The role of small irrigation schemes in Africa

by Geoff Pearce

Research from small irrigation schemes in Zimbabwe and Kenya has identified performance parameters which have resulted in the MIDAS design software package.

The question of how agricultural output in African countries can be increased has become more important as populations have grown and resources have dwindled. The recent series of droughts that has affected certain regions has focused the world's attention on short-term problems, such as crop failure and insufficient food reserves. The challenge facing planners is a long-term problem: how to match food supply with projected requirements. Irrigation is often promoted as a means of meeting these requirements, but it is not the only choice, and it can be inappropriate in many circum-stances. Any proposed irrigation development needs to be examined first against more conventional rain-fed agriculture. Since the further expansion of farming is becoming more difficult as suitable areas become harder to find — particularly around population centres — and as international funding for projects that involve the clearance of natural vegetation is less easily secured, the intensification of farming existing agricultural areas is a good, and for some countries the only, way to increase production. It is in this context that the need for irrigation has to be judged.

The availability of water in sub-Saharan Africa varies dramatically between the high-rainfall central tropical zone to the semi-arid zones to the north and south, and this divergence has increased as a result of recent climatic variations. Similarly the need for irrigation also varies from zone to zone, but some areas cannot be developed unless further water resources become available to them. Because of the difficulty and expense of collecting flow data in remote areas, some schemes can, and have, been based on flow records that cover too short a period to deal adequately with variability in flow volumes. As a result they are vulnerable to low flows that could not have been predicted from the records. In these circumstances just one crop failure is enough to put farmers into a difficult economic situation, limiting their ability to purchase sufficient inputs for subsequent crops.

A data-logger is installed to measure the water flow at a division box at the Mathina irrigation scheme in Kenya.

A flume is built to measure the flow in an unlined distribution channel in the Mutunyi irrigation scheme.

Although there is a large amount of land suitable for irrigation development in Africa, the water resources available are generally less than those in other regions of the world, and are very unevenly distributed.[1] The high evaporation rates in Africa cause further problems. In drought-prone regions, where irrigation could provide large benefits, the flows in the major rivers are very seasonal. Any benefits from irrigation are thus counterbalanced by the high cost of building barrages and dams to regulate the flow, and the risk of them having short life spans because of sedimentation problems. To illustrate the problem of uneven distribution, the Zaire basin has 55 per cent of the mean annual water discharge of sub-Saharan Africa, but covers only 10 per cent of the total area. It has plenty of water, but the farmers do not require widespread irrigation, since there is sufficient precipitation for them to practise rain-fed agriculture.[1]

To complete the comparison between irrigated and rain-fed agriculture, recent figures show that 45 per cent of Africa's land area is too dry for rain-fed crops, 8 per cent is too

variable, and 16 per cent is too wet. Only 30 per cent is climatically well-suited for rain-fed staple crops. The questions for planners are how much of the rest is both suitable for irrigation and has sufficient water with which to carry it out. There is evidence that the soils suitable for irrigation tend to be in rain-fed agriculture areas,[1] but current estimates indicate that between 30 and 140 million hectares could be developed for irrigation; this is from three to fifteen times the area currently irrigated.

Other limitations constraining the use of irrigation are the:

○ lack of capital;
○ lack of trained people;
○ inappropriate economic analysis for assessing viability;
○ high construction costs because of the lack of infrastructure (such as roads);
○ the need for expensive water storage structures;
○ the remoteness of suitable sites; and
○ inadequate data about sites and water sources.

None of these constraints are serious for small irrigation though.

Small irrigation schemes

In choosing to develop irrigation in any area, it is important to consider what type of irrigation is most suitable. The choices of whether the projects should be large or small, and whether it is better to rehabilitate existing schemes that are no longer fully functional or to create new ones, depend very critically on each specific situation. As pointed out by FAO Paper 42,[1] however, experience in Africa so far strongly supports the value of small-scale irrigation and the importance of rehabilitating older schemes.

Small-scale irrigation makes up about 33 per cent of Africa's present irrigated area. The remaining 67 per cent is large formal schemes, though almost half of this is the Nile irrigation systems in Egypt and Sudan. In other areas of Africa the performance of many large-scale schemes has been disappointing, largely because of cumbersome administration and high operation costs. The difficulties involved were not so much a function of scheme size, however, as a gap between the intentions of the designer and the aspirations of the farmers involved.

There has been a marked increase in interest in recent years in the alternative strategy, developing small-scale irrigation. These systems consist mainly of the use of traditional methods, such as simple river diversions, water lifting from *fadamas* (shallow groundwater, in Nigeria), and pumping from lakes. As far as investment in development is concerned, small schemes are much favoured by planners, and this development is supported by the self-help approach promoted by NGOs. The preference for small schemes has emerged because they are perceived to have a good record of success and sustainability, and because they can be adapted easily to suit local conditions. They also require relatively low capital investment and can be constructed in areas where the tracts of irrigable land and the amount of water available are small.

From a designer's point of view, there are constraints to the successful development of new formal small irrigation schemes. Information about the performance of small schemes is rare, as few small schemes have been monitored technically or have had their performance analysed. There is therefore little information from existing small schemes for irrigation designers to use in the planning of new schemes. Further, there has been a shortage of reference works specifically for the designer of a small irrigation scheme in Africa, someone who has to carry out, on his own, a wide range of activities which, on a larger scheme, would be performed by a multi-disciplinary team.

Recent work addressing these constraints has focused on assessing the performance of a number of small irrigation schemes in Zimbabwe and Kenya. This has included both physical and engineering assessments as well as socio-economic analysis. Another major focus has been the development of appropriate and practical computer-aided design procedures for use by design engineers in African irrigation departments. This work has been carried out by the Overseas Development Unit of HR Wallingford, with funding provided by the British Overseas Development Administration. All the work involved has been carried out with the full support and participation of the Zimbabwean Agritex Department and the Irrigation and Drainage Branch of the Kenyan Ministry of Agriculture. The following case studies describe some of the main points that have come out of the work.

Nyanyadzi, Eastern Highlands, Zimbabwe

Irrigation efficiencies below the night storage dam on this 414ha, run-of-river scheme were found to be 40 per cent, but varied from year-to-year and at different places within the scheme. Irrigation was by siphon, usually into border strips. Top-end farmers received twice as much water as those at the lower end, despite a formal system for distributing water that was established by the scheme's management. This created serious shortages at the bottom end of the scheme, which were very damaging for the farmers there. Most of the losses were related to water management practice at and below the field distribution channel, such as the tardy readjustment of the flow after a farmer had irrigated his field. If top-end farmers could reduce their losses, the savings passed on would enable bottom-end farmers to receive enough water for their needs. The run-of-river nature of the scheme has made it very vulnerable during times of water shortage to abstractions from the river by other irrigation schemes upstream. Another major constraint on performance was the very large seepage loss from the canal that came from the river offtake, but the costs of lining the canal and of rehabilitating its offtake structure would be an expensive undertaking.

Exchange, Midlands, Zimbabwe

Irrigation efficiencies on this remote, dam-backed, 165ha scheme appeared, in contrast, to be much higher. The use of siphon irrigation into furrows meant that farmers were necessarily very efficient irrigators, especially since their holdings were small and irrigation rotation was practised in a tight sequential rota that was, as far as the farmers were concerned, reliable. The socio-economic situation of the farmers reflected the difficulty of growing and selling cash crops in such a remote area. The holdings allocated to them were small, only 0.1ha, and were intended to provide support during dry years to farmers with larger dryland holdings elsewhere. Although water supplies were matching demand, and crop yields were generally very high, the scheme was beginning to have problems with rising water tables.

Gem Rai, Nyanza, Kenya

This small, rice scheme near Lake Victoria was found to be an efficient user of water, reflecting the fact that water flowed from field to field. The major problem faced by the local farmers was the need to carry out a major desilting of the scheme's channel network before the fields are prepared. The situation had recently got worse and is a result of soil erosion problems in the upper catchment of the small river supplying the scheme.

Kwa Chai, Machokos, Kenya

Irrigation using small basins, typical in Kenya, is practised on this small scheme which receives water from a nearby spring and grows vegetables

An example of a basin irrigation scheme, a type which is common in Kenya.

the Mushandike Irrigation Scheme. Detailed monitoring of both the snail population and the prevalence of the disease in the local human population have been carried out. The main measures used are structures and procedures that ensure that the irrigation blocks are completely drained and dried out on a regular basis, thereby denying the snails a consistent habitat.

MIDAS Design Aid Software

The MIDAS design package has been developed to help local irrigation departments in the design and development of small irrigation schemes. The package has been adapted for conditions in Zimbabwe and more recently in Kenya, where it is being used by government engineers.

MIDAS includes a digital ground model, DGM, designed by LM Technical, to process raw survey data and produce a contoured representation of the ground surface. The results are passed to AutoCAD, where alternative layouts are prepared, and detailed design processes are carried out using standard structures and simple rules derived from the field studies. This enables the consequences of alternative operation patterns on the system to be investigated, and is able to produce working drawings.

HR Wallingford's project has so far used in-depth research from two small schemes in Zimbabwe, and more recently from seven small schemes in Kenya, to identify scheme performance parameters. These results have been published in a series of reports[2,3,4] so that the information is widely available, and have been fed back into the MIDAS design software. The MIDAS design software package has been the main outcome of this work, and a design manual for conditions in Zimbabwe has been produced. ●

A furrow infiltration test being carried out at the Exchange irrigation scheme, Zimbabwe.

throughout the year. The scheme functioned relatively well at the top end, but the supply of water along the single distributary channel was insufficient to support the farmer's crops at the bottom end. Preparations are being made to provide more water to the lower area by means of a second channel.

Kamleza, Taveta, Kenya

This scheme was dependent on adjacent commercial schemes not to disrupt supply from the shared spring. Difficulties in distributing the water to farmers were caused by complicated field channel layouts. Water bailiffs helped to run a rota, but the scheme was hampered by a lack of resources, and was in need of rehabilitation. Other schemes close-by had experienced high water-tables, and although there was no evidence that this was about to happen, it was of concern to all farmers there.

New study areas

In May 1993 performance assessment studies were carried out at four irrigation schemes in Kenya's central province. These were at Mathina (small basin irrigation), Kangocho (small basins), Mutunyi (small basins), and Kiguru (piped distribution with sprinklers). These will be monitored for at least one year like the previous studies, with data being collected on water supply, water distribution within the scheme, and other physical factors, and also for socio-economic situation.

Schistosomiasis control study, Mushandike, Zimbabwe

The aim of this study has been to develop and test practical methods of controlling the transmission of the water-related disease schistosomiasis in smallholder irrigation schemes. Measures to inhibit aquatic snail populations, the vector for the disease, were designed and built into four parts of

References

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