Technical Report


Mohammed Abdullahi*, MIZUTANI Masakazu**, TANAKA Seiji***, GOTO Akira** and MATSUI Hiroyuki**

Abstract The Mwea Irrigation Scheme (MIS) is a paddy irrigation project servicing an area of 5,890 ha in central Kenya; the scheme was developed from 1954 to 1973. Until 1993, recurrent and sometimes serious shortages of irrigation water occurred in the lower reaches of the MIS. In 1991, a technical cooperation project with the Japan International Cooperation Agency was started in the MIS. One of the activities of the project was the improvement of irrigation water distribution. This paper describes the changes and improvement in water distribution in the MIS from 1994 to 1998. The organisation of water distribution was restructured and a water distribution plan was drawn up based on 9 selected flow-measuring structures named Check Point Nos. 1-9. Water resource shortages, mainly due to droughts, were experienced in 3 of the 5 years that this new plan was implemented. During the implementation period, farmers upstream of the scheme area started using irrigation water for horticultural crop cultivation, especially during the dry season, thus placing further pressure on the limited water resources.

Key words: Paddy cultivation, Water distribution, Water management, Kenya

I. Introduction

The Mwea Irrigation Scheme (MIS) is a paddy irrigation project, which covered an area of 5890 ha at the end of 1996. It is situated in central Kenya, approximately 100 km north of Nairobi, the capital city. The cropping pattern is such that rice is sown from July to August and harvested between December and January. The National Irrigation Board (NIB), a corporation of the government of Kenya, managed the MIS up to 1998. The farmers initially settled in the MIS area on a tenancy basis after land reclamation of swamp areas. In 1991, the Mwea Irrigation Agricultural Development (MIAD) project was started as a project of technical cooperation between the governments of Kenya and Japan. One of the objectives of this project was to improve the management of water distribution and to ensure an equitable water supply throughout the whole scheme. This improvement programme was implemented between 1994 and 1998.

This paper mainly describes the changes and improvement in water distribution in the MIS from 1994 to 1998. The objectives of this paper are to present 1) water distribution and management problems in the MIS, and 2) the progress of the improvement undertaken and its results.

* United Graduate School of Agricultural Science, Tokyo University of Agriculture and Technology, Utsunomiya University, Mine Machi 350, Utsunomiya City, Tochigi 321-8505 Japan
** Faculty of Agriculture, Utsunomiya University, Mine Machi 350, Utsunomiya City, Tochigi 321-8505 Japan
*** Ministry of Agriculture, Forestry and Fisheries, Japan
(Manuscript Received Nov. 7, 2000, Accepted May 13, 2003)
The paper focuses on the area served by the Thiba River.

II. Outline of Scheme Development

1. History

The MIS area is divided into 5 sections — Tebere, Mwea, Thiba, Wamumu, and Karaba — each with an average area of 1200 ha. Table 1 shows the events in the history of the MIS from 1954 to 1999. Part of the development of the MIS was carried out in the period prior to Kenya's independence in 1963. A study was carried out from 1985 to 1987 by the Japan International Cooperation Agency (JICA) to assess the feasibility of expanding the MIS. The study recommended rehabilitating and expanding the scheme. The rehabilitation part was funded by grant aid from the government of Japan. The proposed expansion included development of 3000 ha of paddy fields west of the MIS and construction of a dam on the Thiba River upstream of the MIS area. This expansion was to be funded by a loan. Detailed design for the expansion was carried out from 1994 to 1996; however, the construction of the proposed facilities and land reclamation has not yet been implemented. Along with the rehabilitation of the MIS, technical cooperation was initiated between the governments of Kenya and Japan from February 1991 to January 1996 and executed by the agencies of NIB and JICA. The aim of this project was to develop and verify appropriate techniques for irrigated agriculture to remove the existing production constraints. In the follow-up period from February 1996 to January 1998, these techniques were transferred to farmers. One of the 5 technical sections of the project was the Water Management Section, which pursued the following work programme in line with the overall objectives of the project: 1) from 1991 to 1996 it developed and implemented a new water distribution plan with restructured organisation to ensure equitable water supply to all farmers, and 2) in the follow-up period from 1997 to 1998 it did basic work to establish water users' groups at the farm level. In 1999 there was a sudden change of management in the MIS. This change was not a result of improved water management, but was due to disagreements over paddy buying prices by the MIS. An investigation has been carried out on the new conditions of the MIS under the current management of the farmers' cooperatives, including the actual water management. The re-

<table>
<thead>
<tr>
<th>Year</th>
<th>Activity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1954—1973</td>
<td>Development of irrigation area.</td>
<td>Funds from the Kenyan Government and overseas</td>
</tr>
<tr>
<td>1985—1987</td>
<td>Feasibility study for the Mwea Irrigation Development Project (MIDP)</td>
<td>Carried out by the Japan International Cooperation Agency (JICA)</td>
</tr>
<tr>
<td>1991—1996</td>
<td>Mwea Irrigation Agricultural Development (MIAD) project.</td>
<td>Technical cooperation for the MIAD project</td>
</tr>
<tr>
<td></td>
<td>Organisation for water distribution was reorganised.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The first annual water distribution report was published.</td>
<td></td>
</tr>
<tr>
<td>1996—1997</td>
<td>Implementation of revised distribution plan. Follow-up period for technical cooperation is commenced for 2 years from February 1996.</td>
<td>Water shortages were experienced in both 1996 and 1997.</td>
</tr>
<tr>
<td>1999</td>
<td>Farmers' cooperative took over MIS management</td>
<td>After disagreements over paddy prices</td>
</tr>
</tbody>
</table>
sults of this investigation will be presented in a separate paper.

2. Irrigation system

The MIS is outlined in Figure 1. Two rivers with no storage facilities serve the scheme, namely the Nyamindi and Thiba. The Nyamindi River mainly serves the Tebere (T) section, while the Thiba River serves the Mwea (M), Thiba (H), Wamumu (W), and Karaba (K) sections. Water resources from the Nyamindi River that exceed the sum of water resources required for river maintenance flow plus the amount of irrigation water required for the Tebere section is regarded as surplus water. There is a link canal between the 2 rivers to transfer surplus water from the Nyamindi River to the Thiba River. The transfer is done when there is a shortage of water resources in the Thiba River. The MIS is divided into 60 units, each with an average area of 100 ha. At the end of 1996, 3230 farmers were tending a total of 5890 ha of paddy fields.

III. Changes Made in Water Management

1. Restructuring of the organisation

In the organisational set-up for water management that was in place up to 1993 (Figure 2), water management staff worked within 2 departments, namely the Department of Works and the Department of Agriculture. A Works Officer was in charge of water distribution and maintenance activities. A Senior Head Water Guard was responsible for the distribution of irrigation water to each section as directed by the Works Officer. Head Water Guards were in charge of distributing irrigation water allocated by the Senior Head Water Guard to the units in their sections. Water Guards were responsible for the distribution of the water to the farmers. The Head Water Guards and the Water Guards worked under an Agricultural Officer who was in charge of crop production.

There were communication and co-ordination problems between the water distribution staff in the 2 departments. Both departments had other responsibilities besides water distribution, and water distribution activities were not well organised. A new water distribution plan was drawn up, and to be successful it was necessary to restructure the organisation to solve these problems (Figure 2). The focus of the restructuring was to improve communications between staff and also to clarify their duties. The final goal of this restructuring was to enhance the implementation of the new water distribution plan.

In the restructured organisation, all staff engaged in water distribution were brought together
under a newly formed Department of Water Management. A Water Management Engineer was appointed to head this new department, and was responsible for the overall implementation of the water distribution plan and for publishing an annual water management report. The Senior Head Water Guard was re-deployed as a Check Point Observer who was responsible for daily data collection and record keeping. The Check Point Observer communicated to the Head Water Guards any use of irrigation water above or below the allocated discharge so that the Head Water Guard could adjust the gates appropriately. The responsibilities of the Head Water Guards and the Water Guards remained unchanged except that the Water Guards were also to cooperate with the Feeder Canal Leaders. The informal position of Feeder Canal Leader, chosen from among farmers who cultivated fields alongside the feeder canal, was started; his/her main responsibilities were to organise the farmers along the feeder canal for efficient water distribution. This was done to create a nucleus for future farmer-managed on-farm water distribution. To ease communication problems, a radio call network was established between the sections and also with the main office. In addition to the new positions of Water Management Engineer and the Feeder Canal Leader, Check Point Observers were necessary for collecting unbiased data for implementation of the water distribution plan.

### 2. Establishment and improvement of the water distribution plan

Prior to 1994, no data were collected on river discharge or flow of irrigation water at various locations along the canal system; the Senior Head Water Guard and the Head Water Guards relied on visual appraisal and experience in determining the adequacy of the allocated irrigation water. This led to delayed operation of the headwork gates to cope with fluctuations in available water resources and field water requirements. Sometimes decisions about changes in irrigation flow size were made after a shortage had already affected the paddy fields. The downstream sections of Wamumu and Karaba (sections) were always affected during periods of water shortage. To solve the above problems and to achieve equitable water distribution, 9 discharge-measuring points were selected (Check Point Nos. 1-9; see Figure 1).

1. **Initial distribution plan**

Table 2 shows various components necessary to calculate the water requirements. These data were obtained from meteorological data analysis (for 1992-1993) and water balance studies. The seasonal water requirements (during the rice growth period) necessary for the cultivated area under each Check Point were computed as a guideline for the water distribution plan. This plan was implemented in the 1994 and 1995 cropping seasons.

2. **Revised distribution plan**

After 2 years of following the initial plan, the need arose to reduce the frequency of gate operation, especially at the headworks, because the adjustments in the discharge that were needed

<table>
<thead>
<tr>
<th>Component</th>
<th>Value (mm/d)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1994–95 plan</td>
<td>1996–98 plan</td>
</tr>
<tr>
<td>Evapotranspiration (ET)</td>
<td>3.5–6.5</td>
<td>3.5–7.0 Estimated by the Penman method</td>
</tr>
<tr>
<td>Pre-saturation loss</td>
<td>–</td>
<td>250.0* Water balance data from research in MIAD</td>
</tr>
<tr>
<td>Deep percolation</td>
<td>0.1</td>
<td>0.1 Mwea water balance studies (van Gessel 1982).</td>
</tr>
<tr>
<td>Unit loss</td>
<td>2.2</td>
<td>2.2 Mwea water balance studies (van Gessel 1982).</td>
</tr>
<tr>
<td>Section loss</td>
<td>3.7</td>
<td>3.7 Mwea water balance studies (van Gessel 1982).</td>
</tr>
</tbody>
</table>

* Total water requirement
in each 10-day period were too small to be effected by the large headworks. It was also necessary to expand the plan to cover the whole year, including the non-cropping period. During the non-cropping period from January to July, water is required both for land preparation and for domestic use. The water requirements for a full year were computed using the water requirement components for the revised plan given in Table 2. This plan was implemented from 1996 through 1998. As compared to the initial plan, a pre-saturation requirement component was included for calculating the water requirement during the land preparation period. The meteorological data used were for 4 years, and the other components were the same as the initial plan. Compared to the initial plan there was a slight increase in calculated water requirement during the crop growth period, with the exception of the last 11 days of August and the whole of November, whose values were less than the initial plan (for CP 3). This was caused by using a higher ET value (due to longer period of meteorological data collection) and using a time span of one month instead of the 10-day period used in the initial plan.

IV. Results and Discussion

1. Changes in the performance of the restructured organisation

The most significant impact resulting from the organisational change was improved communication. There was routine daily communication of about 30 minutes between 8 and 9 o'clock in the morning after data collection by the Check Point Observers. The on-farm and off-farm conditions (including water resources) were discussed in these communications. A meeting was also held every 2 weeks in which the water distribution plan was discussed in detail in relation to farming activities and available water resources. In this manner, both the staff and, eventually, the farmers became familiar with the water distribution conditions at any given time during the cropping period. In this way, problems and other urgent information were easily conveyed. The organisational set-up also provided a forum for reviewing seasonal performance and making necessary changes for the coming year. These meetings led to the publishing of an annual water management report; these reports are becoming a source of accumulated experience of water distribution in the MIS.

2. Distribution of irrigation water

Figures 3 to 5 describe the distribution of irrigation water. In these figures, the discharge of the Thiba River (TRD) is presented as a percentage of the planned diversion. Discharges through Check Points Nos. 3 to 7 are shown as a percentage of planned Check Point discharges. The discharges from both the river and the Check Points are 10-day averages. A water supply of 100% indicates conditions of optimum supply, and this equals the planned discharge. In the case of Check Point No. 3, an important point in the water distribution, the discharge shown is the sum of the Thiba River discharge and surplus discharge from the Nyamindi River when there was a shortage of available water resources.

Water supply below 100% indicates conditions of water shortage. During the 5 years in which the improved water management practices were implemented, water shortages occurred in the following 3 years:

1994 (Figure 3, under the initial distribution plan): There was a slight shortage of up to 10% for 2 weeks in September and October. Though the TRD was more than 100% after late October, the C.P. discharges were maintained at less than 100% to prevent flooding during heavy rainfall.

1996 (Figure 4, under the revised distribution plan): There were 2 occasions when water shortages occurred. One of them was during the land preparation period and the other
was during the rice growth stage. The 2nd period lasted for about 6 weeks and reached a maximum deficit of 35%.

1997 (Figure 5, under the revised plan): The shortage started in June and lasted for about 12 weeks until early October. The peak deficit was 50%.

In these 3 years the water resources of the Thiba River together with the surplus discharge from the Nyamindi River could not meet the planned diversion discharge, and it was necessary to adopt a system of rotational water supply to each irrigation unit to conserve irrigation water. During the periods of rotational water supply, the irrigation units were divided into 2 groups, with each group receiving irrigation water for approximately 3-and-a-half days a week under the equity-based water supply policy. In this period all the units’ field canals had irrigation water. During this period new planned C.P discharges were calculated depending on the available water resource and the constituent member units for each group. The discharge values were revised whenever changes in available water resources were noticed.

Under the revised water distribution plan, fair water distribution was realized even during the water shortage period. The recurrent water shortage affecting the downstream areas of Wamumu and Karaba sections caused by inequitable water distribution was solved. The farmers generally voiced satisfaction of the new water management system.

3. Causes of water shortages

Water resource deficits occur due to drought (insufficient rainfall), increased demand, or a combination of both.

(1) Low river discharge
Using trends of fluctuations in river discharge, Mizutani et al. (1997) divided the year into 2 rainy seasons (long-and short-rain seasons) and determined that the long-rain season lasts from April 11 to October 10 and that the short-rain season is between October 11 and April 10. In the crop cultivation period between August and November, irrigation is mainly carried out in the long-rain season. It is also in the long-rain season when peak irrigation water is required. Probability analysis for accumulated river discharge during the long-rain season illustrates that the Thiba River had very low discharges during the 3 years that shortages of water resources occurred. The 1997 long-rain season was one of the driest on record.

(2) Upstream users (Informal irrigation)

Between 1992 and 1996, farmers in the high rainfall areas that extend upstream of the scheme turned to irrigation mainly for horticultural crops (French beans and cabbages). This was done during the drought period, and this further reduced the water available in the rivers. A survey carried out in early 1997 on water abstraction by weir or gravity methods upstream of the scheme intake indicated that only 2 out of the 20 abstractions were authorised by the government. Many of these systems to abstract water were constructed between 1992 and 1996, and their use is expanding.

(3) Neighbouring users (Illegal irrigation)

Although no statistics are available, illegal irrigation activities have been carried out around the MIS beneficiary area since the early 1990s. The farmers of fields adjacent to those of the MIS had no other independent source of irrigation water, so they were permitted to re-use drain discharges from the MIS to irrigate their paddy fields. However, some farmers illegally directed irrigation water from the beneficiary area to their own fields. This was referred to as illegal irrigation. Photo. 1 illustrates one such method. In this example, water is siphoned from the canal to a new ditch dug by the farmer. From 1994, water distribution was carried out on the basis of the cultivated area within the beneficiary area to ensure an equitable supply of water to all farmers; this meant that there was less drained water. In 1996, the water shortage necessitated rotational water supply for 6 weeks. This completely cut off any drained discharge used by neighbouring farmers, which resulted in crop losses. Photo. 2 shows the conditions of fields neighbouring the MIS during the peak of the water shortage. The impact was so great that the area under cultivation dropped in 1997, and large areas of uncultivated paddy fields were observed adjacent to the MIS. The area cultivated in 1997 was also affected by a water shortage. To avoid drought damage to their crops, the affected farmers sometimes re-directed irrigation water illegally from the beneficiary area to their fields.

Photo. 1 Illegal irrigation

Photo. 2 The condition of fields adjacent to the MIS during the peak water shortage
The informal/illegal irrigation led to an increased demand for irrigation water. Initially, it is necessary to protect the legal water users from the illegal (or unauthorised) ones. In the next step, water resource assessment ought to be done to see if it can serve both the legal and illegal water users. If it cannot, then it will be necessary to carry out stricter enforcement or new water resource development, such as dam construction.

V. Conclusions

1. The aim of the water management improvement programme was to improve water distribution management and ensure an equitable supply of water to farmers. The objectives were achieved through a water distribution plan using selected water measuring facilities, namely Check Points Nos. 1 to 9.
2. This plan, which was based on meteorological and water balance data, was implemented from 1994 to 1998 by a restructured organisation in which all staff engaged in water distribution were consolidated under a single department and had clearly defined duties.
3. A nucleus was formed for farmer-managed on-farm water distribution by creating the informal post of Feeder Canal Leader.
4. The necessity of measures against informal/illega l irrigation was discussed.

References