

Irrigation, Livelihoods and River Basins

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Summary

This paper examines the relationship between irrigation, rural livelihoods and river basin management in Tanzania. There are six critical arguments contained in this paper. Firstly, irrigation is a complex livelihood activity that many integrates across many economic, natural, technical and social systems; farmers implicitly understand this, adjusting the extent of their involvement in irrigation, and therefore only in special circumstances do governments need to 'provide irrigation' or to further increase it. Second, irrigation is a sector that consumes considerable amounts of water and may impact negatively on downstream sectors and livelihoods; pastoralists, rainfed agriculturalists, the environment and urban demands, especially during the dry season. Third, irrigation does not reduce poverty in a geographically widespread fashion; this is because water is limited, sites for irrigation are restricted and places for irrigators finite. Fourth, a functioning irrigation system depends on the resolution of its own particular problems not on the application of generic irrigation theory. Fifth, irrigation improvements are often associated with technological interventions; these are prone to be poorly designed and expensive resulting in increased 'maldistribution' of water and therefore conflict. Sixth, in most cases the water resource is sufficiently limited in time and quantity for it to be contested over. In these cases policy should focus not necessarily on irrigation improvement, but on conflict mediation. This too reminds us of the need to take a balanced livelihoods river-basin approach and to establish appropriate institutional frameworks.

Introduction

This paper examines irrigation policy in Tanzania utilising a livelihoods and river basin perspective. It first analyses the current tone of development-thinking regarding irrigation and suggests that this is mainly predicated on the benefits of irrigation with little recognition of the costs and complexities of irrigation. The paper reveals how policy interventions for irrigation support are often flawed. The discussion explores livelihoods access to irrigation, including the subject of livelihoods diversification alongside irrigation. It does not, however, reformulate the rural livelihoods (RL) framework (Ellis, 2000; Carney 1998) to incorporate irrigation, even though the latter has conditions and processes that suggest an alternative RL construct. Finally, it goes onto propose several ways in which policy-makers might support irrigated agriculture in Tanzania.

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The context of irrigation development in Tanzania

The Tanzanian agricultural sector, in official statistics, forms the greatest share of GDP; 49.1% in 1998, and 56% in 2000. It absorbs 84% of the employed population of the 32 million Tanzanians (Tanzanian Government Statistics, 2001; JICA, 2001). Although different strategies are being suggested to raise agricultural incomes, recently, the Government has placed particular emphasis on the development of irrigation. Related to national interests, there has been a recent resurgence of donor interest in irrigation in Sub-Saharan Africa as an engine of rural development and food security as evidenced by increased activity of regional institutions working in these fields; (e.g. SWIMNET, SACCAR and IWMI) and renewed donor support of irrigation, (e.g. from DANIDA, JICA, AfDB, and DFID).

In Tanzania policy documents, irrigation is addressed in the Poverty Reduction Strategy Process paper (PRSP), the Agricultural Strategy Paper (ASP) and the Rural Development Strategy Paper (RDSP). These documents give the perception that the Government should take a leading and interventionist role in irrigation development, as demonstrated by the following quotes from a variety of strategy documents:

“Among factors that contribute to risk in Tanzania's agriculture is the unpredictability of rainfall and the recurrence of drought and floods. Soil and water management practices must be improved in order to reduce these risks and improve the productivity and profitability of agriculture.”

"comprehensive land use maps with district-by-district details" will be prepared so that "zones with cropping and grazing potential are identified”.

"a comprehensive programme for integrating soil and water conservation, rainwater harvesting and storage, irrigation and drainage will be developed by MAFS and MWLD". It will pay particular attention to ensuring long-term sustainability of water resources and making agriculture a competitive user of water in comparison with other sectors. The government will facilitate the programme's implementation by farmers through providing technical advice on these issues.”

"Promotion and support of small-scale irrigation will be given particular emphasis. This support will be based on cost benefit assessments and the willingness of farmers to contribute to proposed investments."

Connected to these interests is the related argument that potential exists for irrigation in Tanzania. MWLD (2001) states that only 15 per cent (6.3 million ha) of all suitable land is used for agriculture, and only a fraction of that is used for irrigation. Kalinga *et al* (2000) states the position:

“the irrigation potential could be far above the estimated 1 million ha if surface and groundwater resources are combined [of which] only 15% is developed. So while we have the responsibility to make sure that the 15% area ...is operated and maintained.., we are even more indebted to make sure the remaining 85% is developed sustainably..” (page 6)

Schultz (2001) echoes this narrative on realising potential in a recent paper on scope for irrigation in Southern and Eastern Africa.

The mechanisms by which this potential will be developed are outlined in the National Irrigation Development Plan, which was prepared in 1994 to stabilise and increase food production. The NIDP of 1994 can be summarised into three priorities (quoted in ASPS 2000, JICA 2001 and Kalinga et al 2001):

1. Rehabilitation or upgrading of traditional irrigation schemes (156 of them).
2. Upgrading water harvesting technology where irrigation is not possible.
3. Develop new smallholder schemes, where demand exists and conditions are appropriate

Although these remain, donor emphasis has mainly switched to priority numbers one and two. Thus in 2001, JICA was asked to formulate a National Irrigation Master Plan (NIMP), for Tanzania. The objectives of the NIMP are rather unclear and circular, however they appear to be a review of existing policies with the intention of expressing lessons learnt in order to establishing new methods of delivering irrigation development. The principles of the latter are also unclear but emphasises 'software' rather than 'hardware'. In other words, the NIMP realises that farmers need to 'own' irrigation schemes – and that this will be achieved through MAFS training of participants. This is an interesting 'top-down' viewpoint that argues that farmers have to be trained to own irrigation schemes. Similarly,

“Thinking about non-performing irrigators especially those who have received assistance in the past and now their irrigation schemes are either abandoned or running inefficiently, one could imagine of having a law that would govern irrigation development in this country. Farmers should be responsible for the support and assistance they receive from their Government.” (Kalinga *et al*, 2001; 23)

Yet in contrast, balancing the interventionist stance described above, the Government understands the limits of its reach. This is also demonstrated in the ASP and NIDP;

"there is a need to define what Government, at central and local level, can and cannot do versus the role of the private sector in agricultural development". (ASP)

"increased private sector participation and agricultural development in general requires the creation of a favourable climate for commercial activities" (which goes on to address tax regimes and incentives). (ASP)

Therefore, as indicated in the updated NIDP (Kalinga *et al*, 2001) government emphasis allows private sector involvement in irrigation, either privatising the existing irrigated state (NAFCO) farms or in the construction of new irrigation:

“With regard to any future proposed irrigation development for large-scale or medium scale irrigation systems, the Government should create a conducive environment for the private sector to establish these developments on a commercial basis” (page 12)

Although it may be viable and contribute to national food security targets, commercial private irrigation is not within the remit of this paper, which tackles the risks, benefits and costs associated with smallholder irrigation.

Implicit in these narratives are two main thrusts to irrigation development in Tanzania; one is emphasis on irrigation expansion and one is on irrigation rehabilitation and improvement (many in Tanzania hold that traditional surface irrigation in Tanzania is inefficient; figures of 15 per cent are widely quoted (MWLD, 2001; Masija, 2001)). Yet because of the high costs and relatively little performance gain associated with recent rehabilitation efforts, some lessons are being learnt. This demonstrated in the new emphasis on 'software' in JICA's National Irrigation Master Plan.

Even so, there is general consensus that irrigation is automatically beneficial, that it needs 'fixing' and but for the removal of a few constraints it would grow to meet its potential. However, as will be seen in this analysis, irrigation is contrary and complex, and an approach to irrigation requires both a livelihoods and river basin perspective. Irrigation policy has to deal with a set of dilemmas. On the one hand irrigation requires government policy and support, and on other, irrigation is only effected, controlled and improved by farmers. How can irrigation 'facilitation' can be formulated in ways that is pro-poor rather than pro-commercial farming; that does not waste resources; that assists but does not undermine the farmers; that encourages 'ownership' but does not force it; that uses available water but does not promote overuse and exacerbate conflict? A balanced methodology is needed for irrigation support – something that ASPS (2000) argues for.

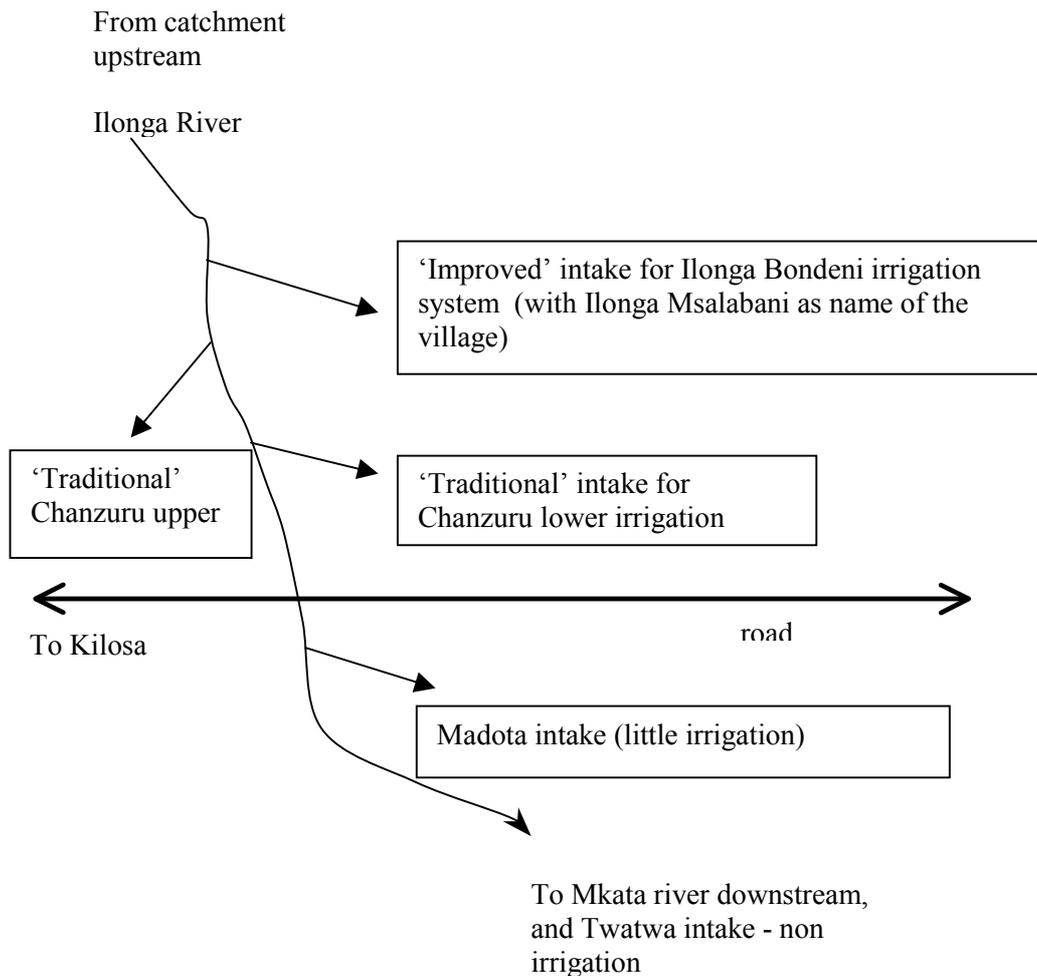
Research methods

The discussion is supported by data collected in the Morogoro region of Tanzania. Three out of six sub-villages in the village of Chanzuru were sampled; Kati, Darajani and Chekereni, although visits were paid to all the villages. Chanzuru is found on the road between Kilosa and the junction on the main Dar to Iringa road. The village lays claim to the Chanzuru Irrigation System, which is typical of Tanzanian systems in that it taps river water running off an escarpment onto a plain before it spreads into pools and swamps or supplies other rivers that drain this plain. Equally typical is that Chanzuru is one of a sequence of intakes on the Ilonga River. More importantly, the Chanzuru irrigation system is downstream of an improved intake that supplies the Ilonga Irrigation System that belongs to a neighbouring village. Figure 1 shows the river system in schematic detail. The area is also representative of the debate on irrigation potential; 3 per cent of Morogoro rivers are used for irrigation (DANIDA/JICA, 2001).

Sampling followed a similar format in each sub-village and is described in more detail in Ellis and Mdoe (2002). PRA wealth-ranking identified three wealth groups that were then sub-sampled using a stratified random technique giving rise to 10 households in the middle and richer households and 15 households in the poorest group. Alongside qualitative and quantitative surveys general PRA exercises and more focussed irrigation interviews were conducted¹.

¹ The analysis is also supported by the author's experience gained while working in the last three years in the Usangu Plains, Tanzania on two DFID projects "Sustainable Management of the Usangu Wetlands and its Catchments" (SMUWC) and "Raising Irrigation Productivity and Releasing Water for Intersectoral Needs" (RIPARWIN).

Figure 1. Schematic map of the four intakes of River Ilonga



Understanding Irrigation

The benefits of irrigation

On smaller-scale systems, and on some farmer plots within larger-scale systems, evidence can be found that farmers benefit greatly from irrigation. Irrigation was mentioned by many of the villagers at Chanzuru as a means of securing greater income. Benefits occur because:

- irrigation secures crop productivity against shortfalls or breaks in rainfall (often mentioned by Chanzuru irrigators);
- irrigation allows rice and other crops that enjoy a cash margin to be grown (also mentioned as why irrigation is desirable);
- by adding more water, irrigation raises crop productivity to profitable levels;
- security of water improves the planning and timing of start of the cropping season by farmers;
- water extends the season length, therefore reducing labour calendar overlaps and assisting farmers further in farm management;
- irrigation extends the area under cultivation and brings more farmers into production;

- irrigation raises the number of jobs conducted on the land (e.g. irrigating, weeding) and therefore employment opportunities;
- irrigation raises the landesque capital of irrigated land, attracting commerce related to land such as renting of plots (clearly visible from increasing rents year on year, which now stand at 20-30 000 Tsh/acre).

In addition, a variety of knock-on effects of these benefits can be identified. In Chanzuru, farmers who had been irrigating at subsistence level recently chose to irrigate 'for the market', growing and selling whole-stick sugarcane and tomatoes. Here, irrigation provided the platform and exposure to home-level entrepreneurship. Some farmers bought produce from others to sell. As the size of irrigation increases, so do the number of people, and importantly the number of economic transactions between active irrigating farmers, labourers, landowners, service providers and surrounding householders.

Many studies support this picture of success from irrigation. DFID (1997), Shah (2000) and Van Koppen, (1998) found that irrigation generated extra cash and jobs in the wider economy. Studies in Zimbabwe (CEH/IOH, date unknown) found that groundwater use in dryland areas brought considerable livelihood benefits to those villages with access to the wells. Schulz (2001) argues that food security at the national and international level is dependent these days on the contribution of irrigation. Chambers wrote cogently in 1988, that benefits of irrigation-based livelihoods occurred at household, regional and national levels.

Yet despite these clear advantages, irrigation has what might be described as 'honey-pot' attractions. Policy-makers are lured to a notionally attractive intervention which, when scaled up in size has trap-like qualities; becoming more glutinous, intractable and risk-prone. Thus, the main message of research of the last 20-30 years has also highlighted the transaction costs, institutional problems, low economic return and environmental impacts of irrigation (c.f. Bottrall, 1985; Chambers, 1988; Postel, 1992; Mazungu, 2000). The next section explores how irrigation systems at the larger scale become more complex.

The complexities and costs of irrigation

This paper skirts the notion that all surface irrigation systems over (say) 50 ha are intractable, complex and subject to livelihood risks. On the contrary, each irrigation system should be treated as being specific, individual and containing important 'stories of success'. Nonetheless, medium- and large-scale systems acquire scalar-related characteristics that make large irrigation analysis and intervention markedly more complex – this relationship is captured in Table 1. Note too, small-scale systems increase in complexity when they conglomerate into a connected patchwork of systems fed by one river or one aquifer. Thus in Usangu in Tanzania, it is the total area of many small systems that has led to problems associated with water shortage (SMUWC, 2001). Although understanding these complexities is a prelude to taking appropriate initiatives, there is space only to give an abridged explanation.

Central to understanding irrigation is the fact that irrigation is four things; a sector consuming water; an input to crop production; a system in its own right; and a human activity. These are discussed below.

The reason irrigation (or water resources) becomes complex is because water connects inter-dependent users as it flows through natural and built environments. Irrigation as a sector is especially important because water is consumed rather than used; water evaporates and is lost from the surface hydrological system. When water passes through a river basin, its consumption in irrigation subtracts from its use in another areas and sectors. The quantities consumed by irrigation are considerable. This contrasts with other sectors that use and recycle water, or use smaller amounts of water. The fact that irrigation sits within a multi-sectoral, water-short environment is often omitted from planning that seeks to maximise development of ‘irrigation potential’ without recognising other sectors and livelihoods.

Table 1. Complexity typology for irrigated water management

Types	Characteristic	Irrigation- livelihood implications
Rainfed farming (no irrigation)	Non-interconnected farming	Farmers are not inter-dependent for their water. Success dependent on timing/amount of rain.
Rainfall harvesting	Smaller, less connected systems	Farmers have high-risk attitude to RH cropping. Success dependent on timing/amount of rain.
Supplementary irrigation	Rainfall contributes significantly to crop	Farmers not critically dependent on irrigation, but irrigation can extend area cultivated
Groundwater-sourced individual surface system	Energy required to source water Non-sequential access	Security of access and costs can promote marginal use of water, higher performance, timely planting and fewer top-to-tail differences.
Piped irrigation systems (sprinkler and drip)	Energy required to source water. Non-sequential access because of pressurised piped delivery.	Particular type of cropping system unlikely to be faced by majority of poor irrigators. Piped highly-structured systems ensure minimised problems of subtractability and sequential access.
Small-scale surface irrigation (<25 ha)	Smaller, lesser-connected systems	On small systems, farmers likely to have built their own canal system have higher social cohesion; have smaller canal distances and fewer bifurcation points.
Medium-to-large surface scale irrigation	Social and canal complexity increasing Water demand increases	Systemic properties and complexity non-linearly increases in size; sensitises system to water shortages, inequality, water shortages and social conflict.
Irrigated river basins & catchments	A number of systems inter-connected by riverine/ aquifer resources	Large distances involved; high complexity, little sense of community, difficult to re-dress water abstraction, considerable transaction costs in water management, control & re-allocation

Secondly, the control of water as a crop input in surface irrigation is complex because a changing, *limited* supply has to be matched with a changing and in cases *unlimited* demand. Often water distribution is hierarchical, creating the need to divide water flows to command areas leading to interactions between flow rate, flow duration, flow interval, area supplied, losses and timing of arrival. In open channels, water is difficult to measure and meter, and takes time to arrive; it cannot be stored, pressurised and be ‘on-tap’ as in pipe flow. Supply is affected by changing rainfall, riverflow and evaporation. On the demand side, cropping patterns, planting dates and soil types change in space and time. Canal losses, multi-purpose uses, unsanctioned abstractions, irrigation at night-time, poor maintenance and farmer perceptions of idealised water demand add further complexities.

Thirdly, irrigation acquires systemic qualities because interactive and multi-functional relationships emerge between infrastructure and users, either locally or non-locally. A

network is not a collection of individual users sourcing water independently. The design and operation of a turnout at the head of a canal influences the operation and discharge of a turnout further down the canal. Furthermore, feedback mechanisms exist between soil type, the design of field layouts and field canals, volume applied per irrigation (including losses) and the amount of water available to begin the next irrigation cycle on time. If one field is over-irrigated, delivery to the next is delayed. Thus scheduling is dependent on water use within fields as well as canal regulation. These factors mean that, at the higher system level, operation criteria less related to individual farmers' wants are required to meet collective needs.

The other 'systems dimension' of larger irrigation systems is that they are situated within national and international markets and political economies. Irrigation systems are concentrated 'bread baskets' that generate considerable income from the sale of crops. For example a 500 ha rice system generates 324 million shillingi from yields of 15 bags/acre sold at 18 000 tsh/bag. Irrigation systems respond to signals related to costs, prices and access to markets and in turn stimulate and influence the development of market services.

Fourthly, irrigation performance is affected by 'activity factors' dictated by human resources such as time, timing, farming and irrigating skills, labour, physical strength and negotiating skills. Irrigation is an activity that sits alongside other livelihood activities. Thus, farmers can turn up late, employ unskilled irrigators, not monitor all of their fields, not fix small problems, go home early, not inform neighbouring farmers about water management issues, request water earlier or later than expected, steal water, release too much water, not have time to join meetings, not agitate for canal cleaning, be marginalized, and so on. All of these activities affect water management, water control and water productivity.

The net effect of the complex nature of 'larger irrigation systems' is to generate inter-farmer, inter-system and inter-sector competition over a scarce resource. The downside of irrigation is increased conflict over water. It is a key thesis of this paper that in water scarce situations (which nowadays is more common) governments and donors should be aware of the need for land and water conflict mediation as much as for irrigation development.

Inappropriate irrigation interventions

Donors and agencies are not unaware of the issues of low performance, social conflict and environmental impacts (e.g. over-abstraction from river basins) associated with irrigation. However, the solutions and interventions designed to improve water management are often problematic. Whereas one may say 'the policy was poorly delivered', one cannot escape the fact that poor understanding of water underlies ineffective interventions. A few examples of such flaws in reasoning are explained here.

The first miscalculation is that participatory community-orientated design and management will improve water management. In many cases, this may hold true, however, water control on large canal systems needs strong main system management able to take decisions that relate more to scale of the system than to its constituent individuals. Likewise, water distribution on a river serving many intakes needs a 'basin approach' implying centralised monitoring or management to reconcile upstream/downstream use. Community projects may work well with stationary forest resources being harvested by geographically bounded communities, but they have their limitations when one community subtracts water from another that may be many kilometres away. A community approach is limited because of the

distances involved in river basins and consequent lack of 'community'. In other words, a centralised view helps meet the necessary needs of many and not the wants of a few.

A second flaw in reasoning can be demonstrated with the way 'modernisation' is conceived and implemented (Lankford and Gillingham, 2001) using a beguiling theory that believes irrigation efficiency can be improved by modernisation of key infrastructure. In Tanzania, improvements to intakes involve changing from a traditional design (usually stones and sandbanks) to a modern design (concrete weir and steel gates). Yet, in case after case, the internal water distribution in irrigation systems is not improved. Instead the result has been the drying up of rivers and increased conflict between abstractors. Concrete intakes allow much more water to be taken particularly during low flow periods (previously the traditional intake would be left 'high and dry' allowing a by-pass flow). Ironically, it is the one intervention that farmers want when they voice their priorities – but this is to save labour on maintaining traditional intakes. This is an example of the risks posed by meeting community-voiced demands, suggested in the previous paragraph.

A third example is the wrong assumption that suggests farmers need to buy their water. In Tanzania, this has been attempted by sale of purchasable water rights. However, the policy is highly problematic (Lankford, 2001a). In Tanzania, irrigation water is unlikely to be metered and monitored and so farmers may take more than their "fair share". With a fixed payment farmers may not use the marginal rule – on the contrary – having paid for a right, they may be inclined to use more water. Institutionally, fee collection is difficult because of weak logistical support in the face of the large distances involved. The fees are not used to provide a better service (again because of logistics) or secure water since this is largely dictated by nature. In some cases, the rights are simply water duties without being reconciled with the size of the system, available water or downstream needs, in which case water is not effectively available. In addition, because rivers change dramatically from wet to dry seasons, and from wet to dry years, the fixed rights approach only works for 'statistically mean' flows. In dry years, the right is greater than the available water, legitimising the abstraction of water until the river is left dry. Conversely, for wet years, the right is less than the available water, and probably less than the actual abstracted amount because intake gates are surcharged with high flows.

Other 'solutions' are also risk-laden. For example, it is believed (particularly by commentators with no experience of managing irrigation) that pipes or lined canals improve irrigation – yet no mention is made of the economics, or the farmer's costs in managing and maintaining piped supplies or of the real gains in water productivity. Others hold that the 'more efficient' private sector (or privatised wings of irrigation departments) should design and manage irrigation systems – again with no explanation of how these institutional reforms will be effective, economically viable, and whether such services are needed.

A paradox arises here; interventions need not be solutions. Options succeed in places but fail in others, impinging deleteriously on water control. Basic irrigation thinking is often an amplification of the following: "Motivate farmers, take water out of a river, move it along some canals and deliver it to crops". Yet the default thinking should be that irrigation is expensive, contrary, complex, and strongly associated with competition over a scarce resource. It is into this multi-dimensional, inter-connected dynamic system that options need to be so cautiously considered, applied and refined.

Analysis of irrigation livelihoods and river basin dimensions

The remainder of this paper explores three aspects of irrigation interventions focused on livelihood issues: 1) the potential and suitability of irrigation; 2) access to irrigation and its 'livelihoods' nature; 3) its fit alongside a diversified livelihood. Subsequently, two additional topics are examined; the dominant intervention in Tanzania designed to improve irrigation, and the competitive, common-property nature of water.

The potential and suitability of irrigation

From a farmer's perspective, irrigation is not always appropriate, economically feasible, required, or likely to be successful in all situations. When left to farmers, a rather narrow window of opportunity exists because of the range of constraints and risks. Too dry and there is insufficient rainfall to create large enough streams to provide secure flows for a season length of at least 120 days. Too wet and farmers utilise rainfall to grow crops. In addition, catchments need to be 'just so' having aquifers or being large enough to yield secure and sufficient water. The economic and demographic context also affects farmer-decisions regarding irrigation. Farmers may see no reason to invest in socially complex irrigation when rainfall meets their needs or when no effective market demand exists for their produce. This farmer-perspective contrasts with the formal institutional view that the Government should deliver the considerable potential for irrigation. There is potential, but this needs to be divided into the following:

Large smallholder schemes located on the eastern floodplains of Tanzania where large rivers are found incising tracts of relatively under-utilised land. They are currently not common because of the substantial amount of capital and engineering needed to construct un-erodable headworks and conveyance networks. Farmer-owned small systems fed by the larger rivers on low-lying floodplains are rare because of the difficulty in lifting water to acquire command (although irrigation is found on smaller banks within the river channel and where farmers use pumps to lift water).

New farmer-owned smallholder might be found in some of the wetter regions of the country. These would emulate the systems found in the Usangu and Kilosa regions, and likely sites are in the Kilombero and Ruvu/Mgeta valleys. Systems are rare because rainfall is sufficient or because population numbers and needs are relatively low and are being met by other livelihood activities such as rainfed agriculture and livestock.

Extension of existing smallholder systems can occur via upgrading and modernising intakes and the canal network to theoretically raise irrigation efficiency, improve water management and increase water distribution. Yet farmers themselves are better suited to decide on whether this is feasible and necessary.²

There are dangers in believing the Government can 'roll out' irrigation expansion without risks. Indeed a lack of contextual analysis could be blamed for the siting of large-scale

² Chanzuru irrigators have had irrigation for more than 10 years, however it is only in the last 3-5 years that irrigation has become more profitable, productive, attractive and larger in area. It is the farmers themselves who are agitating to expand their irrigated area by commanding the Masai land and begin dry season irrigation.

systems in places where smaller systems were already competing over water (e.g. Lower Moshi in the Pangani Basin).

In summary, three issues stand out: 1) farmers choose to irrigate depending on livelihood, environmental and water circumstances; 2) in under-irrigating areas, the government may be more advised to generate an enabling environment that encourages farmers to consider irrigating, and while this may still not provide the first type of capital-intensive scheme, it would attract farmers to invest in new and existing systems; and 3) the 'potential irrigation' narrative of the GoT strategy papers misses a more pressing issue of conflict mediation in existing irrigated areas where the demand to expand irrigation is ever present.

Access to an irrigated livelihood - the privileged nature of irrigation

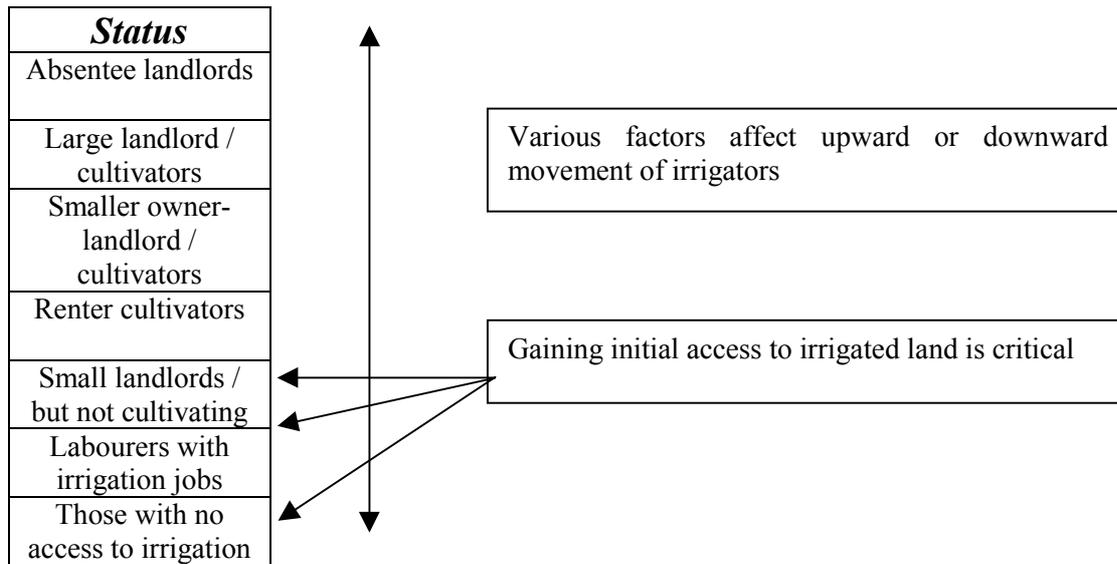
Because water is often the limiting resource, irrigation is a privileged not a widespread solution (Moris, 1997). This is evidenced in Usangu and Chanzuru where it secures benefits at the rate of about 1 farmer or 2 farmers per acre for those able to rent land. In Tanzania, most irrigation systems are found between 10 to 500 hectares, providing for households that number in tens and hundreds not thousands. Furthermore, in areas with a history of irrigation it is a choice of cropping that accrues to farmers who already have sufficient assets, either as a result of irrigated cropping or from other jobs or by borrowing to rent into irrigation. For example, when the Ilonga system was extended, incomers were reasonably well-off villagers and staff from the nearby research station.

Villagers in Chanzuru said that rainfed land was needed to make up the food requirements that irrigation alone could not provide for. In fact a total of 42 per cent of the three Chanzuru villagers owned no land at all, even though these were sub-villagers that had access to an irrigation system, and even though land was available to rent, only 41 per cent of the total village respondents cultivated rice, the key indicator of irrigation activity.

The following subsections describe the issue of access to irrigation where this considers: initial access which turns a rainfed farmer or non-farmer into an irrigator; and deepening or gaining access which turns an irrigator into a more secure irrigator or irrigator with more land. Research in Chanzuru revealed a ladder of irrigation-related wealth (see Figure 1). At the bottom exist those with no access to irrigation; these often tend to be women, the poorest, poor rainfed farmers, incomers or youth (LADDER, 2001). Above them lie a number of tiers that represent greater wealth in irrigation terms. At the top of the scale are found wealthier landlords who rent land out but do not cultivate themselves. A person can occupy more than one rung; he or she can be a cultivator waiting for water to arrive at their field, whilst labouring for a cultivator further up in the irrigation system.

Getting access to irrigation is a precursor to an irrigation-based livelihood - and is therefore a critical step. The Chanzuru study showed that initial access does not need to go via labouring, it can leap directly to renting or owning irrigated land depending on circumstances. Initial access occurs in four main ways, as explained in Table 2. These are; land, water, capital and labour. Also affecting the decision to enter into irrigation are other factors, such as market conditions – but for clarity, they are described in the section on widening and deepening access.

Figure 1. Ladder of irrigation related status



Land

Disregarding for the moment the title of the land, access to either '*irrigated land*' or '*irrigable land*' is critical³. Acquiring either occurs via a number of routes: it can be bought, hired, inherited, re-privatised, or is given away, either by village or by purchase and then by donation. An individual, group, NGO, Government or donor body develops irrigable land and farmers then join the scheme.

There tends to be a minimum plot size below which irrigation does not occur. Understanding the reasons for this is central to finding ways of affecting the distribution curve of land for poor farmers. In Chanzuru, the minimum size plot was 1.0 acre but in rare cases was 0.5 acre, this is because an area below that “does not support a family”, “is not rented out by landlords because they prefer not to subdivide too much” and “because there is high competition for small 1.0 to 2.0 acre plots”. The median rice plot size was 1 acre for men, and 0.75 acres for women.⁴

Land ownership and tenure affects access to irrigable and irrigated land. Some irrigated land in Chanzuru is owned by the village and is rented out to villagers. While this sounds equitable, it is apparently controlled by a few landowners making it difficult to get hold of ‘village land’. Others said that “getting hold of land near the intake is very difficult as it is “controlled by Sido sub-village”, which is seen by many to be the richest sub-village. Of those that rent, 17 per cent do so from own family members, and 83 per cent from other individuals. There was agreement that renting in land was more profitable than renting out

³ Irrigated land is land that comes with an assured supply of water. Irrigable land is land that either has intermittent supply or is land that feasibly lies within the command area of a source of water.

⁴ The dry season irrigation and rainfed area has a median size of 1.0 acres approximately, though the mean for those is 0.9 acres and 2.0 acres respectively, meaning farmers farm larger rainfed plots than dry season irrigation plots.

land⁵ (negotiations are set between renter and landlord, and are not mediated by third parties).

The total area of irrigated land in Chanzuru has been increasing⁶, meaning that both land and water has been available. Chanzuru irrigators have on average cultivated about 1.4 to 1.5 acres for the last three to five years, and most said they had plans to increase to 2.0 acres and to start dry season irrigation next year mainly because the Masai land had become available.

To improve access, pro-poor land redistribution may be feasible. A precedent already exists in Chanzuru because small plots (0.25 acre) of rainfed land are 'given' to poor people in exchange for their labour, yet this is not currently practiced on the rice system where the smallest plots tend to be 1.0 acre. In addition, purposive land distribution can be achieved at the beginning or rehabilitation of a project when outside agencies have room and leverage to manoeuvre⁷. Clearly, here lies an opportunity to apportion land to different types of villagers in different ways as occurred during the upgrading of the Ilonga intake (upstream of the Chanzuru intake), accompanied by an expansion of the irrigated area. One policy insight here is that encouraging and enabling micro-plots of 0.25 and 0.5 acres might be very important to allow the poorest a foothold in irrigation. Related to this is a re-distribution issue from larger plots to normal sized plots of 1.0 acre⁸. There is irrigator interest in re-distribution demonstrated by reports of a letter being sent to the village leaders (who according to some irrigators have large plots) requesting a resolution of this issue.

Chanzuru farmers noted that new farms at the periphery of the system were water short, being "far from the source" and "farmers block the canal" (in order to obtain their own water). This is a classic situation of acquiring irrigable land rather than irrigated land. There were mixed opinions about whether land close to water had a higher rental value than that far away, but clearly competition for land is sufficient to warrant a higher price for irrigated land.

In Chanzuru, large tracts of rainfed land have been appropriated by a local businessman who intends to farm commercially. Although this affects maize, it is a clear example of the way in which land tenure has affected the food security of poor people in the village – irrigated land is insufficient. Counterbalanced against this is the release of new irrigable land because Masai have been evicted following a long-running dispute. This has only recently happened, and it is not clear what this will mean for re-distribution of the vacated land.

With regards to the argument that wholly new irrigation systems can be constructed, this provision is not relevant in Chanzuru because it was found that farmers are already extending the existing layout. Again, the livelihood insight here is to build on existing skills and energies. The policy condition is that if new land development is conducted in the future

⁵ for the latter the "owner only gets the rent price" whereas the renting land allowed "you to grow rice and generate more income"

⁶ mainly as a response to demand

⁷ The work by Koopman *et al* (2001) in Tanzania reveals its plausibility, success and positive community outcome of redistribution.

⁸ There was resentment about those with large plots of land, although facts were difficult to obtain. Discussions in Chanzuru revealed that about 7.0 acres was the upper limit for one farmer to manage; above this and "the management of water would deteriorate". Quite a few respondents felt that the current distribution was unfair.

then institutional establishment processes will be critical to their success. Perhaps the engineering design of new schemes should stop at the headworks only, allowing the distribution system to be worked out by farmers? ⁹

Another important land access route comes from smallholder resettlement. This is not applicable to Chanzuru but in Usangu there is an argument that the existing commercially orientated farms belonging to the parastatal NAFCO could be re-distributed to poor families as an example of irrigation management transfer. Although this is happening informally via private rental agreements, it could be formalised to meet desirable pro-poor outcomes. If conducted at the rate of 1 acre per family, this could provide land for more than 6000 families on both Kapunga and Mbarali farms.

Water

While gaining access to irrigable land is important, equally important is secure water. For the poorest, small amounts of water, or enhanced security of supply is marginally and vitally more beneficial. This curvilinear productivity response is the objective of managing water as a crop input. Reducing top-end surfeit of water to reduce tail-end deficit increases productivity across the whole system.

The picture is muddled because water can have other functions. It can control weeds, to level soils, and to soften soil to allow ploughing. At the end of the season when less crop water is needed, water is used to wet fields to grow dry season crops or rice ratoons. In addition, top-end farmers value security over amount leading to more water hoarded than is agronomically necessary.

In addition, depending on seasonality and location, water has changing value in comparison to changing livelihood strategies. Thus top- and mid-end farmers who have received water on their plot may not transplant but instead seek more immediately profitable work labouring on another's farm (SMUWC, 2001). This livelihood tactic creates a mosaic of wetted but bare plots, which reduces total system efficiency and stops more needy farmers from getting water. Interestingly, in Usangu after the drought of 2000, smallholders on one system agreed new rules about absentee farmers with the intention of tightening up on planting and water distribution.

⁹ In general, developing new lands for irrigation is a risky endeavour, requiring planning, capital, resources and time to assist users in formulating water user groups and conventions for sharing water. Observations show that where local people use their own resources to develop irrigation, the 'debts' in effort, time and money tend to become embedded in their expectations and contributions to on-going management. Where outside institutions attempt to develop or enhance irrigation, these 'social capital' factors tend to be less well developed; water user associations tend to be artificial and less sustainable.

Table 2. Four resources and characteristics of irrigated livelihoods affecting access to irrigated plots of land

Access resource	What is it?	Why does it arise?	What does it lead to?	What is the household livelihoods approach to the solution?	What is the group, village NGO, district & river basin solution?
Access to irrigation land	Below a defined area, people are excluded from accessing direct benefits of cultivating their own crops. In Chanzuru, the area is about 0.5 to 1.0 acre.	There is often intense competition for small plots of land. Landlords tend not to rent out smaller plots, plus farmers feel that that 1 acre provides work & income for a small family unit and more money would be required for larger plots.	The poorest of the poor are not able to get a foothold on the benefits of cultivating and selling their own crops.	People cope by selling their labour to other growers, by cultivating small areas of rainfed land and by micro-diversification.	Demarcate land for micro-plots of irrigation? Revolve plots on an annual basis? (Applicable to village owned land) IMT transfer & settlement
Access to water (Conflict-area tradeoffs)	Access depends on water availability. Improved internal supply and distribution of water resolves conflicts but extends area irrigated leading to additional farmers and increased risk of new conflict.	Irrigation interconnectivity between users reflects a common-pool resource. In middle or tailend reaches, or in downstream irrigation systems, water supply is variable and insecure. Getting access to small amounts of water may have high marginal benefits to the poor. Resolving waste and inefficiency in upstream areas releases water to downstream farmers.	Increased risk of conflict and shocks when water supply contracts, necessitating conflict resolution, a search for increased supply or a contraction in irrigated area. Extending irrigation provides benefits but increases chances of conflict in normal & drier periods.	People cope and are opportunistic. Farmers may move to better served plots. Labour transactions change. Individuals may attempt to hoard water.	Group planning is required to limit & improve irrigation in zones beyond which risky water supply occurs. Improve upstream/downstream control via river basin management. Deliver small amounts of water for lifeline needs (e.g. compensation flows or piped domestic supply)
Access to capital	Farmers in Chanzuru need money to rent land	Irrigated farming has become increasingly commercialised. Obtaining financial capital to purchase land or water may be borrowed money or by providing labour. Very poor farmers may be excluded from this, but increasingly will consider credit.	Borrowing of money against future cropping. Savings from cropping or other income streams	Formal or informal credit systems were found to exist in Chanzuru either at household level or from NGO in Ilonga	Formal or informal credit systems managed by NGO, with enabling environment dictated by Govt.
Access to labour/energy	To gain access to irrigated land at the bottom rung necessitates the provision of labour.	Labour may provide initial means to derive benefits from irrigated land either through direct access, sharecropping or paid labour	Labour or energy is required either to prepare land, or to work on another land or to access water.	People cope by working for water or land. Labour duties are shared out. Planting mosaics.	Guidance still required on impact of labour-selling on water management and efficiency.

In the Chanzuru system, differentiation into well supplied top-enders and poorly supplied tail-enders was not as clearly seen in other systems in Usangu. This is because permeable soils, a fluctuating water table and undulating land wets soil some distance from the intake. In the survey, many farmers did not associate distance from the intake with dryness, except for the most recent farms being added to the system. This is also reflected in the inelastic cost of land rental across the irrigation system, and the fact that research by Bevan (2001) did not detect any trends in livelihood diversification related to top-to-tail water availability.

There is evidence from the Ilonga and Chanzuru irrigation systems that recent improvements in water management have spread water more widely, ensuring greater security of water to tailend areas and a general increase in total irrigated area. Until about five years ago, rice was grown using broadcasting and flooding but, as a result of Sukuma incomers demonstrating basin irrigation, rice is now transplanted in *vijaruba* (small flat basins) fed by a greater number of feeder canals than before. This technology was copied widely resulting in improved water control, doubled yields and extended water coverage. Another change in recent times has been the use of the dry season to irrigate crops, made possible by the perennial (though dry-season reduced) flow of the Ilonga River. Many farmers interviewed said that dry season cropping was on the increase every year.

Importantly these two changes happened without government intervention. In fact as one villager put it, "if the Sukuma practice had been shown by an extension agent we would probably have ignored it".

One unhelpful institutional requirement has been the payment of 35,000 Tsh to the District for a water right (via the collection of 500 tsh from each irrigator). To date, no such right has been issued, or has any information been given to them regarding their abstraction rate.

The key question is: how much more can the area can keep extending? With the removal of the Masai and the closure of rainfed lands there is real pressure to maximise the irrigated area, but this seems problematic despite being desirable. There is a poor relationship between the WUA and the village government which has resulted in reduced fee collection (only 28 per cent of Chanzuru respondents said they belonged to a WUA), a lack of rules being drawn up, a lack of rule enforcement and consequently conflict over water sharing. The corollary to this is that many irrigators want to replace the WUA chairman who is seen to be blocking progress on these issues.

Capital

Although irrigated land may be acquired by non-financial means, access to capital is the precursor to acquiring irrigated land and water. Prices for renting have risen from 3000 tsh/acre in 1998 to 5000 tsh/acre in 1999 to 10-15 000 tsh/acre in 2001, with prices of 30-50 000 tsh also quoted. Gaining access to land via renting is a monetised process; farmers acquire capital to rent land principally by borrowing credit from lenders or the landlord or by partly providing their own labour to irrigators in top-end reaches that have already received an irrigation supply. In rare circumstances farmers undertake sharecropping. Even less observed is the creation of capital from diversified non-agricultural incomes to invest in agriculture. Many villagers also indicated that it was not possible to sell labour at a sufficiently profitable rate to then rent land – though clearly renters mixed their own cropping with selling labour on farms.

One policy insight here comes from an irrigating farmer who said the rural NGO credit scheme (FINCA) located in Ilonga Village had helped him secure capital to rent land. For him access to capital to rent land was vitally important, yet villagers as a whole ranked FINCA as being generally unhelpful because interest rates were high and grace periods short (LADDER, 2001). Lack of credit was seen to be a major constraint by most villagers.

Labour

Lastly, labour may be a way of accessing the value of irrigated land (if not the title) where the intention is simply to become a waged labourer without using that money to start cultivating. Villagers in Chanzuru said this was unprofitable because the labour pool was large and salaries small. However, for the poorest, this is one source of income.

Crop input and agronomic factors

The play of the above factors affects initial access to irrigation, from then on the direction can be upwards, downwards or stationary. Table 3 demonstrates ways that continue to undermine or benefit irrigated livelihoods.

With regards to crop productivity, the Ilonga River irrigators tend to solve their own cultivation problems, including the judicious use of fertiliser in certain kinds of crops. According to the villagers, the extension officer, once reasonably visible now hardly visits (LADDER 2001). However, there were certain yield problems that farmers could not fix such as yellow spot on rice. Here, farmers saw yellow spot as a major problem halving yields, and the lack of extension advice as damaging. In Usangu, farmers complain that top-end fields are declining in soil fertility (i.e. 12 bags/acre), while tail-end fields with water still yield at 18 bags/acre. Yet, farmers with secure water at the top of the Kimani system in Usangu are carting in farmyard manure, an interesting sign of perceived balance between security of water and the costs and benefits of additional inputs.

Farmer incentive environments; markets and inputs

The study of Chanzuru irrigation demonstrates that irrigation expands and is competed over despite a lack of visible intervention by government or provision by the government of inputs. Villagers state that the increasing price of rice relative to costs of inputs is one important reason why rice cultivation has increased in area. Counterbalancing this was a decline in the rice price for 2001 from about 25 000 tsh/bag to 8-10 000 tsh/bag because of good rains throughout Tanzania and a glut of rice on the market. The location of Chanzuru on the main road between Ilonga and Morogoro benefits market access – another aspect of irrigation that farmers implicitly factor in.

By mass-producing high yielding cash crops, irrigation systems become function orientated, responding to a wider economic environment.. Farmers both sense this and the nature of the incentive environment into which they fit. Thus a highly appropriate irrigation-livelihood intervention is not necessarily the upgrading of infrastructure or establishment of WUA's, but the provision of predictable, accessible markets. Lower transaction costs (e.g. reducing the number of rural taxes on the movement of goods) explored by Ellis and Mdoe (2002) help incentivise the desire of farmers to participate in irrigated agriculture.

Table 3. Factors affecting deepening/widening access to irrigation-based livelihood enhancement

Factors affecting movement up/down	Brief explanation	Move up	Move down
LAND <ul style="list-style-type: none"> • Land availability • Land given & inherited • Land bought & sold • Land rented 	The amount of total land available, and the degree to which portions of it are available to villagers affects irrigated livelihood options	Land becomes more available, small plots made available, prices stabilise, landlords provide good contracts.	Land becomes less available, or market for smaller plots becomes more competitive. Richer farmers rent more land marginalising poorer farmers. Prices increase raising risk element when borrowing money.
WATER & CLIMATE <ul style="list-style-type: none"> • Water availability • Improve intake • Acquire new intake or pump • Equitable predictable climate • Control of upstream users 	The amount, predictability, timeliness, location, distribution of water enables farmers to plan and manage water accordingly, enhancing irrigation livelihoods.	Water becomes more secure, available, predictable, better distributed, less prone to disruption by upstream irrigators.	Water becomes less secure, less available, more frequently taken by upstream irrigators, or affected by weeds, leaks etc.
CROP <ul style="list-style-type: none"> • Yellow spot • Rainfed maize yield 	Potential yields are blighted by disease and lack of rainfall.	Good maize and rice yields raise incomes, allowing farmers to invest in further assets	A poor rice yield due to yellow spot infestation or poor maize reduces income and can lead to debt. Poor maize can also knock farmers down.
LABOUR/ENERGY <ul style="list-style-type: none"> • Availability of own/other labour • Cost of labour/energy 	Providing energy for farm work either prepares land or ensures water	Energy/labour cost benefit ratio is advantageous providing land and water.	Land or water has an energy/labour cost exceeding benefits from energy/labour.
DIVERSIFIED LIVELIHOODS E.g. Micro-enterprise, urban-rural migration, rainfed agriculture / dry season irrigation, livestock, labouring	An ability to save money from other activities and not borrow money creates bi-directional investment between agriculture & other streams. Time balance here.	Other income sources become developed. Capital used to access irrigation land or vice versa - irrigation income used to build other enterprises.	Opportunities erode, individuals rely on few sources or permanently /temporarily migrate. Access to rainfed land decreases. Failure in one activity drains others.
ECONOMIC & FINANCIAL <ul style="list-style-type: none"> • Capital, debt, borrowing • Input and labour costs, demand • Credit & financial planning mgt • Market prices, stability & transaction costs 	Access to capital, and costs of borrowing money as a household or individual affect ability to change one's livelihood. Access to functioning markets with acceptable prices and minimal transaction costs.	Terms and cost of borrowing amenable to cover access and initial start-up costs with leeway to allow for delays in payment. Market is accessible, predictable, easy to enter into, prices profitable.	Borrowing costs are high, and terms are unfavourable, capturing or depleting other resources previously built up. Markets not accessible, prices crash, transaction costs high.
SOCIAL <ul style="list-style-type: none"> • Social cohesion & conflict resolution • Social/customary access to land • 'Competition' 	The access to land and water can be affected by social factors such desire and competition to add to assets, and by organisation and conflict resolution.	Village and water user association communicate, incomers bring new ideas, farmers meet to resolve conflicts.	Competition, bullying and intimidation present, poor WUA organisation, break-down in village communication, & gender or age marginalisation/exclusion to land.
WATER INSTITUTIONS <ul style="list-style-type: none"> • Local village & WUA bye-laws • Control of river basin abstraction • Support by zonal irrigation office 	Some social factors affecting access explicitly acknowledge in commonly agreed, written bye-laws and legislation. Supporting policy & project environment	Bye-laws understood, adopted, and used in assisting protection and or development of resources and in resolving conflicts.	Organisation breaks down, legislation is no longer utilised or known about. Policy environment erodes activities/plans made at the household and village level.

Furthermore, market signals generate comparative incentives for farmers to improve water management, underlain by their investments in infrastructure. Thus farmers will decide to line or rebuild canals when the value of doing so outweighs the costs of not doing so. Examples of these decisions are found in Usangu; farmers do not upgrade the intake but will rebuild a canal wall that has collapsed. In the former, the water supply is not under threat, whereas in the latter it is. It is the argument of this paper that farmers are better placed than governments to make these detailed system-level economic decisions.

Social factors

When during the research problem ranking was conducted, villagers did not readily identify those driven by social factors (see LADDER, 2001). Yet a variety of cultural and social norms appear to be affecting access to land and water. For example, female farmers cannot own land, but were renting land and providing labour on other farms. Of the irrigator respondents, 67 per cent were male and 32 per cent were female. Regarding plans by village youth (16 – 24 yrs) to grow rice, interesting observations were made by villagers: “Previously into beer drinking, they now expect great changes in the next two years from the land released by the Masai”.

Villagers also held the view that the ‘vision to adopt new technologies’ was constrained by low levels of education – though this contradicts the rapid adoption of basin irrigation by villagers from Sukuma incomers. In addition, although not expressed during the Chanzuru PRA exercises, the purposive irrigation interviews did reveal that underlying the conflict between the village and WUA leaderships is the desire by irrigators to question the existing socially-determined incentives and penalties of the WUA in order to enhance water management.

Diversification and irrigation

The causal direction of success in irrigation and success in diversifying into other activities cannot always be predicted but it is possible to say that success in irrigation provides a means to diversify, whereas in Chanzuru, diversifying without irrigation is more problematic.

Interviews with villagers in Tanzania (see Box 1) suggest that irrigation is a mainstay of income and that where possible most interviewees wished to have both irrigation and at least one other activity in order to maximise income. Two further facets can be identified. Firstly, farmers with small-scale diversifications (such as beer or selling own labour) saw irrigation as an important but seasonal activity providing much needed income. (“One cannot forget irrigation”). During irrigating times, other enterprises can become dormant. There were also examples where minor business people (such as sugarcane sellers and café-owners) point to irrigation being the source of capital to start their other activities. They used sums of 5000 Tshs to obtain materials or rent land to try other crops. Although irrigation was less necessary in these cases, it was highly desirable and could be 100 per cent prioritised when necessary. It was also likely that another family member would cover non-agricultural duties.

Diversification into irrigation (out of rainfed agriculture) occurs because villagers see the benefit of good prices from rice and dry season crops; and because they are aware of the security of production when compared to dry season maize; for the latter one frequently heard “the rains are not certain”. One of the sub-villages, Chanzuru, provided a third reason for movement into irrigation, namely the closure of access to rainfed lands by a powerful landowner in the area. This is compensating rather than diversifying but it does influence farmers moving in and out of different types of agriculture. It is for a number of these reasons that irrigation rental has increased in the last five years.

Box 1. Case study - female owner of small café in Darajani sub-village

Started in 1999. Every year the owner opens a small café in the off-season after finishing cultivating rice, from March to December. She has 1.5 acres irrigated, 2.0 acres rainfed, but is expecting to increase area of irrigated land to allow her daughter to cultivate some land. Land was originally with village, but she now owns it. Got the capital to start from selling one bag of maize that paid for someone to build the café and money for mugs and plates. She also borrowed money from the credit NGO FINCA in Ilonga to purchase bulk sugar. Now the shop supports itself and the loan repayment. More profit comes from irrigated rice than the café but this may change in the future depending on business. She had to start this because “life is so expensive”, and husband’s income was not enough to meet many needs such as school income and cooking oil. If there was a drought that hit the rice she would be hard hit since customers would stop coming, but if it was just her being hit by yellow spot then perhaps the café could support her. The profit is about 1200 Tsh day, coming mostly from “young men with no wives”. She is taxed by the village development tax, but does not see what the money is used for. Her major problem is yellow spot which halves yields of rice to 8-10 bags/acre. She has recently started buying and selling clothes too.

Movement into irrigation currently requires rental capital (whereas some years ago, land was given out for a nominal sum by the Chanzuru village government). This money, which has been increasing steeply in the last three years, is obtained mostly by borrowing, but augmented by some savings from, and labour within, agriculture.

As mentioned above, diversification into labour-selling alongside irrigation also exists but can create a mosaic of planted and non-planted but wetted plots – a theme discussed more below.

In summary, irrigation in Chanzuru provides capital to diversify; diversification is seen as desirable in itself (without necessarily being driven by a lack of irrigation); it enables minor labour opportunities; but diversification does not generate a sufficient income to wholly pay for rental access to irrigation.

Effect of diversification on sustainability and productivity of natural resource management

At the river basin level, increasing livelihood needs for water inevitably means that water is abstracted into irrigation intakes without much regard to downstream users, so a rural-poverty, livelihoods focus tends to promote upstream irrigation abstraction¹⁰. Constraining this is necessary because of other-sector needs. Theoretically, water rights and intake designs should balance upstream/downstream needs, but this is unlikely while river basin officers have minimal presence in places like Kilosa District and where irrigation intakes are over-designed for peak flow periods. If and when water is throttled, a natural consequence will be irrigators having to make decisions over alternative sources of income – but there is no evidence that diversification helps reduce water demand. This is because irrigation is so much more profitable than other rural activities seen in Chanzuru. Thus it may be necessary to force throttling rather than to expect it to happen as a consequence of ‘progress’.

As far as *in-system* management is concerned, there was conflicting evidence that diversification into other activities negatively affects land and water management. One neutral

¹⁰ This is certainly the case in the Ilonga river system where water is taken from the Ilonga and Chanzuru offtakes up to their respective design maximum flows, in wet and dry season, leaving little water for the downstream intake of Madota.

stance is that water management does not deteriorate because most diversification occurs during the off-crop season. A more negative outlook is that diversifying into temporary labouring when a farmer has received their water leads to a mosaic of uncultivated plots, which reduces overall productivity and utilises water that is more urgently required by other farmers. Farmers clearly feel both the costs and benefits of this, and outcomes depend on collective action or non-action, as exemplified in Usangu.

However, more positively, there may be evidence that diversification, by further raising incomes, is an impetus to improved in-system management. The link is tenuous, but several people expressed plans to increase the area of irrigation to raise capital for various home and business needs. This desire to meet more people's needs and increase the area irrigated will be met by better distribution and management of water. While this has improved over the last 10 years, villagers are aware of the need to make further changes. This awareness can be seen in the disputes surrounding the Water User Association. The village government wants to replace the current WUA chairman to improve general farmer organisation of canal maintenance and draw up new rules and schedules.

Infrastructural approach to improvements

Irrigation lends itself to, indeed requires, technological interventions. This fact means that it is subject to risks of under-design and inappropriate design. The predominant approach to irrigation interventions in the last 20 years in Tanzania is defined by an infrastructural emphasis, notably in the construction of concrete intakes to replace traditional intakes. Chanzuru farmers all mentioned that an improved intake would benefit them. Yet Lankford and Gillingham (2001) reviewed the evidence from the Usangu Basin and saw that improved intakes caused the system to over-abstract, leaving the environment or lower irrigation systems dry (even if they too had new intakes). There is no evidence that Chanzuru irrigators are short of water because of a traditional intake; their desire for a concrete one stems from lower maintenance costs.

There are two policy insights here. Firstly, a policy of non-intervention may be the best; irrigation does not necessarily require considerable investment in infrastructure, though this is what most farmers would wish. Secondly, if intakes are to be built, they should be constructed in ways that explicitly share water between upstream and downstream demands. Proportional or castellated weirs as described in Lankford (2001a, 2001b) are applicable here.

Conflict resolution – institutional arrangements

Related to points made about inappropriate infrastructure, water-scarcity and multi-sectoral demand, special consideration needs to be given to irrigation conflict resolution vis-à-vis providing new irrigation. A range of institutional arrangements can assist communities in regulating and managing their water abstraction, providing important mediating processes affecting access to natural resources.

Three tiers seem appropriate; irrigation-level user agreements; sub-catchment level user agreements, and a higher-level overview. Of the first, water user associations (WUA's) are common examples of this – and such an organisation, albeit moribund, was found in Chanzuru. Of the second, both traditional and new river user associations (RUA's) are found in the Usangu. For example the SMUWC project set up a RUA termed a sub-catchment management resource programme (SRMP) in the Kimani River, which was seen as highly desirable by users. Farmers in the Mkoji-subcatchment in Usangu already meet, without outside involvement, to

agree a share of water abstracted between different intakes. In Chanzuru, river conflicts were rarely mentioned, something that is related to the positive ratio of supply to demand, and the design of the improved Ilonga intake that allows water downstream. Clearly river basin institutions are not always required.

At a higher level, farmers primarily turn to their district council to sort out disagreements, and in rare circumstances, where they exist, to a river basin authority. Even if the latter arrangement is available, its success depends on the relationship between the water right, application and appeals procedure, cost, design and service delivered in terms of conflict resolution. In Usangu water rights imposed to share water were not related to the infrastructure and did not recognise downstream environmental water demands. Furthermore, most irrigators interviewed in Usangu had never met a river basin officer (SMUWC, 2001).

The policy insight here is that improved institutional arrangements and facilitation mechanisms are often inadequate but, if required, need to be attuned.

Policy Recommendations

The following paragraphs conclude on policy insights generated from this work. Connected to each paragraph is an existing and alternative view of irrigation policy given in Table 4. Various players in Tanzania including donor agencies hold the existing view. This argues that irrigation has clear benefits, is inefficient and has undeveloped potential or room for improvement 'which the government must do something about'. The replacement view is a more conditional understanding also held by many in Tanzania. This says that irrigation potential exists in Tanzania, but comes with unforeseen complexities; that it should be balanced against competing demands for water; that it is only realised by farmers operating within a complex irrigation-rural livelihoods system; and that it should be accompanied by an appreciation of the need for conflict mediation and a river basin perspective. Table 4 is further divided into two main sections; the upper argues for a better understanding of the irrigation-river basin approach; while the lower argues that certain policies and strategies should reflect this approach.

An irrigation livelihoods-river basin understanding

The first set of paragraphs in Table 4 relate to an understanding of irrigation livelihoods and river basins to inform policy formulation.

Farmer-livelihood integration. Irrigation can reduce poverty and irrigation systems will expand where and when a certain set of conditions exist:

1. Where physical and technical conditions – *as perceived by farmers* – are correct. This means the following are present: sufficient water as well as high security of water, good soils, slopes, space and command. In addition irrigation systems have technical systemic qualities that farmers are exposed to which dictates local distribution and availability of water. Other technical factors such as roads and location also count.
2. Where social, institutional and human transaction costs – *as perceived by farmers* – are acceptable. For example where the village more or less totally owns the irrigation system or where a system-wide WUA is in place that is synergistic with the village government (so that there are few quarrels between these institutions) so that land tenure issues and water distribution issues are resolved to assist a) landless b) the tail-enders c) downstream users. Where farmer irrigating skills are cost effective, being learnt and adopted. Where diversifications are, by comparison and replacement, either irrigation neutral or promote water management.

Table 4. Existing and ‘livelihoods-river basin’ views of irrigation policy

Stage	Current view informing policy	Irrigation river basin livelihoods view
<i>IRRIGATION UNDERSTANDING</i>		
Whose irrigation performance? (Farmer-livelihood integration)	‘Irrigation suffers from performance problems’, the solutions of which are imposed by external players who often see narrow ‘disciplinary’ problems.	Farmers with irrigation-based livelihoods are integrating across a wide range of social, economic and technical issues, responding and succeeding accordingly.
‘Normal’ vs cautionary irrigation approach	‘Irrigation is the addition of water to crops’. Fad-type thinking influences refinements to this theory.	Irrigation is complex and needs engaging with, using long-term programmes. Approach and fund with care, using long-term interdisciplinary, facilitator-type teams.
Irrigation potential vs actual irrigation livelihoods	‘Irrigation potential exists’, ready to be fulfilled: find it with land suitability mapping & planning.	It exists, can be fulfilled, but observe and understand how farmers see potential, choose to locate & develop irrigation. Assist this by ensuring market signals and economy reduces farmer risk and transaction costs.
A balanced irrigation-river basin livelihoods approach	‘Irrigation potential should be fully realised’. Consideration of downstream multi-sectoral demands tends to be forgotten.	Irrigation consumes water, which dries downstream sectors, this is especially important in a river basin with a seasonal hydrograph. River basin & conflict mediation approach vital.
<i>IRRIGATION POLICY FORMULATION AND DELIVERY</i>		
New large scale systems	No longer popular among donors, but when they are considered; whole system is designed by consulting engineers who do not operate it.	Might be necessary, but only in certain locations and only construct headworks? Let farmers build or sub-contract interdisciplinary teams to create remainder.
Policy vs cognitive approach (Situational analysis)	Policy-hegemony. (E.g. ‘Water must be paid for’. ‘Rights must be introduced’. ‘Community management is required’).	Adopt a problem-focus priority. ‘What realistically can be done to improve water management & reduce water use in this particular irrigation or riverine system?’
Institutional review and strengthening	Create irrigation WUA’s (then these tend to be left to own devices). Train farmers to own irrigation systems.	- Three tier institutions; 1) WUA at irrigation level (related to village govt); 2) RUA at river level; 3) Higher at district/river basin level. - Continue to assist in facilitation and mediation training of all institutional levels. - Promote synergy between levels/other institutions - Respond to farmer requests for help
Conflict mediation	Unrecognised by agencies	Equal weighting along irrigation development Capacity and awareness building needed Responsive, problem-orientated, demand-led
Pro-poor land & water distribution	Generally unrecognised by agencies	Conditional with new or rehabilitated systems. Special focus within institutional mediation projects and programmes? IMT on NAFCO farms Domestic/lifeline water supplies are critical.
<u>Technical issues</u> - Intake bias	Intake improvements over-emphasise upstream abstraction	Either leave traditional intakes alone or consider proportional weirs to divide water
- Within-irrigation technical options	Engineers like to line canals; create divisional networks & insist on water cycling or suggest drip/sprinkler.	Observe/build on what farmers consider are ways of saving/extending water. Help them focus on where water is being mismanaged.
- Formulating water demand and water right	The FAO method of demand = specific field demand x efficiency x area	Other methods: socially agreed division; design in drought; prior use; relate right accurately to actual design. Re-tune design if necessary

WUA – water user association, RUA – river user association, IMT – irrigation management transfer

3. Where economic transaction costs – *as perceived by farmers* – are minimised. On the whole input costs should be low (e.g. people are sufficiently numerous to create a mixing pool of labour availability and opportunities to diversify away from irrigation or within irrigation if necessary), where the cost and availability of borrowing are amenable; where output prices are profitable (related to market demand and stability) and market transactions are transparent and low in cost (e.g. minimal taxes and entry barriers)
4. Where sufficient time is given for the irrigation system to settle and evolve (perhaps at least 4 to 5 years). This also gives users a chance to teach themselves skills, to allow newcomers to bring fresh ideas and to observe cyclical patterns that can be planned for. Irrigation is a long-run endeavour.

Farmers integrate across all these livelihood, economic, community, physical and irrigation system dynamics. The flow charts of problems drawn by farmers as a part of the research (LADDER, 2001) demonstrate this connected complexity. In responding to and affecting these drivers and processes, they generally succeed ‘in context’. In addition, these conditions of success simultaneously mediate irrigation intervention. If successful conditions exist, external intervention is probably not required. If such conditions are deleterious to irrigation, then interventions are unlikely to be physically, economically and institutionally sustainable. Yet, conditions can be finely balanced; for example irrigation systems have downstream effects and externalities. Here, certain types of intervention are required; e.g. on conflict mediation and water management.

‘Normal’ vs. cautionary approach. The default irrigation understanding might be that irrigation systems are vibrant, dynamic and dependent. These dynamics might be interpreted as problems - some of which alarm outside organisations. However, the transaction and impact costs of an inexperienced organisation employing ‘normal’ but fashionable irrigation thinking to fix such problems may be higher than the costs associated with the problems themselves. In this case, there is a default donor situation: unless the donor has a clear track record and advantage in the sector as well as a cognitive strategy for getting involved, it may be best to take a highly cautious, long-term and careful tack, if at all.

Potential vs. actual irrigation. A departing point for policy would be to build on what farmers are themselves choosing to do. This contrasts with a view that considerable irrigation potential exists which must first be mapped and then fulfilled. It is probably safer and cheaper to realise that farmers are more sensitive to the irrigation-livelihood barriers and constraints (referred to above) than officials are and that irrigation growth relates to farmer perceptions. This paper argues that the surrounding regional and macro-economic policies can stimulate market and farming activity and affect the desire to resolve water management issues.

An irrigation-river basin livelihoods approach. Fully realising irrigation potential is risky because irrigation consumes water. The livelihoods approach tends to maximise per capita agricultural use at the local level, while a river basin approach check-balances that against downstream and ‘other-sector’ use of water. The danger is that a local emphasis without a catchment perspective might require a politically expensive re-tuning, post-hoc programme to reconcile upstream/downstream water use.

Policy formulation and delivery

New large-scale systems. In certain circumstances, it may be necessary for donors and GOT to provide the capital for major works beyond the reach of poor farmers. Herein lies the pluralistic nature of the debate; caution is necessary when arguing for a coherent approach to

small-scale irrigation because farmers are usually able to devise the necessary infrastructure themselves. Yet, there are places where new irrigation requires infrastructure constructed with outside help. These would by their nature not result in small-scale works, but in larger-scale developments of smallholder irrigation. There appears to be success already in this approach for example at Madibira and the Kapunga Smallholder Scheme. This argument also seems currently out of favour with donors, who appear to lack the confidence to establish larger-scale systems. One solution might be simply to construct the head works and let farmers develop the canal system. In doing so, farmers generate skills in organising labour to construct the system and indebted themselves to a claim on future water schedules.

Pro-poor elements could be designed into this approach, for example land settlement could part focus on plots for women, young and the poorest.

Theoretical vs cognitive approach. Irrigation intervention should be problem-centred rather than policy-centred. The latter tends to apply generic ideas insufficiently underpinned by detail, appropriateness and flexibility. Approaches such as introducing water rights, while pandering to notions of water management, do not acknowledge the site and stage dimensions of different irrigation systems. Instead, a cognitive approach is proposed, defined by having two key elements. Firstly, the identification of problems and the triangulation of their nature. This acknowledges that not all irrigation systems have problems worth tackling, and not problems have the same roots. The research in Chanzuru shows that rich set of irrigation-related properties, processes and activities exists at the system, village and catchment level. A cognitive approach not only seeks to fully understand this, but it draws on a wide set of ideas, best practices and criteria to solve problems. Secondly, as well as having a flexible analytical framework, stakeholder institutions need to be flexible, interdisciplinary and problem-focussed. This notion is not new in irrigation writing (and is recognised by Kalinga *et al* 2001), but such working modalities remain un-systemised in Government departments (for example the Draft Water Policy barely mentions irrigation, MWLD, 2001). Donors, who have the responsibility to help foster such conditions, often have relatively un-developed irrigation sections themselves (DFID is a case in point). This raises worrying concerns about the ability to tackle irrigation in a dedicated, focussed and relevant manner.

The pro-poor elements of this stem from successfully extending the benefits of irrigated land by a number of routes; from ensuring a more equitable supply of water at different scales; from resolving conflict in a focussed manner; by signalling benefits of irrigation via market accessibility and prices; and by minimising transaction costs (e.g. taxes and costly water rights).

Institutional review and strengthening. The framework of institutions involved in water resources management needs to be expanded beyond focussing on irrigation system water user associations (WUA's). In addition, village, sub-catchment level and river basin institutions need to be given careful thought. It is here that ways can be found of addressing conflict resolution, pro-poor poverty strategies and improved water management. Such a framework needs to be aware of both livelihoods and basin-wide need for water. The newfound World Bank policy of developing river user associations in selected Pangani sub-catchments is an example of this. However, this programme appears to be predicated on assumptions that local institutions are not already present, or that this will solve the problem of allocation without removing other constraints. In other words, the addition of this World Bank-funded institution may be theoretically correct but not necessarily problem-centred.

The pro-poor elements of this are similar to above; appropriate institutional mechanisms for delivering conflict solutions such as agreeing water scheduling rules and customs, and means of ensuring reward, redress and penalty.

Conflict mediation. Conflict mediation applies to both the river basin and sub-catchment scale, but also, importantly to the irrigation system. River basin institutions and appropriate intake design are part of the former. However, irrigation has special significance because, although government and donor institutions do not need to roll out irrigation, there is a case for their involvement and facilitation of improved water management. However, rather than this occurring because engineers dictate that irrigation efficiency is low, it is better framed as a response to requests by farmers who genuinely identify and verbalise water distribution problems. Such an approach has important dimensions of being problem-focussed, service-orientated, responsive, and demand led. Various activities are envisaged; partnership engineering, facilitation sessions, game and role-playing, farmer training, problem ranking and participatory institutional analysis.

The pro-poor elements of this stem from inclusion of the views of the poorest or of those bereft of their usual water supply in resolving issues related to land and water distribution, particularly ensuring the release of marginally small amounts of water.

Pro-poor land & water distribution. Singled out for mention is the need to recognise the special benefits derived from land and water distribution to the poorest within a community. Although this should be locally determined, government attention can be drawn to it, and mechanisms for it enhanced where possible. Land distribution is possible when donors have leverage during construction of new schemes or rehabilitation of existing systems. This includes smallholder settlement and irrigation management transfer on the two NAFCO farms in Usangu; Kapunga and Mbarali, where it is estimated 6000 families could be located.

Water lifeline needs for the poorest are critical; not necessarily for irrigation (since the demand is set by the threshold area cropped) but for domestic needs. Provision of domestic water is usually recognised as being a public good, best provided by governments, NGO's, projects or cost sharing with the community. In addition, surface waters for the environment and livestock have marginal benefits and are secured by having compensation flows below irrigation and domestic intakes. A river basin perspective ensures such balances are met.

Technical biases - intakes. The technical bias of irrigation interventions needs to be recognised but not necessarily diminished. The emphasis is on sensitive, apt and iterative engineering. Most irrigation improvement programmes in Tanzania currently favour upstream abstraction over downstream compensation. Yet, using sensible design protocols, engineering can do much to share water between both the irrigation intake and the river from which it abstracts.

Technical biases - within-system improvements. Likewise, within irrigation systems, design can be used to improve water management and not necessarily by 'lining canals'. For example, a cellular approach to tertiary water distribution can tell farmers where in the 'farmer cell' water is being overused and by whom. Interestingly, hierarchical networks combined with strict schedules, favoured by engineers, are often subverted by farmers who prefer to operate a constant flow. Yet, when water is in short supply, farmers in Usangu were observed to switch to a rotating supply. This flexibility is an important consideration when assisting farmers with new ideas.

Technical biases - formulating water demand and rights. Engineers calculating water demand and water rights should consider the traditional FAO method of determining water need (which is more appropriate for situations where water supply exceeds land or exceeds total downstream needs) as a cross-check to other methods. The latter might consider upstream/downstream needs, or seasonal dynamics and climate variability, or flexibility at the intake to accommodate low and high flows. Clearly this means determining the supply based on different criteria, agreeable to various stakeholders.

Conclusion

A rural livelihoods approach to irrigation is formulated as:

- a) An approach that recognises the many dimensions and complexities of irrigation arising from its role as a sector, input, system and activity.
- b) The understanding that farmers are integrating across a wide range of constraints, costs, benefits and risks when deciding whether to develop, expand irrigation or improve it.
- c) An argument that says farmers rather than officials are better placed to decide on how irrigation can be improved or potential be realised.
- d) A river basin approach that recognises the subtractability of water resources due to irrigation, and therefore the balance between upstream irrigation livelihoods and downstream environmental and livelihood needs.
- e) A recognition that conflict mediation at different irrigation-river basin scales may be as important as promoting irrigation.
- f) A recognition of the site, stage and context elements of irrigation so that ‘problems’ of irrigation are addressed using a cognitive, problem-solving approach, rather than the hurried application of theory informed by ‘normal’ viewpoints of agencies.
- g) An acknowledgement of the strong technical nature of irrigation (often underplayed in rural livelihood frameworks) – yet counterbalanced against the social side of irrigation and guarding against the tendency for design to be inappropriate.
- h) Recognition that farmers are interested in irrigation because of a number of benefits: income generation; food; food security and jobs. The links between these farmer-level benefits and national poverty, food security and unemployment strategies are not direct; suggesting the latter three are by-products of farmer interests.
- i) A recognition that the surrounding economic and cultural environment stimulates irrigation activity and the desire to resolve water-based conflicts (land tenure, markets, crop pricing, etc)
- j) The provision, where necessary, of services and infrastructure to facilitate access to very small amounts of water and/or irrigated land for the poor.
- k) The provision, where necessary, of the capital for major works beyond the reach of poor farmers.
- l) That, within the debate over national food security, a distinction is made between strategies for private-sector involvement, and those required to support pro-poor livelihoods.

In summary, this paper has strong parallels with arguments by Guijt and Thompson (1994) who examined small-scale irrigation, from which these quotes are taken:

“An environmental and socio-economic analysis of irrigated agriculture challenges us to come to terms with the complexity of local livelihood strategies in diverse and risk-prone environments”. (p. 295)

“Assumptions made by engineers and planners about social and economic realities and about the likely performance of systems reflect a limited perspective on landscapes and livelihoods which is often at odds with local realities” (p. 307)

“Irrigated agriculture is almost always only part of rural people’s livelihood strategies” (p. 307)

“Their livelihoods are strongly affected by macro-level economic and political processes, such as structural adjustment and land reform policies” (p. 308)

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