

The Practice of Smallholder Irrigation

Case Studies from Zimbabwe



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Contradictions in standardization

The case of block irrigation in smallholder schemes in Zimbabwe

Emmanuel Manzungu¹

In many smallholder irrigation schemes in Zimbabwe poor water use is cited as one common problem. Water is reportedly lost during conveyance, distribution and application in the field. The causes of this problem are varied. Most of the losses are said to be at or below the field channel gate (Pearce and Armstrong, 1990: 18). Inequitable distribution of water between blocks, between head and tail users along canals and differential water distribution at field level have been documented (Pazvakavambwa, 1984a; Pearce and Armstrong, 1990; Donkor, 1991). Over-irrigating has also been cited as another problem, particularly in gravity schemes (Makadho, 1993). These studies, in various ways, have emphasized the need for solutions to be found to the water-management problem in smallholder irrigation.

Agritex, the government department with the mandate to develop smallholder irrigation in the country, alongside its extension service mandate, has taken steps to address poor water use. One strategy that has been employed is the block system of irrigation. This system is currently used in most 'new' schemes constructed after 1985, in those that are under rehabilitation as well as in other 'old' schemes that are being re-organized. There are perceived advantages associated with this system. These advantages, gleaned by the author from interviews and discussions with a number of Agritex engineers and extensionists, fall into three categories. The most frequently advanced reason is efficient water use through accurate irrigation scheduling. The second advantage which relates to economic aspects of crop production is that it is easier to market the crop produce. Thirdly, block irrigation is conceived as making crop rotations easier to implement which ultimately results in improved maintenance of soil fertility. A related advantage is the possibility of better pest and disease control.

Although the block irrigation bandwagon² is currently on the roll in smallholder irrigation in Zimbabwe, there is no consensus within Agritex about its merits. Some

engineers do not think it is worthwhile to have a system which concentrates only on water use without looking at the disposal of the crops. Block systems produce crops whose markets cannot be guaranteed because of oversupply of the same type of produce. Others take the view that the justification for block irrigation comes from an irrigation agronomy perspective which does not fit within the engineering domain. The debate is not only confined within Agritex though. Block irrigation is often resisted by farmers who seem not to see its advantages. Farmers tend to view it as an attempt to force them to grow crops or crop combinations which are not of their choice. In 'old' schemes where block irrigation is implemented and the re-organization of plots is necessary, block irrigation is seen by farmers as an official mechanism designed to dislodge them from their fields which they have so long tended. This chapter wishes to contribute to this debate.

Apart from revisiting the advantages, which for the most part are of a technical slant, the chapter wishes also to explore to what extent block irrigation is relevant to the reality faced by the ultimate users: first, the smallholder farmers with their diverse needs, and second, the scheme operators who have to implement it. The chapter goes beyond the 'technical' aspects and looks at the activities of the various people involved on opposite sides of the debate. The chapter will show that block irrigation, at a fundamental level, cannot just be understood in its technical terms because the technical advantages adduced for block irrigation mostly apply to technicians and not farmers. Rather, block irrigation should also be looked at from a socio-political dimension by analyzing whose perspective, of Agritex or the farmers, is dominant and why. These issues, that touch on 'technical' and 'social' aspects, will be analyzed in this paper by the notion of 'water control' as suggested by Bolding *et al.* (1995). As defined by Bolding *et al.*, the notion of water control incorporates three interrelated aspects; (a) the desired or planned technical control of water, (b) the managerial requirements necessary to effectuate the desired changes and (c) the socio-political aspects which deal with power aspects or domination. The argument advanced here is that block irrigation is an attempt by government officials to simplify multiple realities faced by different smallholder farmers operating in different circumstances. This simplification of the water-management problem, effected through the application of standard technical arguments, does not, however, result in the perceived advantages. Instead, contradictions become apparent. This is because other issues that are important and relevant to farmers, and to some extent operators, are not considered.

In the following section block irrigation is described and compared to the irrigation system that has been in place. Then, the four tenets of block irrigation, viz 'efficient' irrigation scheduling, 'better' pest and disease control, 'ease' of marketing and 'improved' soil fertility are examined. After the review of the tenets, the next section concentrates on the core principle of block irrigation, that is, irrigation scheduling. The section explores the theory and practice of block irrigation. In the development

of the argument examples are drawn from Agritex resource materials as well as from Fuve Panganai and Chibuwe irrigation schemes where the author has been conducting research since 1993. The subsequent section offers a discussion on the main features of block irrigation and its political implications, as every technology has a political code (Mollinga and Mooij, 1989). On the basis of the arguments presented the main conclusion of the chapter is, that the perceived advantages of block irrigation are a matter of conjecture and that, at a more fundamental level, block irrigation obstructs farmer participation in water management. It is observed that block irrigation, in a different conceptual outfit, may have a place in smallholder irrigation. Some recommendations are given.

A COMPARISON OF BLOCK AND CONVENTIONAL IRRIGATION

Field layout

Block irrigation was introduced primarily as a measure to use irrigation water more 'efficiently'. Its origin is Mushandike Irrigation Scheme in Masvingo Province, a scheme that was opened up for irrigation in 1985. The aim was to make irrigation scheduling possible (Chitsiko, 1995, pers. comm.). This block system involves growing one crop per block of land. A block in this case is an aggregation of many plots belonging to different farmers. These plots are treated as one big plot. Farmers in a particular block are supplied with water to irrigate 'one' crop that belongs to different farmers. Each farmer is allocated two or more plots in different blocks of the irrigation scheme. A typical landholding per farmer in 'new' schemes where block irrigation is practised is 1.0 to 1.5 ha. Depending on the number of plots a farmer is entitled to, and crops being grown per season, a farmer may have two or three crops growing in different blocks at the same time.

In 'old' schemes, herein referred to as conventional irrigation schemes, farmers have their plots in one stretch of land, which contrasts with block irrigation where farmers have part of their landholding in different sections of the scheme (see Figure 3.1 for an illustration). It should be noted that in block irrigation individual blocks are served by different supply canals.

An overview of water distribution in the two systems

The rationale of block irrigation is premised on 'accurate' irrigation scheduling. Irrigation scheduling is defined as 'determining when to irrigate and how much water to apply, or deciding when to start and when to stop an irrigation' (Martin *et al.*, 1990: 156). Quantitative irrigation scheduling methods are based on two approaches: (a) *soil and/or crop monitoring* and (b) *soil water-balance computations*. *Monitoring* methods involve measuring soil water content or matric potential at several places in the field to decide when to irrigate, while *soil water-balance computations* require estimates of soil storage capacity, rooting depth, allowable depletion and crop evapotranspiration to develop an irrigation schedule (*ibid.*). In

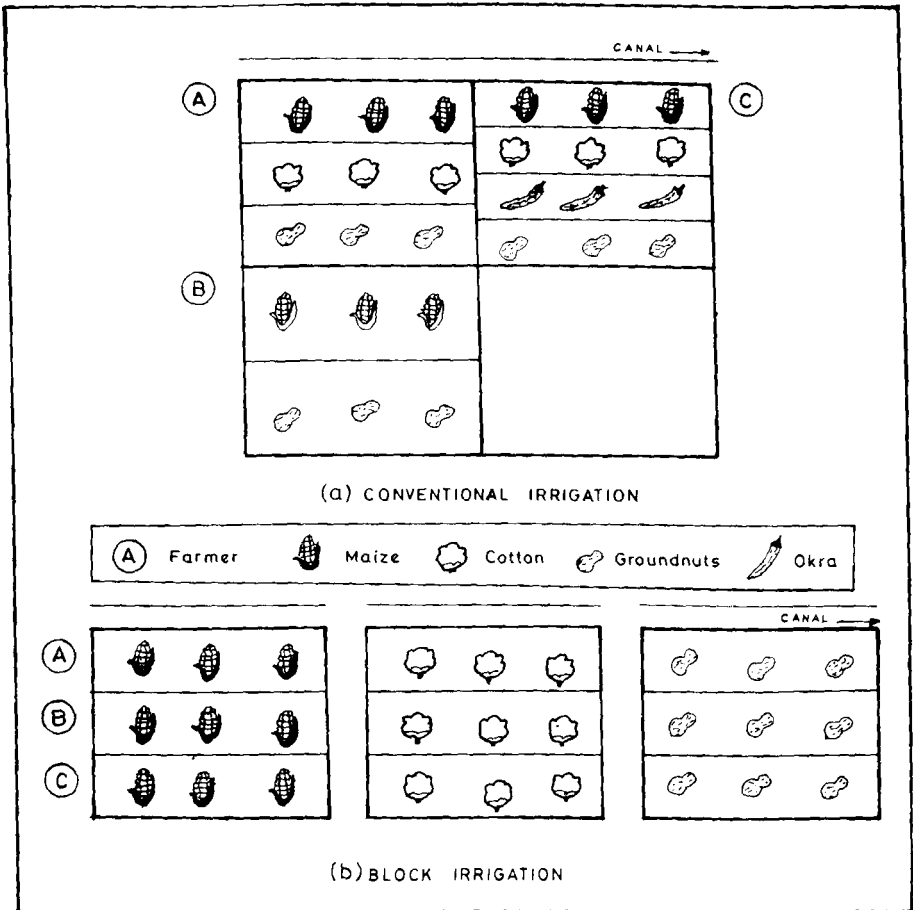


Figure 3.1: Field layout in conventional and block irrigation (schematic)

Zimbabwe irrigation scheduling is by and large according to the soil water-balance approach (see below). Water distribution, as it is conceptualized in block irrigation, can be described as *supply-oriented*, where the irrigation agency, Agritex, shares out water to farmers according to some parameters. The sharing of water which is ideally based on ensuring equity among all users may be adequate to satisfy crop water demand, or to meet what are commonly called *crop water-requirements* (CWR).³ In *on demand*⁴ systems farmers request irrigation water according to their felt needs and irrigate not necessarily according to theoretically determined crop water demands.

On the other hand, irrigation, as it is organized in conventional schemes, can be viewed as a flexible *supply-oriented* system. Water distribution here is a consequence of negotiations between farmers and operators, called water bailiffs, who within the Agritex hierarchy hold the lowest post of general hand. Farmers receive water allotments for their crops from water bailiffs and take turns to irrigate. Under this rotational system once a farmer has received water he/she can apply it to one, or two or three crops that are on his/her plot, since the farmer is not under strict obligation to grow one crop per plot. The crops grown may be in strips or may be intercropped. Intercropping is, however, actively discouraged by Agritex. When water is in short supply farmers are obliged by operators and other irrigators to closely stick to their turn so that each farmer has a chance to irrigate his/her crops. In a water abundant situation farmers are left to irrigate their crops as they wish. Two points can be identified in the conventional systems. Firstly, there is some degree of flexibility⁵ in organising irrigation depending on the circumstances. Secondly, as already hinted, there is a high level of consultation and negotiation at change-over time among the water bailiff, the present irrigator and the next in line. When the water bailiff is not there for some reason, water may pass from one farmer to the next, although this is officially not allowed. In those instances, the water bailiffs, aware of the need to maintain good social relations with farmers, prefer to turn a blind eye. These negotiations and interactions between the different actors make the conventional system a people-centred system which is based on social-technical⁶ considerations. An interesting question is: is water distribution based on social-technical considerations inferior to one where standard technical procedures are followed as in block irrigation? This question is pursued in subsequent sections.

THE FOUR TENETS OF BLOCK IRRIGATION

In this section a description of the four tenets which are cited in block irrigation and their underlying assumptions are given. These tenets relate to irrigation schedules, pest and disease control, soil fertility and crop markets. These are based on an overarching technical frame, which will be shown to fall short of the practical needs of farmers and the organizational requirements necessary for them to work. Because of the centrality of irrigation scheduling in block irrigation, this tenet is covered in greater detail in the next section.

1. Ease of marketing coordination

The economic rationale of bulk marketing

Smallholder irrigation schemes have been reported as being haunted by marketing problems. The problems have been diagnosed as a scarcity of business acumen, exemplified by a lack of forward planning, e.g. crops are usually grown before a market is identified. In order to find secure markets for produce, it is argued that

there is need for market coordination. Block irrigation then is seen as a way of rectifying the marketing dilemma, because planting at the same time helps synchronize harvesting which results in better market coordination. Synchronised harvesting makes it possible to implement bulk marketing of produce, which, among other things, uses resources more 'efficiently'. This is more relevant in negotiating contracts with canning factories and other bulk buyers.

Bulk marketing appears to have its origin in the type of training that agriculturalists on the schemes undergo. What is offered is large-scale commercial marketing, which is reflected in the standard Agritex crop budgets that are drawn up. These budgets tend to be an extrapolation from large-scale commercial farms and thus the experiences of the smallholder farmers are not taken into account (see below). Controlled marketing of most agricultural produce, which used to obtain in the country before 1990, seems to have left its mark on Agritex officials who still draw up crop budgets as if markets can be guaranteed.

The opposing view to bulk marketing

There is evidence that the economic rationale behind bulk marketing fails in the context of smallholder farmers. Smallholder irrigation schemes, where single crops are insisted upon, are known to overproduce one type of produce, thereby flooding the market (see IAP-WASAD, n.d.; Peacock, 1995). Besides, the market for block irrigation products are not guaranteed, so that prospective buyers may take advantage and offer low prices when there is a glut.

Local crop distribution networks are ignored in bulk marketing. These networks are, however, quite important as shown by Vijfhuizen (1995b), who concludes that agricultural produce in smallholder irrigation schemes are more than commodities. They are also part of social networks that guarantee personal relationships as well as labour. Nzima (1990) illustrated that when farmers grow different crops there is a lot of intra-scheme marketing which leads to bigger gross margins. This not only prevents waste of agricultural produce but substantially cuts down on transport costs. Madondo's observation (1993, personal communication) that farmers who grew 'forbidden' crops such as okra in Devure Irrigation Scheme made profit locally, and the fact that farmers in Chibuwe, particularly women farmers, insist on intercropping 'forbidden' vegetable crops among the main 'legal' crops, confirm that the economic rationale of the block system clashes with farmers' perceptions of what is economic.

Apart from crops disposed off the farm, the bulk marketing economic rationale misses one other important dimension. Diversity in crop production, among other things, ensures a greater variety of foods. Block irrigation, on the other hand, presupposes that smallholder irrigation is mostly about production of saleable surplus. While it is true that a proportion of the produce is sold to suffice the cash needs of the people, the food requirement should not be underplayed. During a field day on 6 October 1994 in Fuve Panganai, presentations by senior Agritex officials concentrated

on how much money could be made from a unit of land without any mention of food requirements (see Manzungu, 1995a). Farmers were told that they could make a lot of money from the 0.5 ha, assuming a crop yield of 6 tonnes per ha. The assumption was that each maize cob would sell at Z\$1. The price, however, eventually dropped to Z\$0.30 per cob as the farmers flooded the market with the same product.

From the food security perspective, the enforcement of block irrigation in the Fuve Panganai Irrigation Scheme resulted in maize (the staple food crop) deficit in many households, as every household was forced to grow 0.5 ha of maize. This did not take account of the number of people constituting the different households, which a feasibility report on the scheme reported to vary from 2 to 25, with an average of 9.3. The total available grain per capita using the optimistic yield estimate of 6 tonnes per ha, was therefore less than required for most families. In fact it was much less, since some of the maize was sold green. This was also worsened by the fact that farmers were required to quickly remove their winter maize crop so as to plant the next summer crop. Farmers in the end were forced to rely on the unpopular wheat *sadza* (a thickened porridge used as the staple carbohydrate source) or to purchase grain from rainfed farmers. What seemed to be the underlying problem here was that state officials conceived farmers as commercial farmers, whilst farmers were on a subsistence-commercial farming continuum (*ibid.*).

Besides the loss of freedom to choose which crops to grow, block irrigation reduces the number of crops grown per annum. In block irrigation, crop choice is usually limited to a maximum of three, as it is unlikely that farmers can have more than three plots allocated to them, while in conventional irrigation more crops can be grown. Because of the preoccupation with market-oriented crops, which tend to be grown in block irrigation, women farmers suffer as they are sometimes not allowed crops of their choice for example, in Fuve Panganai they were denied the growing of vegetables (see Manzungu, 1995a).

2. Ease of implementing crop rotations

Block irrigation is also legitimised on the basis of better crop rotations. Claims of improvement in soil fertility are predicated upon harnessing the complementary characteristics of the crops being grown. Shallow-rooted crops can be alternated with deep-rooted crops because the different crops abstract nutrients at different levels and this allows nutrient uptake from the soil to be balanced. Similarly crops that require different types of nutrients, such as legumes and non-leguminous crops, such as maize, are rotated. That a well-maintained soil results in good yields and increased agricultural productivity is the obvious premise (see Savva *et al.*, 1994).

However, the standard arguments for crop rotations seem to be an 'add on' argument because rotation is not exclusive to block irrigation as farmers can practise rotation on sections of their plots. Moreover, classical rotation methods, such as those that add nitrogen through the inclusion of a legume, or those that add organic matter to

the soil, are generally uneconomic. Therefore, instead of relying on crop rotations for soil fertility improvement, inorganic fertilizers are used particularly in irrigation. Besides, farmers pressed with the need to keep planting dates, generally burn crop residues or ferry them to their homes and by so doing defeat the grand idea of crop residue incorporation into the soil.

3. Easy and effective pest and disease control

Pest and disease control also features as another main advantage of block irrigation. Sole cropping, defined as growing one crop variety in pure stands at normal density (Andrews and Kassam, 1976), which is practised in the individual blocks in block irrigation, is claimed to cause easier and more effective pest and disease control.

These 'advantages' are based on the following claims:

- spraying is easily done on a block basis as there is just one crop and this enhances the chances of synchronised spraying which prevents the likelihood of re-infection of crops from the other crops that have not been sprayed;
- pests and vectors of diseases cannot hide away in the other crops that have not been sprayed, as alternative hosts of these insect pests are no longer in the vicinity of the sprayed crop(s);
 - in the case of those pests that can be controlled by practising rotations, for example, nematodes, the block system allows susceptible crops to be rotated with resistant ones.

The cited advantages are however valid only if the following assumptions apply:

- All farmers in a block behave 'responsibly' and spray when due.⁷ This also implies that planting was done at the same time, otherwise coordination of spraying is not possible because different types of pests and diseases attack crops at different times of the crop growth stage, for example, American bollworms in tomatoes are fruit pests and are therefore important during fruiting, while early on in the life of the crop, early and late blight, which are foliar diseases, are important.
- All farmers in a block (as many as 50 sometimes) can be coordinated to do everything together at the same time.
- The crops grown to control nematodes and other pests are of economic and social interest to farmers. If farmers are not interested in growing the crops in question they may simply ignore the advice, or if they cannot do so they may pay inadequate attention to the crop(s).

Just as in irrigation scheduling and bulk marketing, there are a number of unresolved conceptual and practical problems posed by block irrigation with regards to pest and disease control. First, on the practical side, as already stated, the assumption that farmers will plant at the same time, spray at the same time and somehow behave as if they are one, is optimistic. As one farmer in Fuve Panganai (where block irrigation is in place) put it:

The problem is that if you tell your neighbour to spray when you spray so that your crops are not re-infected, he or she does not necessarily co-operate. You are normally told that they have no chemicals. They then ask you for the chemical. In the end you simply have to continuously spray because there is nothing you can do.

Co-operation among farmers with regards to effectively controlling pests does not rest on the fact that there is block irrigation but from a willingness of farmers to co-operate.

Secondly synchronised spraying against pests is only technically expedient when the pest regime is the same throughout the whole block, that is, when the 'economic thresholds' have been reached, otherwise spraying on a block basis is 'non-technical' in that some farmers will spray before the recommended pest levels have been achieved. There are, however, no 'economic thresholds' worked for crops such as tomato, cabbage and rape. Even on cotton where economic thresholds have been established, spraying on the basis of egg counts seems far too cumbersome to the smallholder farmer, who is unlikely to have the willpower or the time to do it as is recommended.

Lastly, there are theoretical inconsistencies. Pests are known to thrive in monoculture environments. It is also known that mixed cropping or intercropping tends to reduce pest and disease incidence. This is due to the slower pest multiplication rate and the increased horizontal resistance that results from the greater ecological diversity (Page and Page, 1991; Litsinger and Moody, 1976). Seen in this light a block system may enhance pests in the individual blocks.

4. Efficient use of water

The block system is seen as a means to improve water-use efficiency in smallholder irrigation. This is supposed to be realized on the basis of the application of scientific principles of water distribution in particular, and to water management in general. The next section provides an examination of how the scientific approach addresses the water-management problem.

THEORY AND PRACTICE IN IRRIGATION SCHEDULING

State-of-the-art procedures

Irrigation scheduling, based on scientific principles incorporating soil, plant and weather data, is associated with accuracy in water application. The 'one crop per block' scenario is seen as making it possible to factor the three basic elements in irrigation scheduling namely, meteorological, soil and crop data (see Doorenbos and Pruitt, 1977; and Doorenbos and Kassam, 1979 among others). The amount of water used up by the crop and which has to be replaced to the soil, also known as the consumptive water use (ET_{crop}), is estimated by factoring evaporation (E_o) and crop factors (kc). The quantity of water is estimated by the simplified formula;

$$ET_{crop} = kc \times E_o$$

According to Savva *et al.* (1994: 774), in a FAO-produced document meant for a Zimbabwean audience, this type of irrigation scheduling can be done in two ways. Firstly, it can be done by using estimated values of Et_{crop} based on the climatic data of previous years. The authors find this method useful but consider it inadequate for 'accurate' scheduling:

While for planning and designing purposes and where other means are not available, this is sufficient, for more **accurate scheduling**, the use of class 'A' pan and/or tensiometer is recommended . . . the Et_{crop} values obtained from (the) calculations are the mean values of the past. However, in reality, the ET_{crop} within a 10- or 30-day period varies. This is why the use of evaporation pans and/or tensiometer provide better means of irrigation scheduling (emphasis added).

A number of conditions are necessary for 'accurate' scheduling to be realized. Relevant (for the different irrigation systems) efficiencies of delivery/conveyance to the field and application of the water in the field are important and need to be known.

Apart from the amount of water to be applied, the timing of irrigation or when irrigation water is to be applied has also to be determined. The timing is a function of the evapotranspiration that is allowed to accumulate before the permanent *wilting point* (WP)⁸ is reached. The objective of irrigation scheduling is to find the 'optimum' point to irrigate. This 'optimum' point also takes account of the allowable moisture depletion of the available soil moisture, which on the average is 50 per cent of field capacity⁹ for most crops but is lower for vegetable crops.

Soil type also influences irrigation scheduling. Sandy soils lose water much faster than clay soils and hence reach WP faster, while in clay soils moisture is held more tightly than in sandy soils. The rate of moisture depletion to the permanent WP is also affected by evapotranspiration that is occurring; high evapotranspiration results in rapid acceleration towards WP. When evapotranspiration figures are accumulated and accordingly weighted with the appropriate crop factors (four crop factors, based on the growth cycle of an annual crop, which are found in standard texts on irrigation scheduling are normally used), the evaporation deficit is obtained. When a targeted deficit is reached the timing of the next irrigation is then arrived at. A typical 'accurate' irrigation schedule is shown in Table 3.1 (refer to Savva *et al.*, 1994, for a stage by stage calculation).¹⁰

There have been numerous efforts in Zimbabwe to develop irrigation schedules such as the one in Table 3.1 for various crops. Meterlekamp (1968) gave a general state-of-the art treatise of irrigation scheduling based on the class 'A' evaporation pan method. He described this method as 'a reliable technique for use as an aid to irrigation scheduling'. There have also been a number of irrigation schedules developed for individual crops, for example, wheat (Watermeyer, 1966, 1971 and

Table 3.1: A Bean Crop Irrigation Schedule

Decade ^a	$E_{t\text{crop}}$ (mm/day)	Rootzone (m)	RAM ^b (mm)	Interval (days)	GIR ^c (mm)	Change ^d (%)
01–10/04	2.00	0.15	7.5	4	10.7	—
11–20/04	1.92	0.21	10.5	5	12.8	+20
21–30/04	2.20	0.27	13.5	6	17.6	+38
01–10/05	2.80	0.33	16.5	6	22.4	+27
11–20/05	3.13	0.40	20.0	6	25.0	+12
21–30/05	3.17	0.40	20.0	6	25.4	+2
01–10/06	3.03	0.40	20.0	7	25.4	0
11–20/06	2.87	0.40	20.0	7	28.3	+11
21–30/06	2.90	0.40	20.0	7	26.8	-5
01–10/07	2.93	0.40	20.0	7	27.1	+1
11–20/07	2.95	0.40	20.0	7	27.5	+1
21–25/07	3.15	0.40	20.0	6	25.2	-8

^a Decade is a period of ten days over which data are calculated. The period is a standard one in irrigation.

^b RAM refers to the readily available soil moisture content that is determined by considering the water holding capacity of the soil, the rooting depth of the crop (root zone) and the allowable moisture depletion, which is usually 50 per cent as already pointed out.

^c GIR refers to the gross amount of irrigation supplied to the crop that incorporates irrigation efficiencies.

^d Change refers to the percentage increase or decrease of water applied compared to the previous irrigation.

Source: Adapted from Savva *et al.*, 1994

1972; McGugan, 1972), tomatoes and peas (Buchanan, 1972), onions (Laver, 1972), coffee (Morkel, 1972) and deciduous fruits (Cormack, 1972). After independence FAO-sponsored documents tailor-made for Zimbabwe such as Savva *et al.* (1991, 1994) were produced. All these schedules take their cue from large-scale commercial farms. This is because of the colonial history of the country where that sector received priority in research while the smallholder sector was ignored. Paradoxically, however, Tembo and Senzanje (1988) reported that irrigation scheduling in large-scale commercial wheat production was not properly executed. 'Improper scheduling' was surmised to persist because:

- water was too inexpensive for farmers to worry about conserving it;
- pumping and energy costs were low;
- farmers lacked the know-how to implement scientific scheduling;

- farmers did not want to be bothered with a management practice that appeared academic;
- there had been inadequate research carried out (in Zimbabwe) to show farmers the benefits of improved water management; and
- the marginal benefits from improved scheduling appeared minimal and were not obvious, compared to the extra effort required. \mathcal{V}

The practical demands¹¹ of the computations of irrigation scheduling seem to be a common problem to all categories of farmers. In fact practical schedules that are utilised on many commercial farms are akin to the (less accurate) first method described by Savva *et al.* (1994). On the same point it can be asked whether these farmer-crafted practical irrigation schedules are devoid of a 'theoretical' base, as every observation is theory laden (Feyerabend, 1975, cited by Leeuwis, 1993). This point will be pursued later on.

Assumptions of irrigation scheduling

The advantages of irrigation scheduling depend on a number of implicit operational and organizational assumptions. These are:

- All farmers who share the same irrigation turn plant their crops on the same day or close to that. This allows the irrigation water requirements to be 'accurately' determined, otherwise variations in crop factors, because of the different crop growth stages, can render 'accurate' determination of irrigation water requirements impossible.
- To be able to factor meteorological data there is in place a device of estimating evaporation, a US class A pan or a similar device. There is then a need to have a skilled person on site who has to take the daily evaporation readings, compute them into evaporation deficits and then inform the relevant farmers when to come and irrigate and how much to irrigate. A mechanism of monitoring the irrigation practice so that farmers stick to their turns in the various blocks is also necessary.
- The computed irrigation water requirements are successfully related to how the physical-technical infrastructure is operated for example, how the intake, the pump, water control structures such as gates are operated to take account of the variable water supply to cater for the different crop stages. There is also a need to link the computed irrigation water requirements to the number of siphons (if present) in surface schemes. In overhead systems, details like how long to keep sprinklers in one place, where sprinklers are rotated, need working out.
- Farmers' fields have uniform soils in terms of depth, texture, available water holding capacity so as to make the planned irrigation duration in practice worthwhile.
- Water is not limited in the scheme so that crop productivity per unit area is the ideal parameter.

The practical reality

After dwelling on the mechanics of irrigation scheduling it is now time to turn to the organizational or managerial requirements of irrigation scheduling. The main points are tackled in turn.

Equipment and human resources

Savva *et al.* (1994: 774) underline the importance of equipment and human resources in implementing irrigation scheduling:

It requires proper recording and some management skills since the timing of the different irrigations will depend on the day-to-day variability of the climatic factors.

In practice, however, the opposite seems to be the case. There are very few (less than one per cent) smallholder irrigation schemes in the country where class 'A' pans are in place. Secondly, the personnel to manage the type of irrigation scheduling as required by block irrigation is non-existent. For example, Agritex personnel in the schemes have little idea of the actual water flows in the primary, secondary and tertiary canals (see Makadho, 1994). Pump capacities are also not known, nor are siphon discharges.¹² Block irrigation, supposedly based on 'solid' figures, does not in fact have those figures.¹³

On accuracy

Accurate irrigation scheduling is relative. According to some studies the pan method and the Penman formula, which are used in computation of CWR and irrigation schedules in one form or another in the country, in some cases are not correlated (Koen and Watson, 1987; Butlig and Makadho, n.d). This is significant given that irrigation scheduling in the country is based on the class 'A' pan method. A study in Zimbabwe reported that the modified Penman and the Penman-Monteith methods of estimating maize crop water-requirements differed to the tune of 30 per cent (IAP-WASAD, n.d.: 32). Concern has also been raised about the lack of local (Zimbabwean) soil and crop data for inputting into irrigation scheduling. When these 'accurate' data are used in smallholder schemes, where water use efficiencies in most cases are no higher than 50 per cent in surface schemes (Pearce and Armstrong, 1990), the rigid adherence to that 'accurate' data in the end pays little dividends. Furthermore, the mostly small differences in irrigation amounts to be applied for the greater part of the irrigation schedule (see Table 3.1) mean the differences are of no, or little, practical irrigation consequence. These differences mean that to strive for accurate irrigation scheduling is not only tedious but may be impossible to achieve because the existing irrigation systems are not sensitive to small changes. Viewed in this light, crop water-requirements determination and the subsequent irrigation schedules

are superfluous.

There is yet another problem. Block irrigation is supposedly executed according to actual depletion of soil moisture while conventional irrigation can be thought of as based on average expected depletion. Savva *et al.* (1994: 772) conclude, after reviewing a number of studies, that the concept of depletion and estimation of root depth are areas of 'interesting controversies' and go on to recommend that one should not strive to irrigate according to actual depletion. A contrasting view is expressed by Nyamugafata (1993: 4) who believes that irrigation should be according to actual rooting depth and that farmers should occasionally do a random assessment of actual rooting depth to see whether it matches the one used in the design.

In conclusion, the desire for 'accurate' irrigation scheduling which has been demonstrated to be full of conditionalities, has resulted in a water management system that is inflexible and unsuitable to farmers. This is because it leaves very little room for negotiations over water, as irrigation is deemed to be based on what are taken to be almost infallible physical laws. Such uncritical use of engineering concepts such as efficiency that are applied without much notice of the circumstances (Vincent, 1980) brings up difficulties. In most cases flexibility of operation which is considered important in keeping harmony among irrigators is totally neglected (Mahdi, 1986; Vincent, 1994).

Managerial requirements

The phenomenon of a variable water supply, which is a consequence of 'scientific' irrigation scheduling, poses practical problems. Frequent changes in the quantity of water to be delivered in the canals in the case of surface schemes, or pushed through pipes in the case of overhead systems, in relation to crop growth pose management challenges. A continuously variable water supply over the growing season is a problem to both farmers and operators alike. The water bailiff has to deal with the variable flows which in practice means that he has to operate, for example, the sluice gates differently in surface schemes. In the absence of any guideline on how to use these gates to deliver the desired irrigation quantity of water (Manzungu, 1995b) the task becomes difficult. The pump operator also has to contend with these changes. In the event of a single capacity pump being in place it is impossible to adjust the pump to the calculated variations in water demand. Other factors that nullify this 'metering' of water are, for example, differences in evenness, levelness and compaction of the soil in different fields.

A related problem is the changing intervals of irrigation. When accumulated evaporation deficits are used, the timing of irrigation depends, to a large extent, on the weather. From the farmers' perspective irrigation becomes less predictable. This means that when irrigation is due farmers have to be coordinated, which is not easy considering that farmers are involved in other activities, including non-farm ones. How a farmer can meaningfully plan for an irrigation, the basis of which depends on

varying evaporation figures, remains to be answered. ⊙

On recognising the impractical nature of accurate irrigation scheduling Savva *et al.* (1994: 784) advise that:

Once the irrigation schedule is known, simplifications can be introduced in order to make the schedule practical and 'user friendly' for the farmers, for example, irrigation intervals and irrigation duration can be made uniform throughout over a period of a 14-day cycle or a month. This is particularly important in group irrigation schemes where a number of farmers are involved, living at some distance from the scheme. If they knew the irrigation schedule for the next month, they are in a better position to organize their work, household tasks and family life accordingly.

Land or water-based productivity?

Irrigation scheduling basically is premised on maximization of yield per unit land area rather than maximization of yield per unit of water. In smallholder irrigation, where water is in short supply, this can be considered a contradiction. Irrigation intervals of more than 30 days have been reported (see Bolding in this volume). In circumstances of scarce water supplies, a maximization of the water resource, which can be achieved through deficit irrigation and irrigation at critical crop growth stages, is most appropriate (see Tembo and Senzanje, 1988; English and Stoutjesdijk, 1995). In such cases yield per unit of water is the useful parameter.

Technology

The issue of technology is one other relevant factor. Overhead systems may not have the problem of gate operation, for example, but the issue of calculated hours of irrigation may still not correspond to the different field conditions. In overhead systems where the draghose system is in place, which allows farmers to operate independent of other farmers, there is a likelihood that farmers may not want to be restricted to schedules and instead may prefer an *on demand* system of irrigation. This happened in Fuve Panganai Irrigation Scheme, where farmers took advantage of the low pressure buried pipe technology to take water when they wanted, thereby rendering unattainable the advantage of using water 'efficiently' due to irrigation scheduling (Manzungu, 1995b).

Attempts at block irrigation

As a corollary to the preceding subsection on the problems of irrigation scheduling, an example is presented. The example is from Chibuwe Irrigation Scheme. Blocks C, D and E were earmarked for rehabilitation in 1994. This meant the old earth furrows were to be replaced by concrete-lined canals. Instead of just diverting the flow to the plot by a shovel, siphons were to be introduced. Through the adoption of

these measures water was going to be saved, and leakages, seepage and deep percolation were going to be reduced. The rehabilitation work was carried out in phases. The first phase was on an area of 20 ha in block C that was identified as C1. After the canals were put in place irrigation was then ready in the summer of 1994.

In the same season it was decided to implement block irrigation. The irrigation supervisor was of the mind that it was easy to enforce block irrigation in the rehabilitated blocks before its implementation in blocks A and B, where concrete canals were in place. It appeared that the irrigation supervisor, who is the manager of the scheme, had convinced the irrigation officer, his superior who is not involved in the day-to-day running of the scheme, that he needed block irrigation in his scheme.¹⁴ Neither the irrigation supervisor nor the irrigation officer had any experience with block irrigation, what they had heard through colleagues had apparently convinced them of its merits. Block irrigation was embraced because of its ring of 'scientific' irrigation scheduling. As a result farmers were not necessarily issued with their original plots although this was possible.

The irrigation supervisor, as the implementor, did not want to tell the farmers before the actual date of hand-over as that would "embroil everything in controversy". Even the Irrigation Management Committee was not informed. When the matter was finally put before the farmers there was widespread opposition. Farmers complained that they were not prepared to swap their plots with some individuals who did not take good care of their plots. In a scheme where cultivation started in 1940, the complaints appeared genuine enough given the long time span that could have resulted in changes in soil conditions due to poor or good management. Appeals were made to the Irrigation Management Committee, which supported the farmers, but to no avail. However, the fact that only 20 farmers were involved made it possible for the irrigation supervisor to overrule them. Reluctantly, the farmers then accepted the new arrangement.

There were a number of problems encountered in the bid to establish block irrigation. The first was the number of crops to be grown and their spatial arrangement. Since the rehabilitated section was served by three supply canals, farmers were allocated two plots each along the supply canals as it was not practically possible to split the landholding further. Each area served by a supply canal was earmarked for a specific crop. Thus there was what could be called the maize, cotton and groundnuts supply canal. Since farmers wanted to grow three crops, a problem arose, as any one farmer could only grow a maximum of two crops. Under the conventional system, on the other hand, farmers used to sub-divide their plots and grow all three crops and even more!

There was also a problem related to the actual distribution of water. A number of deficiencies became apparent in a bid to operationalize water distribution. The amount of water down the supply canals and how it was to be released via operation of the gates was not spelt out. Secondly, the supply canals had 'on and off' gates which

were not operated as such because in the full open position these would release too much water. Without the necessary guidelines a number of intermediate positions were tried by the water bailiff together with farmers so as to 'meter' the right amount of water down the canal. This method involved placing a foot against the direction of flow of water and when the water level rose to the ankle that flow was deemed sufficient for one farmer whose field was near the gate. For farmers further on, the level of the water was allowed to rise a little above the ankle. This was in contrast to block A where there were sluice gates with notches/holes where water was shared out on the basis of a number of holes or notches.

The siphon discharge was not known either. Together with the irrigation officer, the irrigation supervisor organized for that measurement to be made. Some preliminary calculations were done and passed to the irrigation officer for guidance. That was the end of the matter.

The irrigation supervisor also realized that he had to determine the time it took for the water to travel to the end of the field. An exercise was started but later abandoned because fields were not level to the same degree. Lastly, the absence of an evaporation pan in the scheme resulted in another hurdle to be overcome. Faced with these block irrigation-inspired problems and challenges, and unsupported by technical staff, the irrigation supervisor became an ex-enthusiast of block irrigation. The irrigation supervisor and the irrigation officer discovered that block irrigation involved much more than implementing crop zoning. As the supervisor shyly admitted afterwards, block irrigation was suspended because of that.

DISCUSSION AND CONCLUSION

After a presentation of the main features of block irrigation this section aims to complete the story by offering some theoretical insights. This is necessary so as to have a unifying framework for what appears to be disparate human activities. It is hoped that a theoretical explanation will assist in coming to grips with the substantive issues in block irrigation. Arguing for theoretical treatment of empirical material, Byres (1995: 3) noted that:

Our treatment needs to be structured by theory. We are not in pursuit of unmediated empirical diversity. . . . One may finish with a fractured vision, a loss of perspective and a preoccupation with the ephemeral, the fashionable and the irrelevant.

Three key areas are chosen here for analysis. The first deals with the phenomenon of exclusion by inclusion, whereby the scientific frame (a) confines farmers' views and experiences to the rubric of the 'social', and in so doing relegates their views and experiences to the 'social', while the 'technical' is regarded as superior; and (b) treats diversity as abnormal in need of (technical) regulation or standardization. The next related issue is (c) the validity claims of science in block irrigation or agriculture

in general. To summarize the argument, the socio-political dimension is used to show that at the base of block irrigation are power relations between the state (represented by Agritex) on one hand and farmers on the other.

Unidirectional solutions for multidirectional problems

Block irrigation represents in many ways an attempt to bring smallholder farming within the fold of the scientific paradigm. Whether we are talking about irrigation scheduling, soil fertility, pest and disease control or marketing, standard technical methods or procedures are used by state officials. The application of these scientific procedures are thought to result in the improvement of all water management and other aspects. However, as demonstrated in the preceding sections, this is not always the case. Instead, inconsistencies and sometimes contradictions in the scientific/technical procedures are common. Even where the technical content was not at fault, there were problems in relation to the organizational requirements necessary to realize the technical aspirations of block irrigation. Furthermore, the fruitfulness and relevance of the technical legitimation *vis-a-vis* the reality of farmers' requirements is doubtful, as the technical procedures yielded less benefits to farmers. For example, the economic rationale of bulk marketing was sometimes clearly out of touch with reality and became a threat to farm viability and farmer livelihoods, as demonstrated by projections of green mealybugs in Fuvu Panganai. Nzima's (1990) work also illustrated the same point. The problem, it seems, lies in the assumptions upon which the projections or models are founded. The assumptions, deriving from a standardization of all farming operations in the scheme, simplified reality (through the overarching technical frame that simplifies physical, technical and social diversity). Farmers' experiences were not used as they were either not known or it was not known how they could be incorporated in the scientific models.

Validity claims

In block irrigation, the scientific paradigm is posited as the only legitimate perspective to the debate by officials. As noted above, farmers' experiences are ignored. The validation of that position, we have seen, is through symbolic power play, by alluding to 'scientific' arguments which further erode farmers' perspectives. Thus crop budgets, irrigation schedules, and economic thresholds are used to maintain the hegemony of Western science over traditional agriculture, for example, intercropping (see Page and Page, 1991 for a more exhaustive discussion). In other words, there is no chance given to a world view of farming other than the scientific one. However, Page and Page have demonstrated the scientific basis of what has been termed traditional farming practices in pre-colonial Zimbabwe. The crux of the matter is: is farmers' technical knowledge, which has been termed local knowledge or indigenous technical knowledge a credible knowledge system? If so, does it have a place in the scientific paradigm? Watson-Verran and Turnbull (1995) have argued that there are many similarities between scientific knowledge and indigenous knowledge systems.

While there is no denying the contribution of scientific knowledge to agriculture, there is a danger of not realising what that contribution should be. As has been demonstrated, instead of offering guidelines, scientific knowledge can easily become a dogma. The result of such a preoccupation with technical standards and arguments, may be a failure to appreciate diversity in farming, and to consider it as abnormal. Thus confronted with plots of different farmers without the same soil conditions, scientific dogma would rather pretend that all plots are the same and should be treated the same. From the evidence presented we can certainly see too much rigidity in the way block irrigation is being implemented. This explains why quite logical actions by farmers are marginalised. However, there is now a worldwide recognition that experiential knowledge, which may as yet have no scientific explanation, is just as valid.

Block irrigation may also be viewed as a strategy to simplify tasks for the government officials. This point can be made with regards to the validity claims of block irrigation. Contrary to Agritex's stated policy of only promoting proven technology, block irrigation represents a negation of that stance because it cannot be said to have been 'proven'. At the end of the day block irrigation is about crop zoning, which can easily be implemented because it can be 'designed' even by extensionists. The issue of proven technology raises the question of what 'proven' means. In my understanding, 'proven' is a relative term: it depends on the present stock of knowledge (which is ever-changing) and on the ability and capacity of the people involved.

There is evidence, even within the engineering field, that farmers should be taken as capable people in water distribution. For example, Shanan (1992: 171, cf. Horst, 1983), for long a World Bank expert on irrigation, suggests to:

provide a reliable division of the water and let the farmer use his skills and enterprise in the full exploitation of a known predictable resource, than to attempt to regulate the resource to an individual farmer's demand.

He further comments that a rotation system with fixed flows minimises the number of gates to be operated and thus simplifies management (*ibid.*: 150). As we have seen, this situation prevails in conventional irrigation where farmers receive nearly a constant flow. After receiving the constant flow, farmers cognitively take account of a number of factors, such as the age of the crops, by shortening or lengthening the time of irrigation. The fact that farmers interact with other farmers and the water bailiff means that there are mechanisms to guard against excesses that might happen.

Disguised power relations

The foregoing observation that farmers' perspectives are downgraded brings us to the power issue between farmers and the state. In other words, the objective of state officials when they enforce block irrigation becomes an issue.

As a beginning to this question one would start with the observation that any technology has a political code (Mollinga and Mooij, 1989). Thus the block irrigation debate (if it can be called as such) is not just a technical debate but a power or political one as well in that the outcome of the debate does not depend on rational arguments. State officials can continue enforcing block irrigation, not because they have won the argument, but simply because they have the power that their institution confers upon them. In other words, the technical arguments that are propounded cannot be separated from the socio-political realm. It is obvious that if farmers had more clout in the schemes, for example, through the Irrigation Management Committee, block irrigation would be in a different state. In a similar vein, Rukuni (1995b) has observed that there is a disenfranchisement of the smallholder irrigation farmer, in much the same context as would apply to broader issues of development. According to him, there is a lack of love, respect and understanding of rural society and institutions by bureaucrats and technocrats, in preference to technical and bureaucratic subject matter.

This observation has implications on the issue of farmer participation in irrigation schemes. Handing over schemes to farmers and other forms of farmer participation¹⁵ has been the talk for a number of years (see Derude, 1983; IAP-WASAD, n.d., Zimbabwe, 1994) This was considered desirable because it was thought that farmers would identify more with the scheme as their own. A secondary reason was shifting the operation and maintenance burden to farmers. The question becomes: In what areas are farmers allowed to participate? Can they participate in technical issues? And if not, for what reason?

RECOMMENDATIONS

In conclusion, it can be said that the advantages of block irrigation are a matter of conjecture, for the reasons discussed above. However, block irrigation, in a new conceptual outfit, may have a place in smallholder irrigation. This may include, for example, having garden areas where vegetables can be grown, which are not often adequately catered for in smallholder irrigation schemes. Since vegetables require more frequent irrigations it makes sense for this to be considered in designing. Where soils vary considerably in the scheme, block irrigation can ensure that some farmers are not confined to poor soils. Where water is a problem, block irrigation may be used to create 'wet' blocks where each farmer can have a plot and is assured of having a successful crop even in a water-scarce situation. Every farmer can also share the risk in the 'dry' blocks. When block irrigation is conceptualised this way, without the element of crop restriction, and farmers' interests are at the centre, it has a chance of succeeding.

NOTES

1. I would like to thank Dr Dayo Ogunmokun of University of Zimbabwe, Professor Linden Vincent of Wageningen Agricultural University and authors of the other chapters in this book for their useful comments on this paper.
2. The term is used here to denote the fact that block irrigation represents, to some extent, a fashionable preoccupation in smallholder irrigation in Zimbabwe. Quite frequently such irrigation 'fashions' are taken up and implemented without much analysis, as this paper hopes to illustrate.
3. Crop water requirement represent the amount of water which must be applied to the soil to replace that lost to *evapotranspiration*, a combined term for water loss as a result of evaporation and transpiration.
4. There are different classifications as regards water delivery to the farm. For more elaborations see, for example, Horst (1983: 28-33), Clemmens (1987) and Ankum (1992: 245-254). Ankum, however, sees such classifications based on supply and *on demand* notations as inadequate when applied to the main system supply level.
5. The notion of flexibility in irrigation is ill-defined (see van der Zaag, 1993). In the context of this paper it is used to refer to a situation where farmers have the possibility and ability of having a say in the way the water is shared out or distributed.
6. By socio-technical I refer to the fact that there is an attempt by farmers and water bailiffs to reconcile social and technical factors (although the technical are not labelled as such), while block irrigation is premised only on technical aspects. As will be shown later, the *Agritex/FAO Irrigation Manual*, prepared for Agritex engineers who exclusively work in smallholder irrigation, recognises the fact that irrigation schedules should take account of farmers' circumstances. However, this realization is a mere anecdote to the technical discourse which the Manual espouses.
7. In some cases the timing of spraying is not easy to implement because the method of determining spraying levels is based on insect egg counts, which represents a formidable task for smallholder farmers to undertake. Linked to this problem is whether the timing should be based on pest levels on one farmer's field or over the entire block, and by whom?
8. Wilting point is the soil water content at which plants can no longer get enough water to meet transpiration and it is generally determined at a soil water potential of -1.5 mPa.
9. Field capacity is defined as the soil water content at which drainage becomes negligible.
10. The last column is not in the original table; it was inserted as an illustration for a later point.
11. One large-scale commercial farmer who was not convinced about the need for 'scientific' irrigation scheduling told me that he timed his irrigation when the dust began to rise behind his truck as he drove through his fields!
12. Two factors are responsible for this water flow 'innumeracy' on the part of Agritex personnel. Firstly, their training does not include that aspect of irrigation. Both irrigation courses A and B which are available concentrate on crop water requirements, irrigation scheduling and economics of irrigation. As a consequence, block irrigation based on accurate and verifiable figures has no enthusiast. In the second instance, there has been

a design rather than a management culture in the (Agritex) Irrigation Branch, that is, the emphasis has been solely on designing. Shanani (1992: 171) underlines this fact by observing that in developing countries management staff do not generally know the flows in the network within 10 per cent; in many existing schemes irrigation projects are fortunate if flows are known within 25 per cent at any given time.

13. The same picture (of lack of personnel to execute the irrigation scheduling tasks) was painted at an Agritex workshop for Manicaland extension workers and supervisors held at Manesa from 5 to 9 September 1994, where the presenter of the lecture was not clear on the very principles he was supposed to teach.
14. The irrigation supervisor is entrusted officially with the day-to-day management of the scheme. In this he is assisted by three extension workers who manage one or more blocks depending on the size of the blocks in question. At the time of the reported episode there were three extension workers. One was responsible for block A (size, 90 ha), the second for blocks B and D (combined size, 95 ha), while the third had responsibility of blocks C and E which totalled 80 ha. The role of extension workers in advocating block irrigation was minimal, it appeared that they went along with it. This could have been because they did not know anything about it for none had any experience with it, or they could not bring themselves to contradict the irrigation supervisor.
15. Indeed it can be asked who is participating in what? Should farmers participate in what state officials in their (technical) wisdom are doing or vice versa, that is, state officials participate in what farmers are doing which is securing their livelihoods? Rukuni (1995b) thinks that farmer management rather than farmer participation is the idea.



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