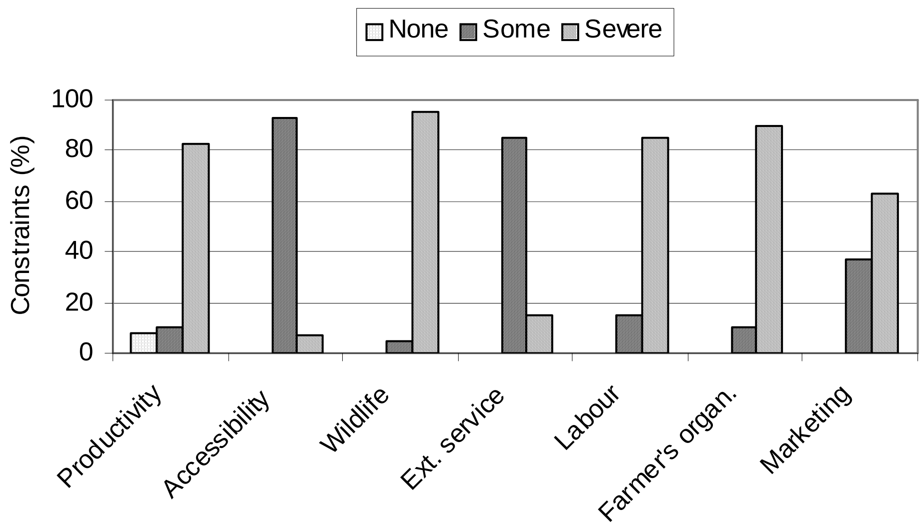


**Figure 3.3** Productivity, wildlife and social related constraints and their extent at the Godino traditional irrigation scheme

**Scheme water supply**

Irrigation water is supplied to the Godino scheme from the Wadecha Dam, which is situated about 17 km north of the scheme. Since the watershed of the dam is situated in the central highlands of Ethiopia, the water is of good quality, there are no salinity problems and no other form of land degradation was observed (OWMERDB, 1996). However, since the sediment load of the river is high, sediment deposition in canals is very high and this, in turn, requires frequent desiltation.

The research result of the scheme's water supply indicated that January was the month with the highest water supply to the scheme to satisfy the peak water demand of the crops (Fig. 3.4).

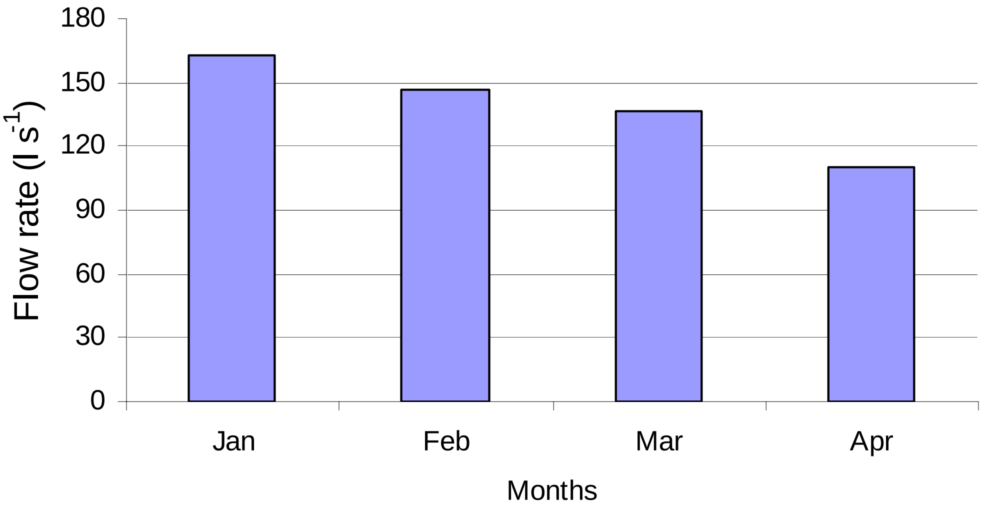


**Figure 3.4** Average daily scheme water supply (l $s^{-1}$) for Godino traditional irrigation scheme

The scheme water supply gradually decreased from February to April. These months are very important for irrigation as most crops are then at their vegetative growth stages, requiring adequate water supply. These growth stages are most critical to water stress, which would significantly decrease the yield and quality of most produce.

The farmers' response to the questionnaire of water adequacy revealed that water supply was adequate at the head and middle of the scheme, while it was a serious constraint at the lower end of the scheme. Most of the respondents agreed that, for several fields, shortages of water were due to overlapping of irrigation schedules during the peak water demand. This was also substantiated by the fact that information on crop water demand (when to irrigate and how much water to apply) was not available to farmers. As a result, most of the farmers applied too much of the water amount that their crops needed at the head of the scheme, and too little water at the tail of the scheme. Most farmers at the tail end of the scheme overcame the shortages of water by using low yielding and less marketable crops. They also selected more stress-tolerant crops with low yields to avoid a total loss due to water shortage.

**On-farm water application**

The slope of the Godino irrigation scheme varies from flat to gentle slope, making the management of surface irrigation very difficult on top of water shortage (Fig. 3.1). Land levelling was not practiced in the past. Under such circumstances, systematic cropping and land terracing are essential to avoid overflow of water before the soil water deficit of the entire profile is replenished. No canals, from primary to tertiary, have water-regulating structures. Off-take gates were all made of earth and regulated by stop log or stones. This has created difficulty in limiting the amount of water to be distributed among the various sections of farmlands. Huge quantities of water will be delivered for a limited period to a group of farmers in the same direction. During this period, the farmer at the upper part of the scheme would have ample time and water to over-irrigate his/her crops, while the farmer at the lower end would have only limited water and time available. Water is in short supply to fully replenish the root zone profile, coupled with long irrigation intervals that resulted in frequent under-irrigation of crops in the lower scheme (Fig. 3.5 & 3.6). Consequently, most farmers at the lower end of the scheme were forced to use more drought-tolerant crop cultivars with low productivity.

The on-farm water application is also much dependent on water availability in both amount and interval. Farmers in the scheme have no water-measuring facilities. Most farmers apply the concept of irrigating the same amount of water to all crops at the same interval. The amount of water applied is mostly determined by visual observation of the water overflow or by the availability of water to the farmer. The farmers' response to the questions on the amount and interval of irrigation indicated that most of them applied the same water quantity to all crop species, but used relatively longer intervals for tree crops and sugarcane. Currently, due to the prevalence of water scarcity and the intention of the government of Ethiopia to charge for irrigation water, farmers are very concerned about the correct amount of irrigation water to use.

The farmers' traditional water application amount was recorded by using a three-inch (7.62 cm) throat-width Parshall flume for onions, potatoes and tomatoes.

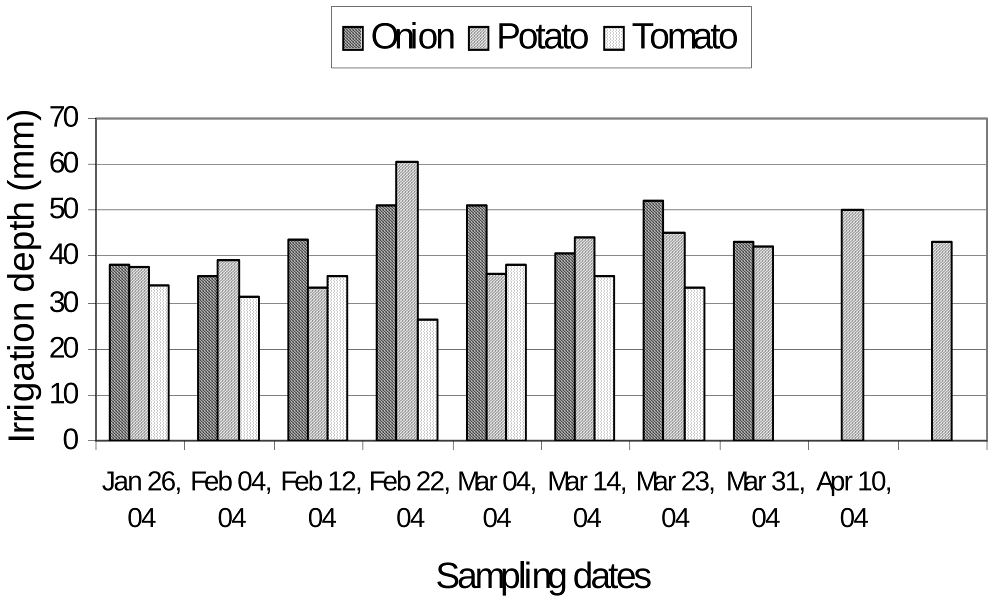


**Figure 3.5** Farmers' irrigation water application depth (mm) for onion, potato and tomato crops at the Godino traditional irrigation scheme

As can be observed in Figure 3.5, the amount of water traditionally applied varies widely from time to time and from crop to crop, with the variation governed solely by water availability. The farmers' watering depth varied from less than 30 mm to 60 mm under furrow conditions (Fig. 3.5), where the overall irrigation efficiency is less than 50%. This amount seems to be too low to replenish the soil profile to the full rooting depth of crops, especially where irrigation intervals last up to or more than ten days.

Similarly, the irrigation interval traditionally practised at the Godino scheme varied from crop to crop and from time to time and, once again, depended on water availability in both amount and interval. The watering interval varied from 9-14 days for onions, 8-10 days for potatoes and 7-11 days for tomatoes (Fig. 3.6).

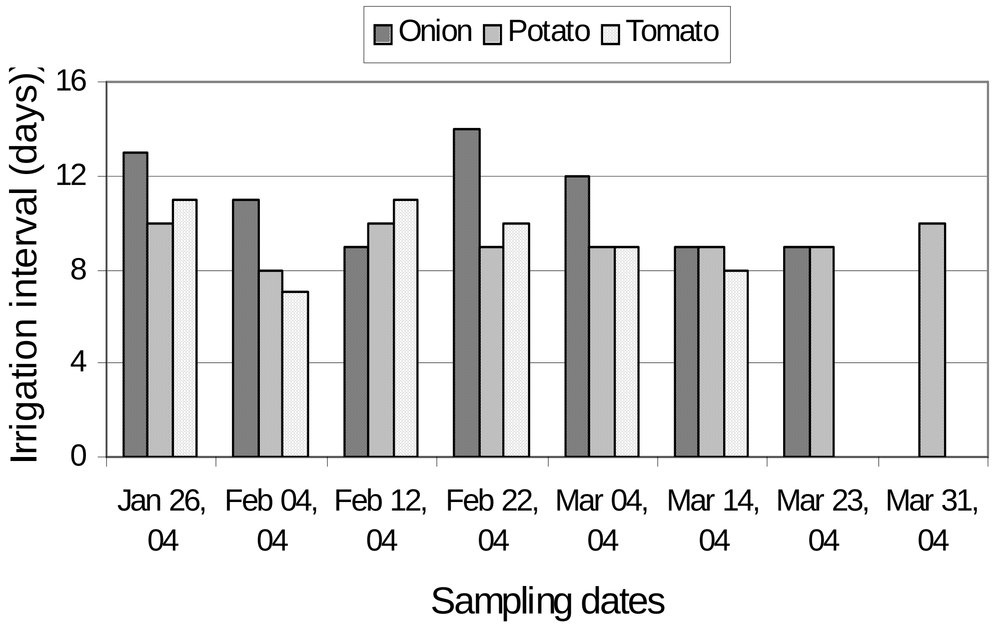


**Figure 3.6** Farmers' traditional irrigation interval (days) for onion, potato and tomato crops at the Godino traditional irrigation scheme

A questionnaire was distributed to the farmers to identify reasons for the large variation in irrigation intervals. Most farmers responded that variations in both irrigation intervals and depth were not projected on either the basis of crop water demand or crop type itself, but were rather governed by the availability of water for intervals and during the peak crop water requirement. This practice often led to wilting of water sensitive crops. According to the perception of most farmers, crops were generally under-irrigated at the lower end of the scheme due to water unavailability, while there could be over-irrigation at the upper end of the scheme. In general, farmers assumed that applying large amounts of water will ensure high yield, regardless of crop species or maturity stage. On the other hand, researchers (Al-Kaisi & Broner, 2005) agree that crop water use is influenced by the evaporative demand, the crop stage and soil water content. As soil dries, it becomes more difficult for a plant to extract water from it. At field capacity, plants use water at the maximum rate and when the soil water content drops significantly below field capacity, plants use much less water.

The soil water status was recorded for onion, potato and tomato fields just before irrigation, to assess whether traditional irrigation depths correlate with the soil water deficit. The soil water content results indicated that the top soil layer (0-200 mm) was most dry and followed by the middle layer (200-400 mm), whilst the deepest soil layer (400-600 mm) contained relatively more soil water (Fig. 3.7).

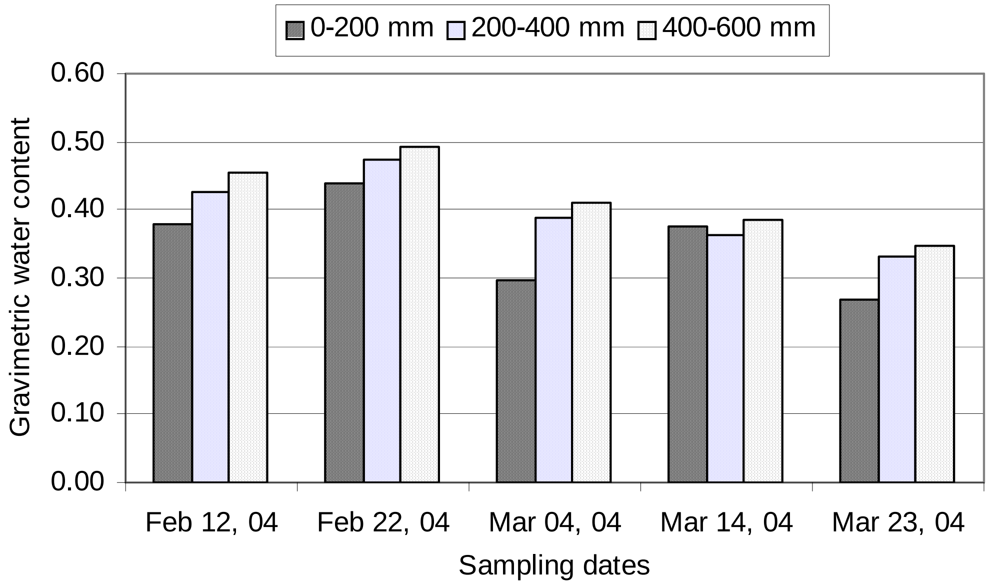


**Figure 3.7** Gravimetric water content measured before irrigation water application at the Godino traditional irrigation scheme

The soil water deficit to field capacity/irrigation required was computed from the soil water measurement to compare it with the irrigation amount traditionally practised (Fig. 3.8).

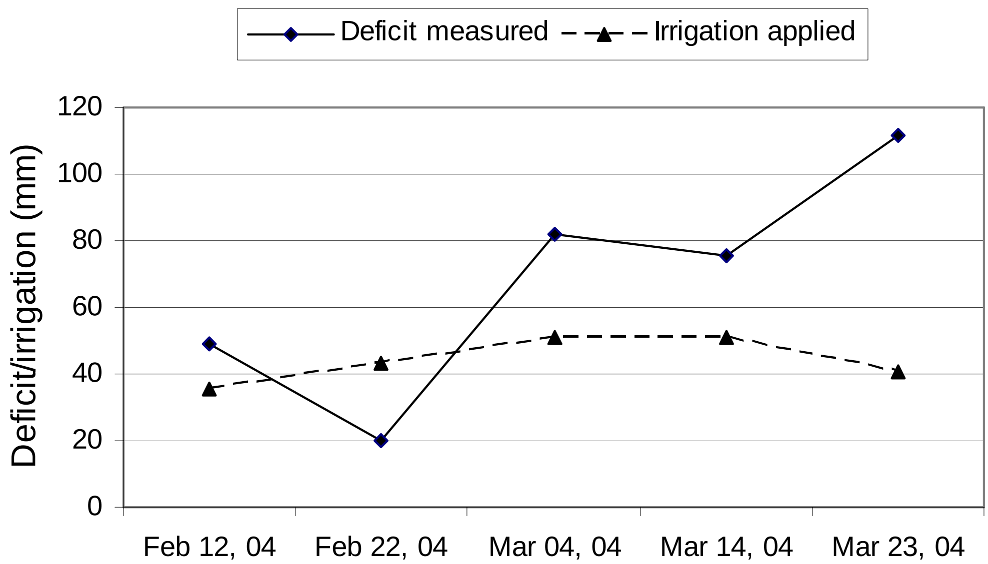


**Figure 3.8** Soil water deficit before irrigation (irrigation requirement) in comparison with the water amount the farmer applied

The graph indicates that the irrigation required was greater than the applied water, except during one sampling occasion (February 22, 2004). The amount of water farmers traditionally applied was found to be very low compared to the irrigation required; sometimes more than twofold (Fig. 3.8). Once again, this confirmed that traditional irrigation application depth is much less than the soil water deficit to the field capacity. Most farmers on the scheme blamed the low scheme water supply for under-irrigation of their crops, coupled with too long intervals between water supply cycles.

Efficient irrigation is about refilling the soil profile to field capacity. Application of more than the soil deficit leads to wastage of water that reduces the application efficiency, whilst an irrigation amount less than the soil water deficit may lead to more frequent application or reduction of crop ET. According to Al-Kaisi & Broner (2005), significant evaporation can take place only when the soil's top layer or plant canopy is wet. Once the soil surface is dried out, evaporation decreases sharply until the next rain or irrigation. Crop water use is influenced by prevailing weather conditions, available water in the soil, crop species and growth stage. At full cover, crops will have maximum ET rate if soil water is not limited and the soil root zone is at field capacity.

### 3.4 Discussion and Conclusions

The irrigation water management at the Godino scheme remains solely traditional. Population growth and the diminishing irrigation water resources are becoming critical constraints for producing enough food in the region. The overall result indicated that traditional water management at the Godino scheme seemed to be poor: too long irrigation intervals and too low water depths per application. The application efficiency is poor due to lack of land levelling. Farmers at the Godino scheme blame the shortage in water supply and too long intervals between supply cycles for under-irrigation of their crops. In addition, the lack of a water users' organisation resulted in inequitable water distribution. Furthermore, a lack of improved irrigation technologies, high yielding crop cultivars and other agronomic practices also aggravate the production constraints on the scheme. Nowadays, irrigated crop production without proper plant nutrient management cannot be feasible. Therefore, traditional irrigation schemes need to be supported by improved water management techniques, improved crop cultivars, and proper fertility and crop protection managements.

The performance of scheme water management is widely dependent on scheme water supply and its efficient distribution. In areas where a water shortage exists, careful distribution is essential to avoid crop damage due to water stress. Crop choices and the determination of critical growth stages to water stress could promote optimum crop growth and finally reduce yield reduction. Different crops have various critical growth stages that respond to water stress. Once a critical growth stage to water stress is identified, it is possible to share the scarce water resource on a priority basis. Identification of appropriate irrigation intervals and depths also significantly helps to optimise water application. On the other hand, characterisation of soil water content before irrigation will also aid to determine the amount and intervals of water application. Under conditions of water scarcity, it is always advisable to avoid water movement below the plant's active root zone. Light irrigation, but more frequent application, may safeguard yield reduction and quality. Application during the evening or avoiding sunny conditions would minimise water evaporation and promote water storage in the crop root zone.