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Reducing Poverty through Investments in Agricultural Water Management

Poverty and Gender Issues and Synthesis of Sub-Saharan Africa Case Study Reports

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IWMI International Water Management Institute

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Part One

Poverty and Gender Issues

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Part Two

Synthesis of Sub-Saharan Africa Case Study Reports

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List of Acronyms

ApproTEC	-	Appropriate Technology for Enterprise Creation
DFID	-	Department for International Development
DANIDA	-	Danish International Development Agency
EU	-	European Union
EW	-	Enterprise Works
FAO	-	Food and Agricultural Organization
FGN	-	Federal Government of Nigeria
FIP	-	Farmer Initiative Project
IFAD	-	International Fund for Agricultural Development
IWMI	-	International Water Management Institute
NGOs	-	Non-Governmental Organizations
PHBM	-	Upper Mandrare Development Project
PIP	-	*Petite Irrigation Privée*
PIDP	-	Participatory Irrigation Development Program
RBDA	-	River Basin Development Authority
RELMA	-	Regional Land Management Unit (East and Central Africa Region)
SDARMP	-	Smallholder Dry Areas Resource Management Project
SSA	-	Sub-Saharan Africa
UNDP	-	United Nations Development Program
USAID	-	United States Agency for International Aid Development
WB	-	World Bank
WUA	-	Water User Associations

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Summary

The overall goal of the Collaborative Program on 'Investments in Agricultural Water Management in Sub-Saharan Africa' is to contribute to broad-based sustainable poverty reduction and smallholder agricultural growth. The component on 'Poverty considerations in investments in agricultural water management' focuses in more detail on poverty and gender dimensions. It consists of two parts. The first part is thematic and elaborates poverty and gender issues emerging from the literature that complement the other components of the Collaborative Program. Part two is empirical. Acknowledging the lack of empirical data on poverty impacts of investments in agricultural water management, the Collaborative Program initiated case studies throughout Sub-Saharan Africa. Eight case studies on 'Agricultural Water Development for Poverty Reduction in Eastern and Southern Africa', for which the field research was conducted in 2003/2004, were supported by IFAD (Peacock, 2005). Further, the African Development Bank supported three case studies in West Africa in 2004, two by Kamara et al. (2004), and one by Babatunde Omilola (2005). Part two synthesizes the empirical findings of these case studies.

Part One: Poverty and Gender Issues

Part one starts with the well-known global consensus underlying any program focusing on investments in agriculture for poverty eradication in Africa. This is the global recognition that agricultural growth has been the engine of overall economic growth in the past in all countries where such economic growth has been realized, with only mineral-based economies as exceptions to that rule. This fact underscores that agricultural growth can have a similar role for Africa and the few other parts in the world where such growth is still absent, if similar public investments and similar marketing and trade support for agriculture are provided. Moreover, it requires accounting for typical African endogenous conditions, but, above all, the more adverse global conditions due to the low world market prices, cheap imports and dumping of food aid that constitute stronger obstacles for agricultural growth than any other country faced in the past. Some of these challenges are addressed in other components of the Collaborative Program. The role of diverse forms of improved water control, and likely impacts on poverty and gender dynamics, is also addressed in other components.

The second theme concerns an important endogenous factor: the agrarian structure, which underpins targeting strategies. One aspect of the agrarian structure is farm size: is agricultural growth to be achieved through large-scale farming (which requires less public investment), or by promoting smallholder family farming (which definitely requires public support to take off, though returns on well-designed investments in smallholder agriculture seem to justify such investments)? Asian literature comparing poverty and productivity aspects of investments in agriculture in general is unanimous about the win-win scenario of agricultural growth through poverty alleviation at low levels of mechanization – the preponderant Sub-Saharan African condition. The few Asian studies explicitly on poverty and irrigation also confirm that less poverty goes hand in hand with better productivity through irrigation. The scarce literature on the farm size – productivity issue in Sub-Saharan Africa seems to suggest the same.

However, given the lack of empirical data, there is an urgent need to monitor poverty and gender impacts empirically in order to further substantiate poverty reduction impacts. Recommendations to this end include the need for a clear poverty definition and differentiation between various categories of the poor benefiting from public investments. These may include self-employed farmers

and/or wage workers as the most direct beneficiaries, or those benefiting through the multiplier effects, for example local service-providers responding to increased demand for local goods and services, or poor net food buyers. Such definition includes the poorest, who more often than not benefit less than the 'cream of the poor' and local non-poor, and may even become worse off.

A second aspect of the agrarian structure and targeting strategies is gender. A similar synergy between agricultural growth and increased equity holds for gender, given the fact that dual farming systems prevail in most of Sub-Saharan Africa. Exhaustive African evidence has proven that gender-sensitive targeting of investments, that is, targeting the farm decision-maker, whether a man or a woman, is not merely a welfare issue, but a major factor to achieve agriculture growth. Further growth can be reached if accompanying measures ensure that women farm decision-makers are vested with access to land, water, inputs, markets, training, and control over the fruits of their labor on the same footing as men farm decision-makers. Given women's strong roles in African agricultural decision-making (and not just family labor provision), the potential acceleration of growth if agricultural development is more gender-equitable is higher in Sub-Saharan Africa than elsewhere in the world. This endogenous feature of African smallholder agriculture and irrigation is insufficiently recognized.

The third theme of Part One complements the other components of the Collaborative Program by focusing on the poverty implications of the formal legal and institutional environment of water development and management, in particular Integrated Water Resources Development (IWRM) reforms. Comparing the compatibility between the Collaborative Program objective for investments in water development and management to achieve poverty alleviation and IWRM reform as implemented in Africa since the 1990s, one emerging field of incompatibility is that IWRM reform focuses on formal regulation of water management through elaborate formal administrative water rights systems, new basin organizations, and pricing of water. As such, these measures may be effective to regulate the few large-scale users – but they are difficult, if not impossible to implement in a cost-effective and equitable way among the masses of informal water users, the target group of the Collaborative Program. More importantly, though, the Collaborative Program seeks to promote investment in new development of Sub-Saharan Africa's often abundant water resources – an option only gradually being recognized as a legitimate part of IWRM in Africa.

Another issue, the conventional role of government as investor in water infrastructure development is not yet addressed in the IWRM debates either. The private sector component of the Collaborative Program highlights the potential opportunities if government creates a more enabling environment for private initiatives by farmers, local small-scale private sector, national and international private sector, and civil society. Yet, it is also increasingly being realized that the private sector will not replace governments in their roles as investors in water development, especially in poor rural areas. The planning and implementation component of this study also identified a lack of sustainable structures of the receiving governments with whom new projects could be implemented, local capacity built, and innovations upscaled. This report discusses ongoing initiatives to transform governments to strengthen their roles as investors and implementers, especially at local level, and to deliver in a participatory, transparent, and accountable way with strong involvement of rural communities.

In sum, for more effective poverty reduction through broad-based agricultural growth:

a. Allocate public funds to targeted agricultural growth as an investment with sufficient economic returns and as the single most effective way to trigger overall economic growth and to improve the wellbeing of Africa's majority of poor.

b. For combined poverty and productivity considerations, target the poor and monitor progress through poverty impact assessments, based on clear definitions of poverty that differentiate between the poor and poorest.

c. Remove gender obstacles for women producers to promote agricultural growth at a potentially massive scale.

d. Re-design the roles of governments as investors in water infrastructure, including building capacity for sustainable project implementation.

e. Integrate governments' roles as water regulator and as investors, in order to provide an optimal legal and institutional environment for investments in water infrastructure that contribute to poverty alleviation.

Part Two

From the understandings gained from the case studies and literature reviews done by Peacock (2005) in East and Southern Africa, Omilola (2005) in Nigeria, and Kamara et al. (2004) in Ghana and Niger, the following conclusions can be derived:

a. The performance of irrigation water management with respect to economic growth and poverty reduction is greatest when complementary investments are made in related infrastructure and services. Thus, along with investments in water resources development, invest also in roads, education, agricultural related industries and services.

b. Irrigation water, though critical, is only one of the factor inputs or services essential for enhancing farm productivity and income. Therefore, strengthen the support services such as agronomic research, extension system and financial services.

c. Related to the above is the finding that access to irrigation alone by the poor or poorest does not automatically guarantee improvements in the wellbeing of the poor. Poor people with access to irrigation are found to operate at less than half the productivity levels achieved by the better-off farmers. Therefore, special consideration needs to be given to the poor in terms of training to upgrade their agronomic and others skills, credit provision, extension and access to inputs and other services.

d. Consider the special needs of women in irrigation technology design; and remove gender obstacles for women producers to promote agricultural growth at a potentially massive scale.

e. One of the single most important problems raised by farmers is the lack of markets or the inefficiency of markets. Special institutional, organizational, legal, and regulatory mechanisms that enhance the functioning of markets need to be instituted.

f. The adopters of water lifting pump should be given specific training on self-maintenance of the pumps rather than entirely relying on NGOs so that sustainability is ensured.

Resume

L'objectif global du Programme de collaboration axé sur l'investissement dans la gestion des eaux agricoles en Afrique sub-saharienne (*Collaborative Program on Investment in Agricultural Water Management in Sub-Saharan Africa*) vise à contribuer à la réduction durable de la pauvreté sur une grande échelle, ainsi qu'à la croissance basée sur les petites exploitations agricoles. Le volet 'Questions sur la pauvreté dans le cadre des investissements dans la gestion des eaux agricoles' (*'Poverty considerations in investments in agricultural water management'*) se concentre de manière plus détaillée sur les aspects liés à la pauvreté et à l'égalité entre hommes et femmes. Elle comprend deux parties. La première partie est thématique et approfondit les sujets liés à la pauvreté et à l'égalité entre les hommes et les femmes qui apparaissent dans la documentation et complètent les autres volets du Programme de collaboration. La deuxième partie est empirique. Après avoir constaté le manque de données empiriques concernant l'impact sur la pauvreté des investissements dans la gestion des eaux agricoles, le Programme de collaboration a mis en place des études de cas dans toute l'Afrique subsaharienne. Le FIDA a financé huit études de cas relatives au 'Développement des eaux agricoles pour réduire la pauvreté en Afrique orientale et méridionale' (*'Agricultural Water Development for Poverty Reduction in East and Southern Africa'*), pour lesquelles le travail sur le terrain a été réalisé en 2003-2004 (Peacock, 2005). Ensuite, la Banque africaine de développement a financé trois études de cas en Afrique occidentale en 2004: deux études de Kamara et al. (2004), et une troisième de Babatunde Omilola (2005). La deuxième partie résume les résultats empiriques de ces études de cas.

Première partie : Questions liées à la pauvreté et à l'égalité entre hommes et femmes

La première partie commence par une idée généralement admise et bien connue à la base de tout programme axé sur les investissements dans l'agriculture pour éliminer la pauvreté en Afrique. Tout le monde s'accorde à reconnaître que la croissance agricole a été le moteur de la croissance économique générale dans le passé de tous les pays où cette croissance économique a eu lieu, les seules exceptions à la règle étant les économies basées sur l'extraction de minerais. Cette réalité souligne que la croissance agricole peut jouer un rôle similaire en Afrique et dans les rares autres parties du monde où cette croissance reste inexistante, à condition de prévoir des investissements publics similaires ainsi qu'un soutien commercial et des efforts de marketing comparables au profit de l'agriculture. De plus, elle oblige à prendre en compte les conditions endogènes propres à l'Afrique et, par-dessus tout, le contexte mondial plus défavorable dû au bas niveau des prix sur le marché mondial, aux importations à bon marché et à l'aide alimentaire, autant d'obstacles à la croissance de l'agriculture qui s'avèrent plus difficilement surmontables que tous ceux qu'ont dû affronter les autres pays dans le passé. Certains de ces défis sont abordés dans d'autres éléments du Programme de collaboration. Le rôle de différentes formes d'amélioration du contrôle des eaux, ainsi que leur impact probable sur la dynamique de la pauvreté et de l'égalité entre les hommes et les femmes, sont également l'objet d'autres volets.

Le second thème porte sur un facteur endogène important : la structure agraire, qui étaye les stratégies de ciblage. Un premier aspect de la structure agraire est la dimension des fermes : la croissance agricole doit-elle passer par l'agriculture à grande échelle (qui nécessite un investissement public moins important) ou par la promotion des petites exploitations familiales (qui ont certainement besoin d'aide publique pour démarrer, alors que les retours sur les

investissements bien conçus dans les petites exploitations agricoles semblent justifier ce genre d'investissements)? La documentation asiatique qui compare les aspects liés à la pauvreté et à la productivité des investissements dans l'agriculture en général est unanime: la croissance agricole par la réduction de la pauvreté à travers un faible niveau de mécanisation, ce qui est généralement le cas en Afrique sub-saharienne, aboutit à une situation de gagnant-gagnant. Les rares études asiatiques spécifiquement axées sur la pauvreté et l'irrigation confirment également qu'une réduction de la pauvreté entraîne une meilleure productivité des programmes d'irrigation. Les quelques documents portant sur le rapport entre productivité et dimension des fermes en Afrique sub-saharienne semblent suggérer les mêmes conclusions.

Suite au manque de données empiriques, il est cependant urgent d'examiner de manière empirique l'impact sur la pauvreté et l'égalité entre hommes et femmes afin de démontrer plus clairement cet impact sur la réduction de la pauvreté. Dans cette optique, on recommande notamment d'élaborer une définition claire de la pauvreté et de différencier les diverses catégories de pauvres bénéficiant d'investissements publics. Il peut s'agir de fermiers indépendants et/ou ouvriers agricoles qui sont les bénéficiaires les plus directs, de ceux qui bénéficient des effets multiplicateurs – tels que les fournisseurs de services locaux qui répondent à une demande accrue de marchandises et services locaux – ou encore des pauvres acheteurs nets de nourriture. Une telle définition englobe les plus pauvres, qui bénéficient trop souvent moins des investissements que le 'gratin' des pauvres et la population locale plus aisée. Ils risquent même de devenir encore plus pauvres qu'auparavant.

Un deuxième aspect de la structure agraire et des stratégies de ciblage est la dimension de genres. Une synergie similaire entre croissance agricole et équité accrue s'applique aussi à l'égalité entre hommes et femmes, puisque les régimes agricoles duales, c'est-à-dire des regimes agricoles dans lesquelles a peu pres autant d'hommes que de femmes sont decideurs des systemes de production dominent dans la plus grande partie de l'Afrique sub-saharienne. De nombreux cas observés en Afrique ont démontré que l'attention accordée par le ciblage des investissements à l'égalité entre hommes et femmes, à savoir un ciblage visant le décideur de la ferme, qu'il soit un homme ou une femme, n'est pas seulement une question de bien-être, mais encore un facteur important pour réaliser la croissance agricole. La croissance peut être prolongée si des mesures d'accompagnement garantissent que les femmes décisionnaires dans les fermes puissent accéder à la terre, à l'eau, aux matières premières, aux marchés, aux formations et au fruit de leur travail au même titre que les hommes décideurs dans les fermes. Les femmes jouant un rôle décisionnel important dans l'agriculture africaine (elles ne se limitent pas à la fourniture de main-d'œuvre familiale), l'accélération potentielle de la croissance sera plus importante en Afrique sub-saharienne que n'importe où ailleurs si le développement agricole accorde plus d'attention à l'égalité entre les hommes et les femmes. Cette caractéristique endogène de l'agriculture et de l'irrigation des petites exploitations africaines est insuffisamment reconnue.

Le troisième thème de la Première Partie complète les autres éléments du Programme de collaboration en se concentrant sur les effets quant à la pauvreté de l'environnement légal et institutionnel formel du développement et de la gestion des eaux, et plus particulièrement des réformes de la Gestion intégrée des ressources en eau (GIRE). Une comparaison de la compatibilité de l'objectif de réduction de la pauvreté du Programme de collaboration par les investissements de développement et de gestion, et de la réforme de la GIRE se concentrant sur la réglementation formelle de la gestion des eaux par des systèmes administratifs formels détaillés des droits des eaux, la creation des organisations de bassin et la fixation du prix de l'eau. Ces mesures, prises isolément, peuvent s'avérer efficaces pour réguler les rares consommateurs à grande échelle mais elles sont difficiles, voire impossibles à mettre en œuvre de manière rentable et équitable parmi les masses de consommateurs d'eau informels, qui sont le groupe cible du Programme de collaboration. Cependant,

ce qui est plus important, le Programme de collaboration cherche à promouvoir les investissements dans un nouveau développement des ressources hydriques souvent abondantes de l'Afrique sub-saharienne, une option qui n'est que progressivement reconnue comme une partie légitime de l'action de la GIRE en Afrique.

Une autre question, celle du rôle conventionnel du gouvernement en tant qu'investisseur en développement d'infrastructures hydriques, n'a pas encore été abordée dans les débats de la GIRE. Le volet 'secteur privé' du Programme de collaboration souligne les opportunités potentielles que peut favoriser le gouvernement en créant un environnement plus favorable aux initiatives privées de la part des fermiers, des petites entreprises privées locales, du secteur privé national et international et de la société civile. On réalise toutefois de plus en plus que le secteur privé ne remplacera pas les gouvernements dans leur rôle d'investisseur en développement hydrique, surtout dans les zones rurales pauvres. Le volet 'planning et mise en œuvre' de cette étude a aussi identifié un manque de structures durables des gouvernements bénéficiaires avec lesquelles de nouveaux projets pourraient être mis en place, des compétences locales être construites et les innovations gagner en ampleur. Ce rapport parle d'initiatives en cours pour transformer les gouvernements afin de renforcer leurs rôles d'investisseurs et d'exécuteurs, surtout au niveau local, et d'assurer ce rôle de manière participative, transparente et responsable avec une forte implication de la part des communautés rurales.

Bref, pour réduire la pauvreté de manière efficace par une croissance agricole diversifiée :

a. Il faut allouer des fonds publics à la croissance agricole visée comme investissement assurant un rendement suffisant et comme la manière la plus efficace de stimuler la croissance économique générale et d'améliorer le bien-être de la plupart des pauvres en Afrique.

b. Pour des raisons liées à la fois à la pauvreté et à la productivité, s'adresser aux pauvres et surveiller les progrès en évaluant l'impact sur la pauvreté sur la base de définitions claires de la pauvreté qui font une distinction entre les pauvres et les plus pauvres.

c. Éliminer les obstacles liés à la dimension de genre auxquels sont confrontées les productrices afin de promouvoir la croissance agricole à une échelle potentiellement énorme.

d. Repenser le rôle des gouvernements en tant qu'investisseurs dans l'infrastructure hydrique, y compris le développement de compétences permettant de mettre en œuvre des projets durables.

e. Intégrer le rôle de régulateur et d'investisseur des gouvernements en matière d'eau, afin de créer un environnement légal et institutionnel optimal pour les investissements en infrastructures hydriques qui contribuent au soulagement de la pauvreté.

Deuxième partie

On peut tirer les conclusions suivantes des connaissances apportées par les études de cas et de documentation réalisées par Peacock (2005) en Afrique orientale et méridionale, par Omilola (2005) au Nigeria, et par Kamara et al (2004) au Ghana et au Niger :

a. La gestion des eaux par irrigation est plus performante en termes de croissance économique et de réduction de la pauvreté lorsque des investissements complémentaires sont consacrés aux infrastructures et services liés. Tout en investissant dans le développement des ressources

hydriques, il faut donc aussi investir dans l'infrastructure routière, l'éducation, les industries et les services liés à l'agriculture.

b. L'eau d'irrigation est critique mais n'est qu'un des facteurs ou services essentiels pour améliorer la productivité et le revenu des fermes. Il faut donc renforcer les services de soutien, tels que recherche agronomique, systèmes d'extension et services financiers.

c. Le point ci-dessus entraîne la conclusion que la disponibilité de l'irrigation à la portée des pauvres ou des plus pauvres ne suffit pas pour garantir automatiquement des améliorations de leur bien-être. On constate que la productivité des pauvres qui ont accès à l'irrigation est inférieure à la moitié de celle des fermiers plus aisés. Il faut donc accorder une attention particulière aux pauvres en termes de formation en vue d'améliorer leurs capacités agronomiques et autres, l'accès au crédit, l'extension et l'accès aux matières premières et autres services.

d. Envisager les besoins spécifiques des femmes dans la conception de technologies d'irrigation ; et éliminer les obstacles liés à la dimension de genre auxquels sont confrontées les productrices afin de promouvoir la croissance agricole à une échelle potentiellement énorme.

e. Un des plus gros problèmes évoqués par les fermiers est le manque de marchés ou leur inefficacité. Des mécanismes institutionnels, organisationnels, légaux et régulateurs spéciaux améliorant le fonctionnement des marchés doivent être mis en place.

f. Afin d'assurer leur viabilité à long terme, les utilisateurs de pompes d'extraction d'eau devraient pouvoir suivre une formation spécifique pour apprendre à entretenir eux-mêmes ces pompes, plutôt que de dépendre entièrement d'ONG.

Part One
Poverty and Gender Issues

Barbara van Koppen and Constantina Safilios-Rothschild

1. INTRODUCTION

The overall goal of the Collaborative Program on 'Investments in Agricultural Water Management in Sub-Saharan Africa' is to contribute to broad-based sustainable poverty reduction and smallholder agricultural growth. The role of agricultural growth in reducing poverty and triggering overall economic growth has been thoroughly studied and has led to wide consensus in the international development community and academia that agricultural growth has been the engine of overall economic growth and poverty eradication elsewhere in the world and can potentially become so in Africa (World Bank 2003; IFAD 2001). Improved agricultural water management has been identified as one of the critical conditions for agricultural growth. In section two, the evidence for this starting point is briefly recapitulated.

Thus, the question is not *whether* agricultural growth can potentially be the engine of overall economic growth and poverty eradication, but *how* can agricultural growth, targeted to the poor and women, be achieved in today's global context, which presents harder conditions for poverty alleviation through agricultural growth than for the high- and middle-income countries that escaped poverty in this way in the past? Two key issues are further elaborated: the agrarian structure with related targeting strategies, and the current legal and institutional environment of water development and management, often referred to as Integrated Water Resources Management (IWRM).

Section three focuses on the importance of the agrarian structure and examines targeting approaches underpinning broad-based agricultural growth by poor smallholders, both women and men, and planning and monitoring tools according to wealth-status and gender-differentiated impact assessments.

Section four discusses a crucial aspect of the legal and institutional environment required for pro-poor investments in agricultural water development, in particular the role of government both as the custodian of the nation's water resources and as the key-investor in infrastructure. During the past decades much emphasis has been placed on the untapped opportunities of the private sector, community-based groupings, NGOs and civil society, as also highlighted in the other component studies of the Collaborative Program (e.g., Penning de Vries et al. 2005). However, this was often accompanied by curtailment of government investments in water development, and the introduction or strengthening of government's role as regulator of the nation's water resources. As in other domains, such as input provision, where withdrawal of the state has left a vacuum that the private sector failed to fill, especially for the majority of poor smallholders, the same is found for investments in water infrastructure (World Bank 2004). Current planning and implementation of major projects also tend to be along *ad-hoc* parallel structures that may even further drain under-sourced government machineries rather than building their capacity for sustainable functions (see Planning and Implementation Component, Morardet et al. 2005). Section four explores initiatives in which government itself is sought to be *transformed* to address weaknesses identified in the past as service provider to the poor.

2. AGRICULTURE AS ENGINE OF ECONOMIC GROWTH AND BROAD-BASED POVERTY REDUCTION: THE ROLE OF WATER

2.1 Agriculture as engine of economic growth

As economists have pointed out since the 1960s, agriculture has been the engine of overall economic growth and, therefore, broad-based poverty reduction throughout history (Johnston and Mellor 1961, World Bank 1982, Timmer 1988, Abdulai and Hazell 1995, IFAD 2001, DFID 2002, Koning 2002).

This conclusion is based on the analysis of the historical development paths of countries worldwide. Economic growth in high-income countries and recent growth in the Asian Tigers such as Thailand, Malaysia, Indonesia, Vietnam, or parts of China were typically preceded by and based upon agricultural growth. Higher farm productivity enhanced producers' own incomes, in cash and in kind, and created demand for agricultural labor. This growth was multiplied in various ways: first, through backward linkages with an agricultural input supply sector; second, through forward linkages with agro-processing industries, transportation, and trade, and, third, through consumer linkages when enhanced rural prosperity leads to new demands for goods and services from especially rural, but also urban providers. Further, production of export crops brought foreign exchange. Last but not least, the availability of food at relatively low prices enabled the growing labor force (employed in agriculture, expanding secondary and tertiary sectors) to feed itself at modest wage rates. This reduced hunger among poor net food buyers, who spend more than half of their incomes on food, and facilitated other sectors to grow at the same time, while expanding national food demand kept food prices sufficiently high to encourage farmers to enhance productivity. The few exceptions to this remarkably uniform pattern of economic growth in the world prove the same: only in oil- or mineral-based economies, agriculture may have lagged behind (World Bank 1982). In all cases of agricultural growth in the past, governments and other public agencies played and still play a critical role in investing in agriculture, for example by investing in irrigation development and other measures to boost productivity and output, as during the Green Revolution in Asia.

In Africa and South Asia, the regions where poverty is most prevalent, it is sometimes assumed that off-farm enterprise, industries, trade, eco-tourism, and services are the 'more important' sectors. This tends to be based on the observation that growth in GDP is typically accompanied by a decline in the share of agriculture in GDP and in the share of the labor force employed in agriculture, and urbanization. In this reasoning, stimulating a backward sector like agriculture would even 'block the poor in a poverty trap'. However, this reasoning confuses causes and effects. Secondary or tertiary production is not an *alternative* growth pole, but depends heavily upon agriculture. Growing rural and urban off-farm employment *reflects* agricultural growth. During the agrarian transition of today's high- and middle-income countries, the rural labor force got increasingly absorbed in sectors that developed *as a result* of agricultural growth. Similarly, in today's developing countries, rural poverty alleviation contributes to urban poverty alleviation, but not the other way around. In Sub-Saharan Africa, the stagnation of agriculture is the major *cause* of overall economic malaise and marginal secondary and tertiary sectors, at least in countries without major mineral resources.

The fact that African smallholders today are poorer and less productive than farmers elsewhere in the world is largely explained by precisely this lack of public support for, if not underdevelopment of, African farmers. Historically, smallholder agriculture in Sub-Saharan Africa has been taxed rather than subsidized. Limited public support during the first three quarters of the 20th century was biased towards large-scale, mechanized, white settler agriculture and capital-intensive, notoriously inefficient state-managed estates. Extractive marketing boards appropriated a substantive proportion of the value of export produce and kept food prices artificially low to favor an urban minority. International development policies since the 1980s, including structural adjustment programs, restricted public investments in agriculture again. At the same time, smallholders face increasing market competition from imports (IFAD 2001). Food demand is increasingly met by imports, either on a commercial basis or in the form of food aid. While only 15 percent of cereal imports were met by aid in 1970, food aid now meets about half of the aggregate food gap. These and other factors explain the alarming declines in per capita agricultural productivity to less than two percent in the past two decades and the declining shares of African exports in world trade (Benneh 1996).

While there is little doubt that agriculture is the single most important potential engine of broad-based poverty alleviation and economic growth in Sub-Saharan Africa, the question *how* to effectuate is considerably more complicated than for the more developed world. The position of the still agrarian economies of Sub-Saharan Africa in the global agricultural markets is worse today than it was in the past for other parts of the world, in particular because of declining world market prices for agricultural commodities since the 1960s (Dorward et al. 2003). The farm supports and market and price policies in Europe, USA, and recently in emerging Asian countries like Japan and Korea have ensured high incentives for their farmers from the early stages of development onwards. These subsidized products dumped on the world market undermine African smallholder agriculture by drastically depressing farm prices (Lipton 2005). Most of the debate on how to respond to this unfair and poverty-aggravating competition focuses on the abolishment of these subsidies by the developed countries (Lipton 2005; Dorward et al. 2003; OXFAM website). However, others point at the option of setting import tariff barriers. The latter option has been successfully implemented in the past by middle- and high-income countries and is, in principle, more in the hands of African governments themselves. The belief that protection necessarily leads to inefficiencies may be true for monopolistic industry, but there is no such empirical evidence for the agricultural sector, where millions of enterprises compete. Significantly, market protection in agriculture in Europe went hand in hand with *increases* in land and labor productivity (Koning 2002).

2.2 Irrigation for agricultural growth and poverty reduction

Among the many closely related aspects of agricultural growth, discussed in the Collaborate Program, improved control over water for cropping is an important supply-side factor. This is both a matter of intensifying cropping and to some extent opening up currently barren lands for cultivation. The effects are well-known: improved water control increases and stabilizes agricultural yields during the main cropping season. Moreover, it enables another cropping season up to year-round cultivation, which also encompasses the hunger season and seasons in which employment tends to be low. Improved water control reduces the risk of crop failure, which is critical to motivate farmers to invest and adopt higher-yielding varieties of food crops, diversify into higher-value cash crops, apply fertilizers and pest management, and intensify farm labor and practices. Improved water control also prevents soil erosion.

The importance of water development for livestock, agro-forestry, fisheries, small businesses, brick making, and, last but not least, domestic water provision is also evident, and certainly for the poor and for women (see also the Livestock Component, Peden et al. 2005).

These straightforward linkages between improved control over water and cropping and related impacts underlie the consistent Asian research findings that irrigation development alleviates poverty in rural areas of developing countries (Mellor and Desai 1985; Chambers et al 1989; Hossain 1989, Hussain 2005). These studies document the impacts of investments in irrigation. Evidently, ultimate impacts on wellbeing also largely depend upon other factors than water. So while poverty can be better and more cost-effectively alleviated if such concerns are also taken into account, as elaborated in the cost and health and environment components (Inocencio et al. 2005; McCartney et al. 2005), the overall conclusion of the poverty and irrigation research is clearly that investments in irrigated agriculture in developing countries alleviate poverty through agricultural growth, in some conditions massively, with water as the key trigger for this progress.

At least in Asia, there is ample evidence at different aggregate levels of the logical implication of the above argument (Desai and Mellor 1985; Chambers 1989; Hossain 1989), and this is further

confirmed and nuanced by studies by the International Water Management Institute and others. Globally there is a strong positive relationship between higher density of irrigation and lower poverty rates, as Lipton indicates (Lipton et al. 2003). In Africa, only 3 percent of cropland is irrigated and the region has experienced very little reduction in the 1990s (World Bank 2000). In contrast, those regions that have the greatest proportion of cultivated area irrigated (namely East Asia, Pacific, North Africa and Middle East) have experienced the greatest poverty reduction. In addition, 30-35 percent of cropland in Asia is irrigated and poverty reduction in the 1970s, the period immediately following the Green Revolution in which much initial investment in irrigation was made, was substantial (Lipton et al. 2003). Similarly, for example in Gujarat, India Shah (2003) found that poverty incidences are lower in districts (*talukas*) with more irrigation. However, irrigation is a sufficient condition for lower poverty rates, but not necessary. There are also talukas with low poverty incidences and with low irrigation. In those talukas other factors than irrigation account for poverty reduction.

Hussain (2004; 2005) examined the impact of irrigation on poverty reduction by comparing poverty in large-scale canal irrigation and in rainfed agriculture in six Asian countries. He found that chronic poverty levels in the irrigated perimeters were 20 to 30 percent lower than in rainfed agriculture. Moreover, this study and other studies confirm higher poverty levels in the tail ends where access to water is weaker (Hussain 2004; Van Koppen et al 2002). Further, Hussain (2005) showed that land reform was the single most important factor explaining the good performance of irrigation schemes of China and Vietnam, as compared to the highly skewed systems in Pakistan, Bangladesh and India, in terms of poverty alleviation. Moreover, productivity in the more equitable systems of China and Vietnam was just as good, if not better, on small farms as on large. Equity appears to be good for economic growth as well as for the poor.

3. TARGETING AGRICULTURAL INVESTMENTS FOR PRODUCTIVITY, POVERTY REDUCTION, AND GENDER EQUITY

3.1 Rational for productivity enhancement through poverty reduction

Since the early 1990s, a clear policy change has taken place towards targeting of investments in agriculture and agricultural water management to poor smallholders, at least in the ultimate project goals (World Bank 1990, Jazairy et al. 1992). This obvious condition for effective and broader poverty reduction is justified by ample evidence of the productivity of poor smallholders and the sound economic returns of public investments in their enterprises. While most research has been carried out in Asia (*cf* Berry and Cline 1979), findings from Côte d'Ivoire confirm the same finding (Adesina and Djato, 1997). Both in Asia and Africa, the processes explaining the well-documented inverse relationship between farm size and land productivity are the most important justification of ongoing redistributive land reform. In Africa, it is true that large-scale private farmers and estates need less public support for their establishment and expansion. These trends continue, for example in Zambia, Ethiopia, Nigeria, Tanzania, or Mozambique, where large-scale farmers from, e.g., Zimbabwe and South Africa increasingly settle. However, this *laissez-faire* approach relying on highly skewed agricultural growth by large-scale farmers, who may employ some wage laborers but are often already rather mechanized, exacerbates pressures on land and landlessness, increasingly a serious problem in Africa. Although well-negotiated joint ventures may generate more substantive rewards for smallholders, agricultural growth that relies on a minority of large farms is no alternative

for the need and potential to boost broad-based agricultural growth, and also build the purchasing power of the large majority of Africa's farmers.

Investments in smallholder agriculture make economic sense because poor farmers are more efficient producers than large farmers if they receive similar support, or even under slightly more adverse conditions. The processes through which this inverse relationship is effectuated have been well documented for Asia, even under conditions in which larger farmers benefited more from state support, scale effects, and input and output market than small farmers (Berry and Cline 1979; Jazairy et al. 1992; IFAD 2001). However, the very poorest in Asia, as well as smallholders in countries where support has been highly skewed in the past leading to huge current differences in skills, level of mechanization, access to input and output markets, as in South Africa, may have been too disadvantaged to maintain such an inverse relationship.

The following three reasons explain the inverse relationship (Berry and Cline 1979; Jazairy et al. 1992; IFAD 2001; Hossain 1989). First, smaller farmers tend to produce more per unit of land than larger farmers, because of a higher-value crop-mix, more double cropping and intercropping, and less fallowing. Yields are often also higher, especially in Asia. Second, labor input is higher among smaller farmers. This involves family members, but in some cases wage labor per unit of land was also found to be higher in smaller farms than in larger farms (Hossain 1989). Third, prosperity among small farmers leads to a demand for goods and services that are locally produced, including food, while better-off farmers tend to spend their newly acquired incomes on non-local non-farm products and services (Lipton 2005).

As the majority of farmers in Sub-Saharan Africa are poor smallholders, their aggregate potential as both producers and consumers of food and other goods and services of fellow-smallholders is significantly more important than that of a small minority of large-scale farms. Moreover, returns to investments in totally un-serviced sectors of the population are even claimed to the have highest rates of return (Jazairy et al 1992).

3.2 Gender and productivity

Investing in both women and men farmers and removing gender obstacles that women face in farming is critical for agricultural growth in Sub-Saharan Africa. Women constitute not only the major agricultural labor force but they are often also the farm decision-makers. Women more often tend to be involved in the cultivation of vegetables and fruits but also in cash crops such as tea, coffee, cocoa and rice. Since long, rice cultivation in wetlands in West Africa but also in parts of Southern Africa is a 'female farming system'. With the feminization of agriculture and men's growing migration to the highly gender-segregated urban labor markets, women also become more often the farm decision-makers in formerly male-managed fields. For example, in Southern African countries the proportion of female-headed rural households and women-led farms in incidental districts may go up to 50 to 90 percent (Safilios-Rothschild 1994; FAO 1998; Makhura and Ngqaleni 1996; Van Koppen 2002). In Burkina Faso**,** married women typically have their own production sub-unit, besides their labor contributions to men's plots. Women cultivate independently 20 to 25 percent of the total land (Imbs 1987; Burkina Faso, Ministère de l'Agriculture et de l'Elevage 1989). Also in Kenya it was found that in general the smaller the size of the total land, the higher is the percentage of land in wives' plots (Safilios-Rothschild, 1986).

While there is great variability in the gendering of farming systems from ethnic group to ethnic group even in the same village, in many countries in Sub-Saharan Africa the prevailing farming system is a dual farming system in which women have a separate farming system that they control

but for which they do not have secure land tenure. The land they cultivate is given to them by their husbands (or other male relatives) to cultivate in order to ensure household food security, but they do not have the title of the land. This insecurity of land tenure makes women reluctant to make investments to increase farm productivity because they are afraid that their husband may then decide to take back the improved land in exchange for an unimproved and infertile land. Furthermore, most women do not cultivate only for household consumption; they try to sell as much of their production as possible, often treating some food crops (especially tomatoes, onions and other vegetables and fruits) as "cash" crops, since they are usually able to keep the earned income (Safilios-Rothschild, 1991). Projects aiming to provide women farmers with access to water need to keep these facts in mind and understand that unless governments and donors are able to bring about changes in laws and policies that will provide women with security of land tenure, they may be hesitant to make irrigation-related investments.

In dual and female farming systems, a new, unprecedented pattern of agricultural growth is needed that is not based on the exploitation of the labor of women 'helping' their husbands and that strengthens producers' property rights to productive resources, in particular land and water. An example where this productivity issue is paramount is the revitalization of smallholder irrigation schemes in the former homelands in South Africa, which are dual and female farming systems (Van Koppen et al. 2004). The productivity arguments in favor of a non-exploitative mode of agricultural growth are analogous to the arguments in the land tenancy and land redistribution debates, where the importance of non-exploitative resource rights has already widely been operationalized into reform policies – for men (*cf* Jazairy et al. 1992; see also ECA 2005).

There is ample empirical evidence that gender-equitable agricultural production boosts productivity. Studies in the past decade from Africa underscore that women producers are as efficient as men, provided they obtain equitable access to productive resources and human capital and reap the benefits of their efforts by controlling the output (for an in-depth discussion of these studies see Quisumbing 1996). Also for irrigated agriculture, research has confirmed that the productivity of women farm decision makers is at least equal to that of men, for example in Burkina Faso (Zwarteveen 1997) and Senegal (Deuss 1994). Even stronger, it is clear that exploitative intra-household production relations are counterproductive. A wetland improvement project in Burkina Faso even collapsed because irrigated land was given to men, instead of to women, the traditional rice cultivators and land titleholders. Later schemes, in which improved land was allocated to women, performed significantly better (Van Koppen 2000). Other studies in Africa also highlight women's intra-household negotiations to allocate their labor in ways in which they themselves, rather than their husbands, benefit. Lack of control over, and too limited sharing in, the harvests of husbands' fields, were important reasons for women to reduce their overall labor input on their husbands' irrigated plots to the minimum level of culturally defined obligations. Sometimes, women even completely abandon irrigated agriculture and return to their original villages, as observed in the Mwea scheme in Kenya (Hanger and Morris 1973). Women avoid exploitative farming relations if they have alternative income-generation opportunities. Carney (1988) found in Gambia that Wolof, Fula and Serrahuli women with alternative options to cultivate highland groundnut plots, tend to put in less labor on male-controlled irrigated rice fields than the Mandinke women who do not have that option (Carney 1988). Similarly, higher remuneration by their husbands motivated women to contribute more labor in the SEMRY irrigation project in Cameroon: Jones (1986) highlighted that women rejected too low compensation, primarily by engaging in alternative income-generating activities like their own sorghum fields. Also, married women receiving below-average compensation generally spent more time hiring themselves out as paid laborers the following year. Women's remuneration could be in kind, usually as a share of the output, or a lump sum in cash 'in return for their sweat.'

Indeed, a gender-equitable mode of production is likely to be *more* productive than male-dominated farming. The Kenyan study by Ongaro (1988) showed that the introduction of new weeding techniques increased yields of farms managed by female heads of households by 56 percent and of those managed by men by only 15 percent. Ongaro argues that female heads may have a greater incentive to adopt better weeding practices (traditionally a women's task) when they control the proceeds of their increased effort (cited in Quisumbing 1996, citing Elson 1995). Higher farm viability under more gender-equitable production relations also emerged from a study in Greece. While in Greek rural areas traditionally male farming systems used to prevail, important unplanned social changes were introduced by the Common Agricultural Policy of the European Union according to which, farmers with a full-time non-farm occupation could no longer be formally registered as farmers and receive agricultural subsidies. Since in order to survive they were not able to abandon their non-farm employment but also needed the subsidies, those who could overcome gender stereotypes about women's roles in agriculture legally transferred land ownership and management to their wives. In most of these cases, wives replaced their husbands as farm managers performing traditionally "male" and "female" farm work as needed and their agricultural roles were institutionally recognized. These small farm enterprises characterized by gender role flexibility were found to have much better survival chances than similar farm enterprises lacking such gender role flexibility (Safilios-Rothschild 2003).

In sum, in today's farming systems of Sub-Saharan Africa, which largely depend upon women's efforts as farmers, the issue of gender and irrigation in smallholder agriculture has become important for the first time in history. The design and implementation of a mode of agricultural growth and irrigation development that strengthens women producers' land and water rights (while women now only tend to have secondary use rights), and that avoids exploitative family labor relations has become critical. The production potential is increased by ensuring that both men and women producers directly control the production factors (labor, land, water, technologies, inputs, credits and markets) and reap the benefits of their efforts.

Evidently, such agricultural growth contributes not only to gender equity but also to long-term poverty reduction. Women as a gender score generally lower, often considerably lower, than men from the same social class on *all* common dimensions of human wellbeing and are disproportionately represented among the poor (World Bank, 1986). Even life expectancy in Zambia and Zimbabwe is one year lower for women than for men (in Zambia 33 years for men and 32 for women and in Zimbabwe 34 years for men and 33 for women) (World Population Policies, 2003). Intra-household gender inequalities and poverty increase with scarcity of resources and higher level of household poverty (Safilios-Rothschild, 2001).

In most countries in Sub-Saharan Africa, one cannot think in terms of family income; in most cases men's and women's incomes are separate and not pooled (Fapohunda, 1988). At poverty levels, the incomes of both men and women are needed for survival and both must be improved since men's income covers different expenses than women's incomes. Furthermore, in some areas women's income is more often than men's income spent for household food security. Women's enhanced economic security can better guarantee security in old-age and might reduce the need for many children, in particular sons (Fapohunda, 1988; Safilios-Rothschild, 1991).

3.3 Defining 'poverty' for designing and monitoring targeted interventions

While the importance of targeting investments in agriculture in general and water management in particular for poverty reduction through agricultural growth is well recognized, the operationalization

of such targeting strategies is still an unfinished business. A major handicap in more effective operationalization of targeting is lack of a clear definition of poverty, a fact that also hampers the effectiveness of impact assessments to orient future projects. Measuring poverty reduction impacts of investments in water for agriculture requires, above all, a clear definition of who are the poor. Similarly, leakage to the non-poor also occurs frequently because of a very broad definition of the poor that in fact includes many non-poor (Safilios-Rothschild, 1998).

The term "smallholders" covers a broad category of farmers; but it is not synonymous and cannot be used interchangeably with the term "poor" because it prevents the differentiation among different categories of rural people and farmers with different assets, development potential and needed development strategies. Furthermore, the poor need to be distinguished into the less poor and the very poor (or the poorest); otherwise the asset categories of the poor may be too broad, thus clustering the poorest together with the less poor and making the poorest invisible (Safilios-Rothschild, 1998). For example, those having less than 5 cattle may often be different in terms of wealth ranking than those who have 20 cattle. A serious illness or another crisis may force them to sell the cattle and become even poorer while those with 20 cattle may not be so vulnerable to crises. Similarly, those with 0.5 ha may often be different in terms of wealth ranking and development potential than those with 1.5-2 ha. It is important to distinguish the poorest from the relatively less poor because this will make possible the determination of the extent to which the poorest have been reached (since they are more difficult to reach being usually excluded from all types of formal and informal organizations and groups) and the extent to which they have benefited from project interventions. Otherwise the broad definition of the poor allows project implementers to be satisfied with reaching the relatively less poor (the "creaming" of the poor) and to claim that they have reduced poverty while they have in fact included and benefited only the better off among the poor and the poorest are being further marginalized (IFAD 1995; Safilios-Rothschild 1998; World Bank, 2000).

Targeting of the poor, especially of the poorest, presents a number of difficulties because most often they are not included in existing groups such as farmers' organizations. Poor women are even less often than poor men members of farmers' organizations, except for some female heads of household, after their husband's death. The same holds true for existing informal groups organized by the rural people themselves or by different NGOs. Also in many countries in Sub-Saharan Africa, poor men are less often organized into informal groups, thus increasing their invisibility but even poor women do not fare much better, especially the poorest as well as older women who are also often systematically excluded. In Burkina Faso, for example, in many villages there are no women's or men's groups; but even in villages in which there are such groups, the poor, the old and members of marginalized ethnic groups are usually excluded (Hesseling, Kessler and Safilios-Rothschild 1993; Cleaver, 1998). Similarly, in many villages in Mali the numbers of women who do not belong to women's (or village) groups are often twice as many as the members and are usually the poorer ones (Safilios-Rothschild 1994). In order, therefore, to ensure that all categories of poor men and women are targeted, especially the poorest, it is necessary to devise specific strategies in order to reach them and to assist them to organize and access project support.

The targeting of all categories of the poor is further hampered because of a prejudice and negative stereotypes against them (especially against the poorest) held by many people in the public and private sector and even by those involved in designing and implementing development interventions. Although the existence of such prejudice and negative stereotypes is usually denied, it affects the design of interventions and the manner by which they are implemented. The existence of these prejudicial attitudes is primarily responsible for the fact that the poorest are seldom reached or they are eventually pushed out of programs, even by the less poor (Mayoux 1999), thus further increasing inequalities. It is necessary, therefore, to develop a poverty-training program for the public

and the private sector (even NGOs that work with the poor) that will present facts about the ability of the poor, even the poorest, to save, to repay small loans, to use their loans productively, to become entrepreneurs, to learn important skills for water conservation and water management and to escape poverty with appropriate development assistance. Without such poverty training, the same mistakes will be repeated again and again with the top of the poor improving their condition while the impacts remain meager on poverty reduction among the poorest men and women.

Since poverty has many dimensions, impact assessments need to include several indicators so as to tap as many of these dimensions as possible before it can be claimed that poverty has been reduced (Safilios-Rothschild 2001). It is important that such assessments provide a picture of which poverty dimensions have been alleviated with greater water availability and which ones have not. Quantifiable indicators of impact assessment can include:

Whether or not poor households run out of food (rice, cassava or other type of basic local food) and number of months during which the households run out of food during the pre-harvest season:

- Whether or not the poor have easy access to safe water (women do not have to walk to long distances for clean water);
- Whether or not boys and girls are attending schools or have dropped out (and if they had dropped out before project onset, they went back to school);
- Number and percent of poor men and women with wage employment or a stable income-generating activity;
- Number and percent of poor men and women who have been trained in water conservation and management;
- Increases in poor women's and men's income (not only in men's or family income);
- Decrease in level of indebtedness of poor and very poor households;
- Changes in number and types of assets of the poor and the poorest;
- Whether or not poor men and women (especially the poorest) are included (beyond token representation) in village collectivities (e.g., water users associations, village associations of savings and credit, farmers' organizations, local women's and men's groups, etc.);
- Irrigated "cash" crops have been introduced in poor (and poorest) men's and women's farming system (in male, female and dual farming systems);
- Housing improvements among the poor and the poorest.

Poverty criteria can also be set through participatory wealth-ranking and dividing villagers into four categories: relatively better-off, middle, poor *and* very poor. For example, in wetlands in Zambia (FAO Netherlands Partnership Programme 2004a) and Tanzania (FAO Netherlands Partnership Programme 2004b), villagers gave values to the following criteria: cattle numbers, small livestock numbers and types, farm size, food security/number of meals per day, housing, off-farm sources of income during the year, use of health and education services, bicycle, radio, number of wives, exemptions from payments of health and education services, assets, connections to well-off relatives, carrying out manual wage labor/ hiring wage labor, ability to buy inputs in large quantities, and prostitution.

4. TRANSFORMING GOVERNMENT AS KEY INVESTOR IN AGRICULTURAL WATER DEVELOPMENT AND MANAGEMENT

4.1 The government as the key investor in water infrastructure

As indicated above, poverty reduction through agricultural growth makes economic sense and is feasible though complex, provided adequate investments and support are available. Governments are key actors in enabling the range of conditions to be in place, like output markets, input supply, training, and technological innovation required for such agricultural growth in general.

The importance of public support is especially high for investments in agricultural water development. Up till the 1990s, this was a global consensus: governments are pivotal in facilitating investments in water development, from local to national and inter-basin level. The rationale for attributing governments the role of main investor and implementer for water infrastructure was that, at least until the recent spread of individual mechanized pumps, most public investments in new water infrastructure are typically for groups and collectivities. Such investments in water infrastructure are longer-term investments for multiple goals, larger areas, and multiple users. A range of goals, both public and private, are combined and are often difficult to distinguish. Private investors are not likely to come forward under such conditions. Moreover, investments by large private investors, if they come forward, entail the same risk of monopolization as state investments. Unaccounted externalities still warrant a strong public overseer (World Bank 1993). Thus, investing in water resources development and management is a proper function for governments – hardly anyone else is likely to do it otherwise, especially in poor rural areas.

However, in the past decade this role of government has been challenged. Decentralization is now promoted, but this has often implied curtailment of government's role at the same time. Participatory irrigation management has become the norm. It is true that farmers' own investments in water development are better recognized, for example when individual technologies, such as small mechanized pumps and manual treadle pumps become available. In other spheres as well, farmer 'bright spots', NGOs and the private sector offered new possibilities. Communities' customary arrangements of natural resources management are now also emphasized. In Sub-Saharan Africa, for example, communities' social capital, catalyzed by the tribal authority structures that govern community's human and natural resources appeared resilient, especially for land tenure.

Yet, in spite of the many efforts deployed to decentralize and attract private investors, experiences up to now also confirm the validity of the earlier rationale: just decentralization often means decline of the activities and private investments in collective water infrastructure are not automatically coming forward. The conclusion of the evaluation of past experience of private financing of water resources development at the Stockholm World Water Week 2004 reflected precisely the same bottlenecks that indicated the need for a government's role in this field a decade earlier (SIWI 2004). Similarly, the World Bank Water Resources Strategy (2004) notes that private investors are not as eager to invest in water infrastructure as one had hoped. While private investments in infrastructure rose dramatically during the 1990s, they had declined considerably by the end of the decade. Moreover, only a small proportion of private investment in infrastructure went into water-related infrastructure – about 5 percent into water and sanitation (mainly in urban areas), and another 5 percent into hydropower (World Bank 2004).

The accompanying report on private investment opportunities (Penning de Vries et al. 2005) has emphasized the great potential of private investments by small farmers and business people. But here too governments place a critical role: to create the conditions that induce, facilitate and encourage local level private investments. Thus, well-targeted investments in larger-scale public

goods (roads, water supply infrastructure) can induce substantial local investments, especially if the institutional and policy environment are conducive to making reasonable returns.

In sum, if governments and the international development community seek to promote investments in agriculture in general and water development in particular, as this study proposes, the role of government as the key investor in water infrastructure needs to be revisited. Transformation is needed, but not curtailment. The planning and implementation component of this study (Moradet et al. 2005) also identifies the problem of *ad-hoc*, top-down and temporary government structures to implement donor-funded irrigation projects. The study on costs of irrigation in Africa (Inocencio et al. 2005) demonstrates the potential cost-effectiveness of irrigation investments in sub-Saharan Africa. A longer-term vision is desirable on the type of sustainable government institutions that should be crafted in order to implement new projects better and upscale the lessons from the current ones. Evidently, governments are potentially the most powerful drivers for upscaling of successful government-facilitated innovations. Investment projects should cease to be 'isolated islands of success in oceans of misery', by incorporating the replicability and pathways for upscaling of lessons learnt. Lastly, it is surprising that the crucial role of government is clearly recognized for domestic water supply in poor rural areas, while this recognition suddenly stops for productive water uses by the poor and integrated water resources management.

4.2 Emerging principles for pro-poor local investments in water

Local government development in Sub-Saharan Africa not only suffers from lack of resources, but also from the legacy of Africa's colonial past leading to the complex co-existence of, if not contest between, 'traditional' tribal structures, still largely governing land issues, and 'modern' local government (Mamdani 1996). Yet, innovative approaches for local investments are emerging, such as the Community Driven Development Approach (CDD) of the World Bank, which applies this approach also on domestic water and small-scale irrigation. UNDP's Community Water Initiative (UNDP 2004) is also testing new principles that effectively create an institutional and legal setting that facilitates financing streams to reach poor communities and delivers sustainable, pro-poor local investments in water. Such tested principles can guide efforts for transformation of line agencies and administrative government horizontally and vertically.

The CDD is taken as an example to illustrate such principles (*http://lnweb18.worldbank.org/ESSD/sdvext.nsf/09ByDocName/RegionsAfrica*, Binswanger and Van Nguyen 2005; De Regt 2005; Rogier van den Brink personal communication). The five main components of CDD are empowering communities, empowering local governments, re-aligning the center, improving accountability, and building capacity. Moreover, it recognizes that the poor and even more the poorest need special empowerment that enables them to understand what the issues are, what are their rights, what is negotiable, and how to negotiate with other more powerful community groups. Such skills are almost entirely lacking and are essential if the poor are going to be able to obtain some development benefits. CDD starts with the empowerment of local groups, whether belonging to the same locality (e.g., village) or having similar interests (e.g., irrigation scheme), or operating through customary water management arrangements, or fully embedded in local government structures, if they function well. According to the subsidiarity principle, decision-making about new initiatives is at the lowest appropriate level, where the multiple aspects of any intervention, including those in water development, can be integrated and fully adapted to the holistic specific local conditions and needs. Starting with small investments, for example some US$ 25,000 as in Brazil (Roumani personal communication), good performance entitles groups to increasingly larger amounts. Empowerment

encompasses inclusion of the marginalized to avoid elite capture, and accountability by leaders or elected councils to all members, as the basis for participatory problem diagnosis, planning and implementation of whatever activity the group sees as their priority. Contracting by the group or local government of outsourced activities and tapping of 'latent' skills available at local level improves commitment and relevance to the local conditions, while reducing costs. Funding, preferably matching funding to reward villagers' good performance is disbursed upon delivery of phases of the planned deliverables. Most importantly, local governments are entitled and encouraged to charge levies and taxes that remain at local level to be reinvested in the activities concerned. The incentive for higher-level bureaucrats is not merely fund disbursement, but especially the delivery of good services to the villagers. Bureaucratic requirements are as lean and simplified as possible and in local language. Such 'bright spots' of institutional reform for investments in water resources are now also being upscaled nation-wide - over an even longer period - through government structures as major conduits for upscaling (Binswanger and van Nguyen 2005) These and other initiatives provide important lessons for transforming government's legal and institutional environment in rural areas towards delivering investments in integrated water uses at local level.

4.3 Integrating water development and regulatory functions of government

If governments are to expand their roles as investors in water development, an important aspect of government that also requires strengthening is its simultaneous role as water regulator. While government's function as water developer dwindled in the 1990s, efforts to stipulate and extend its role as 'custodian of the nation's water resources' increased. Many governments in sub-Saharan Africa, e.g., Tanzania, Kenya, South Africa, Zimbabwe, Ghana, Uganda, and Mozambique, engaged in the drafting of new policies and legislation, strengthening administrative water rights system, introducing water resource management fees for higher-level or central water management functions, and introducing or strengthening basin-level water management bodies with, in principle stronger water user participation[1].

The goals of such reforms are usually referred to as Integrated Water Resources Management (IWRM). There are various (potential) contradictions between governments' roles as investors in water development and their roles as regulators according to the prevailing IWRM interpretations that need to be better identified and reconciled. Taking again the principles of Community-Driven Development as an example, fields to integrate better include the following:

The water scarcity problem to be addressed:

The underlying rationale of the current IWRM water reform is that water scarcity is increasing and that the only solution to this water scarcity is central regulation in order to share optimally a limited pie. The water rights system to implement such regulation is steered by the central department of water affairs and, in principle, uniform throughout the country.

In contrast, CDD's main trust is to 'increase the pie' for the benefit of the poor, by developing wet season storage and infrastructure for better accessibility to water for rural communities. In most of sub-Saharan Africa, the water scarcity problem only poses itself in the dry season months. In the other period of the year, water is abundant and can be stored for use in the dry season – if initiatives to 'bridge the infrastructure gap' are implemented.

[1] Water quality and pollution prevention are beyond the scope of this chapter.

Integration of both functions warrants assessing the nature of water scarcity in any particular area first, before any intervention. The concept of one unified water rights system throughout the country needs to be replaced by a system that starts by differentiating between 'red' areas, where the physical limits of the available resources and 'green' areas, where water resources are available and the development of new infrastructure is feasible (Garduno 2003), and where an administrative water rights system has no problem to solve, so is not worth the enormous effort.

Conflict resolution and bureaucracies

IWRM reform is top-down. Central government introduces a central uniform administrative water rights system, which is delegated to offices at basin level, and further delegated downwards to sub-basin level and water users associations. This top-down system tends to exclude the many poor, scattered small-scale water users – as the majority of sub-Saharan Africa's are. As in all administrative systems, the need for title deeds tends to disadvantage the poor and illiterate. It seeks to solve water conflicts on the basis of certificates with names, water uses, a rough indication of the site, and, at best, an annual average volume of water use. However, annual averages of volumes used, or no data about quantities used at all, provide no basis to solve the temporary dry season problems. The argument for adopting such a centralized approach is that upstream – downstream scarcities take place at too aggregate levels for 'localized' customary arrangements to be valid. Moreover, for certain conflicts, external arbitration that stands the law is indispensable. Conflict resolution by state officials on the basis of certificates ignores, at least formally, the locally existing arrangements to address water scarcity during the dry season, which may cover long stretches of streams and diverse populations over large areas, such as settled agriculturalists and pastoralists.

In contrast, CDD adheres to the subsidiarity principles and fosters maximum empowerment of local communities. CDD pro-actively seeks to build upon existing and customary arrangements, which are usually much more accessible to the poorest community members than administrative certificates. Only for certain issues, CDD imposes certain criteria, supported by capacity building, as condition for loan/grant disbursement. An example is inclusion of the marginalized. Simplifying bureaucracies is central to CDD.

This contradiction can be reconciled by thoroughly by revisiting the trade-off between newly introduced administrative water rights systems and their various purposes. While an overview of water uses and some specifications (e.g., on a simple spreadsheet) may serve very well to give water managers a cheap, effective insight in the resource they have to manage, their linking to legislation and conflict resolution may warrant much more thought. Other conflict resolution mechanisms may work much better. Firstly, therefore, such other conflict resolution mechanisms and their efficacy to really solve water conflicts need to be formally recognized. Effective customary conflict resolution mechanisms may be formally recognized as first resort to manage water scarcity, and incentives could be designed to solve problems at the lowest possible level – only ensuring that further marginalization of vulnerable groups is avoided. Local government and local water officers should play a facilitating and mediating role first. Only as back up for conflicts that cannot be solved locally, should government enter as arbiter. Lack of logistical realism on the efficacy of paper water rights to solve water conflicts, especially those in which the poor risk losing out, should never weaken poor small-scale water users' bargaining position. This may imply that administrative water rights are first introduced among the few large-scale users, while blanket authorizations formally protect water use by the poor, certainly in 'green areas'. Only in 'red areas' should water development initiatives be preceded by obligatory assessments of possible impacts on downstream users and aquifers.

Local government

IWRM reform up till now emphasized the need to organize water users in specific water user groups, in a top-down mode from central to basin to local level. Water management institutions are rather organized as a parallel structure to local, district, and provincial, and central administrative and taxation government departments. The role of local government in IWRM often remains rather unclear.

In contrast, CDD seeks an integrated approach at local level – where the issues *are* integrated and very locally specific. Empowerment of local government is key, although potential roles vary with the efficacy of local government. The importance of local government in collective investments is especially clear for domestic water supply, often its mandate, but investments in small-scale productive water uses can also fall under local government by mandate. Yet, there are often no incentives for either local government or local level water departments in charge of water rights systems to collaborate.

Integration can be achieved by stipulating and harmonizing the role of local government as *both* key investor in water infrastructure development *and* factual water regulator, facilitating conflict resolution at the lowest level possible.

Sectoral integration

IWRM reform, as interpreted up till now by most African governments, tends to further strengthen the already existing divide between the domestic and productive water sectors, reserving 'real' integrated water resources management for productive uses only. This was in line with global interpretations up till the early 2000s. However, in its handbook for developing integrated water resources management and water efficiency strategies for example, Global Water Partnership (2004) has explicitly acknowledged multiple-use supply systems as a potentially substantive approach to poverty reduction.

CDD fosters integration. This is especially important in poor rural areas with underdeveloped water infrastructure and reticulation, where water from multiple sources is typically used for multiple purposes by multiple users – as recognized in the irrigation sectors since very long (Yoder 1981; Bakker et al. 1999; Van der Hoek et al 1999; Boelee et al. 2004) and more recently also the domestic water sector (Moriarty et al. 2003).

Integration in water management is in the first place integrating the range of domestic and productive sectors where such an integrated approach is most relevant – poor rural areas. An integrated approach to local water development that considers all sources, all potential uses, and all needs at the same time allows tapping important synergies (e.g., in cost of multi-purpose infrastructure, 'illegal' use of water because people use the schemes as they need, ability to pay if water is also used for productive activities) [2].

Thresholds

Besides excluding individual domestic water uses, IWRM often seeks to set a threshold in productive uses, below which volumes used are so small that they are negligible from the viewpoint of total volume of water resources. Such uses would fall within the errors of hydrological models. Realism about the logistical implications of having to cater for all users above that threshold may be another criterion to set such a threshold. Yet, the criteria are often expressed in terms of their

[2] An example of the new global dialogue on gender and poverty mainstreaming in merging domestic and productive water sectors is the Challenge Program Project on Multiple Use Supply Systems (www.iwmi.cgiar.org/multipleuses) This project conducts action-research to develop and test guidelines for community-level implementation of Multiple Use Water Supply Systems and for upscaling Multiple Use Water Supply Systems at district, national and global levels. These guidelines seek to tap the synergies of integrated, affordable and labor-saving investments in water development for multiple uses to create more wealth, health, and happiness, also among the poorest households.

'insignificance for production', such as for 'subsistence only', or 'not for commercial purposes' – denying the tremendous importance of small-scale water users for the poor, who, as indicated above, are efficient producers if markets and other conditions are available. However, in the regulations in the 1990s in Tanzania, the setting of a threshold was rejected, because it was realized that the large majority of water users are small users and one cannot exempt a majority. The result is that such thresholds are typically extremely vague among the legislators, the officers implementing the thresholds, and, above all, the people. Moreover, as the criteria for setting thresholds remain unclear, they may suggest a denial the importance of small-scale water uses for the rural majority.

CDD pursues simplification of all bureaucracies, meeting the genuine needs of the poor, and adaptation to local realities. Dry season water scarcity may well affect domestic uses and cattle watering – obvious local priorities. The varying viewpoints on the threshold can be better integrated by clearly stipulating the purpose of setting thresholds, and connecting water resource management tools with legal tools, only if it is really functional and logistically feasible. The importance government attaches to small-scale water use for poverty alleviation and agricultural growth should be reflected in legal *promotion* of small uses for productive uses, besides already recognized domestic uses – recognizing that they are often difficult to distinguish among the rural poor.

Financing streams

IWRM reform, from the top, introduces or strengthens upwards financing streams through the payment of water charges by water users to finance new – and often expensive – water resource management bodies at basin-level, or finance central government functions of water resource management. In contrast, CDD emphasizes both the channeling of funds downwards and the need for fiscal autonomy at local levels, in particular for local government to tax and spend that money at local level.

These financing streams are contradictory; therefore a choice is needed. This chapter argues in favor of accelerating financing streams downwards, and empowerment of the poor to invest in infrastructure for agricultural water development. At the same time, taxation of large users who receive the most benefits from using water is justified and feasible. As the Mexican experience shows, an administrative system to introduce taxation of water users can be considerably simplified, and even introduced before introducing a water rights system (Garduno personal communication). Various ultimate purposes of the administrative system, including solving water conflicts and regulating large users, can be kept in mind for possible later harmonized adoption, but certainly do not need to be implemented all at once.

5. CONCLUSIONS AND RECOMMENDATIONS

The well-known global consensus that agricultural growth has been the engine of overall economic growth in the past in all countries where such economic growth has been realized entails important lessons for Sub-Saharan Africa. Similar public investments and marketing and trade support for agriculture in Africa may trigger the same broad-based economic growth. However, typical African endogenous conditions need to be considered and even more so the more adverse global conditions due to the low world market prices, cheap imports and dumping of food aid.

With regard to the important endogenous factor of the agrarian structure, which underpins targeting strategies, farm size is critical. Asian literature is unanimous about the win-win scenario of agricultural growth by investing in smallholder agriculture in general and in irrigated agriculture in particular. Given the lack of empirical data for Sub-Saharan Africa, there is an urgent need to monitor poverty and gender impacts empirically in order to further substantiate poverty reduction impacts. A clear

poverty definition that differentiates between the poor and poorest, besides differentiation between various categories of the poor benefiting from public investments is the prerequisite.

A second aspect of the agrarian structure and targeting strategies is gender. A similar synergy between agricultural growth and increased equity holds for gender. Given the fact that dual farming systems prevail in most of Sub-Saharan Africa, gender-sensitive targeting of investments to the farm decision-maker, whether a man or a woman, is not merely a welfare issue, but a major factor to achieve agriculture growth. Further growth can be reached if accompanying measures ensure that women farm decision-makers are vested with access to land, water, inputs, markets, training, and control over the fruits of their labor on the same footing as men farm decision-makers.

The examination from a poverty perspective of the formal legal and institutional environment of water development and management, in particular Integrated Water Resources Development (IWRM) reforms as implemented in Africa since the 1990s, highlights two fields where the IWRM reform seems incompatible with a program of poverty-focused investments in agricultural water management. First, the emphasis on formal regulation of water users through elaborate statutory administrative water rights systems, new basin organizations, and pricing of water is not only very difficult to implement among the masses of informal water users, the target group of the Collaborative Program; it is counter-productive. This regulation agenda also diverts scarce human and financial resources from developing Sub-Saharan Africa's often abundant water resources. Second, the role of government as investor in water infrastructure development is not addressed in the IWRM debates. It is increasingly acknowledged that the private sector will not replace governments in their roles as investors in water development, certainly not in poor rural areas. Therefore, pilot projects to transform governments to strengthen their roles as investors and implementers, especially at local level, and to deliver in a participatory, transparent, and accountable way with strong involvement of rural communities will be of increasing importance in setting the institutional and legal environment for pro-poor investments in water development and management.

In sum, the following recommendations are made for more effective poverty reduction through broad-based agricultural growth:

a. Allocate public funds to targeted agricultural growth as an investment with sufficient economic returns and as the single most effective way to trigger overall economic growth and to improve the wellbeing of Africa's majority of poor.

b. For combined poverty and productivity considerations, target the poor and monitor using poverty impact assessments, based on clear definitions of poverty that differentiate between the poor and poorest.

c. Remove gender obstacles for women producers to promote agricultural growth at a potentially massive scale.

d. Re-design the roles of government as investors in water infrastructure, also building capacity for sustainable project implementation.

e. Integrate governments' roles as water regulator and as investor, in order to provide an optimal legal and institutional environment for investments in water infrastructure that contribute to poverty alleviation.

Part Two
Synthesis of Sub-Saharan African Case Study Reports

Regassa Namara

1. BACKGROUND

Poverty reduction is now the undisputed overriding goal of development and the primary challenge facing the development community today. Poverty in all its manifestations in sub-Saharan Africa remains deep, pervasive, and intractable. At the heart of making poverty reduction an important concern is an evaluation of the effectiveness of past development projects designed to trigger economic growth and reduce poverty, and derive lessons from successes or failures for further development planning purposes. Even though empirical evidence showing the efficacy of investments in agricultural water management in poverty reduction, particularly in developing countries of Asia[3] are available; in sub-Saharan Africa no comprehensive study of the effect of investments in agricultural water management (irrigation) on poverty is available. This may be due to the fact that: (1) such investments are at an early stage in sub-Saharan Africa, (2) there is little or no temporally and spatially disaggregated data that enables establishing a conclusive empirical link between investment and poverty reduction targets, and (3) the limited available studies fail to adopt an appropriate framework for poverty analyses and are usually geared towards assessing the economic viability of the investment projects.

Even those studies explicitly concerned with measuring the poverty impacts of investments have dealt mainly with average improvements in the beneficiaries' income. However, overall positive improvements (on average) in income can be observed side by side with the deterioration of the condition of the poorest section of the potential beneficiaries of agricultural water investment projects. Thus, measuring the poverty reduction impacts of investments in water for agriculture requires, above all, a clear definition of who are the poor. Otherwise the broad definition of the poor allows project implementers to be satisfied with reaching the relatively less poor and to claim that they have reduced poverty while they have in fact included and benefited only the better off among the poor and the poorest are being further marginalized (IFAD 1995; Safilios-Rothschild 1998; World Bank 2000). Leakage to the non-poor occurs frequently because of a very broad definition of the poor that in fact includes the 'cream of the poor' (Safilios-Rothschild 1998).

The effects of irrigation or access to agricultural water on poverty are transmitted through a long chain of intermediate variables such as size of irrigated area, cropping pattern and cropping intensity, land productivity and labor productivity. There are two fundamental routes through which investments in agricultural water management (irrigation) affects poverty: production or productivity effects, and employment or income effects (Saleth et al. 2003; Lipton et al. 2003). These effects can be direct or indirect, positive or negative and include changes in food production, employment, food prices/consumption, empowerment, risk and vulnerability, education and capacity. Water use in agriculture (irrigation) may also have negative impacts on the wellbeing or poverty status of the target beneficiaries through, for instance, increasing the incidence of water borne diseases such as malaria, loss of natural habitat, induced problems of waterlogging and salinization, displacement of people due to development of infrastructures such as dams (Saleth et al. 2003; McCartney et al. 2005). Asian research findings consistently indicate that irrigation development alleviates poverty in rural areas of developing countries (Mellor and Desai 1985; Chambers et al 1989; Hossain 1989; Hussain and Hanjra 2003). The overall conclusion of the poverty and irrigation research is clearly that investments in irrigated agriculture in developing countries alleviate poverty through agricultural growth and in some conditions do so massively with water as the key trigger for this progress. The magnitude and net poverty impacts of investments in agricultural water management depends

[3] For a detailed understanding of the poverty impacts of investments in agricultural water management see Hussain and Hanjra, 2003; Shah and Singh 2002; Saleth et al.2003; Narayanamoorthy 2000; Lipton et al. 2003; Hussain 2005.

individually or synergistically on the prevailing policies, institutions, governance issues and level of investment in other sectors of the economy. Thus the economic development and poverty reduction impacts of investments in agricultural water management need to be evaluated within the contexts of the prevailing support policies and services.

This document provides a preliminary understanding of the poverty reduction impacts of a range of agricultural water development interventions in sub Saharan Africa, including lower cost alternatives to conventional irrigation investment projects, identifies factors that constrain the poverty reduction impacts of projects and technologies, and derives conclusions and recommendations useful for further water resources development planning in the region.

2. METHODOLOGY

This document is a synthesis of eight case studies in eastern and southern Africa, three case studies in western Africa and literature reviews. The east and Southern Africa case studies include six recently completed small and medium scale irrigation investment projects in Madagascar, Tanzania, and Zimbabwe, assisted variously by DANIDA, EU and IFAD. The remaining two case studies in Eastern and Southern Africa considered alternatives to conventional irrigation development projects[4] such as various water harvesting techniques and low cost water lifting technologies in Kenya, Tanzania, and Zimbabwe (Peacock 2005). These case studies were mainly based on field and desk work carried out in 2003 and 2004 by IFAD consultants and IWMI. Information pertaining to western Africa was obtained from three case studies undertaken in Ghana, Niger and Nigeria by a consultant and the staff of the International Water Management Institute's West Africa sub-regional office. The Ghana case study analyzed the impact of treadle pump adoption on income, poverty and food security based on before and after comparisons of the situations of 101 sample adopters selected from Brong Ahafao and Ashanti Regions of Ghana (Kamara et al. 2004). The Niger case study is based on literature reviews (Naugle, 2000; Cambell and Hyman 2000, Kamara et al. 2005). The Nigeria case study involved a survey of 80 *fadama*[5] farmers (i.e., 40 beneficiaries of Fadama I project[6] and 40 non-beneficiaries) drawn randomly from a village called Likori located along the banks of the Burum Gana Channel within the Hadejia-Nguru floodplain wetlands in Jigawa State of northern Nigeria (Omilola 2005). Except the Nigerian case study, the rest of the studies both from eastern and southern Africa and west Africa measured the poverty impact of the projects and technologies using changes in the average income of the beneficiaries. Therefore, these studies only present interesting changes in income rather than specifying whether income changes accrue to the poor or the non-poor. However, some of the case studies have complemented the quantitative changes in income with qualitative poverty indicators such as food self-sufficiency.

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[4] Many analysts claim that because of the typically high costs and low economic returns of conventional irrigation investment projects in sub-Saharan Africa, low cost alternatives such as soil moisture conservation techniques, runoff harvesting techniques, and low cost pump technologies need to be promoted.

[5] *Fadama* is a local word in Hausa language for irrigable land, which is popularly used in Nigeria to refer to the seasonally flooded or floodable floodplains or valley-bottoms or lowlands along major savanna rivers and/or depressions on the adjacent low terraces. In other parts of Africa, features similar to fadamas are called *dambos* (Zambia); *vleis* (Zimbabwe and South Africa); *mbugas* (East Africa) and *bolis* (Sierra Leone).

[6] Between 1993 and 1999, the World Bank supported the Federal Government of Nigeria (FGN) to make substantial investment in the development of small-scale irrigation in Nigerian fadama lands through the implementation of the National Fadama Development Project, known as Fadama I. The project was designed to serve as an important instrument for implementing the FGN's poverty reduction program through the economic empowerment of the rural poor by developing small-scale irrigation through the extraction of ground water, using low-cost petrol-driven pumps and at the same time improve the socio-economic welfare of the rural poor.

The Nigeria case study employed a quantitative poverty assessment method to evaluate the poverty reduction impact of Fadama I project using both "before and after" and "with and without" comparisons and income poverty measures derived from Pá indices of poverty proposed by Foster, Greer and Thorbecke (FGT) (1984). The three most widely used measures of income/consumption poverty proposed by Foster, Greer and Thorbecke (1984) are the poverty headcount ratio, the poverty gap and the squared poverty gap or poverty severity. These income poverty measures are defined from Pá indices of poverty as follows:

$$P_{\alpha} = \frac{1}{n} \sum_{i=1}^{q} \left(\frac{z - y_i}{z} \right)^{\alpha} \qquad (1)$$

where individuals have been ranked from the poorest (*i=1*) to the richest (*i=n*, where *n* is the population size), where *q* is the number of individuals defined to be poor, z is the poverty line, *yi* is the income/expenditure of person i and á is a parameter reflecting the weight placed on the welfare levels of the poorest among the poor or what is called measure of "inequality of aversion".

The three popular measures of income/consumption tell us different things about the extent and nature of poverty from the Foster, Greer and Thorbecke index as follows:

The Poverty Headcount Ratio (*P0*)

The headcount ratio measures the incidence of poverty (the proportion of the population defined to be poor) and it is obtained for the special case á= *0* as follows:

P0 = q/n (2)

This is simply the number of poor people divided by the total population. The headcount ratio fails to take account of the degree of poverty by ignoring the extent of the short-fall of incomes of the poor compared to the poverty line. For instance, the headcount ratio will remain the same when there is a reduction in the incomes of all the poor without affecting the incomes of the rich. In other words, it will be unaffected by a policy that makes the poor even poorer since it is not sensitive to distribution of income among the poor. Moreover, two societies may have the same headcount ratio but the poor in one society may be much poorer than the poor in the other society (IFAD, 2001). Yet this measure appears to be the mainstay of poverty analysis on which policies targeted to reduce poverty are based.

The Poverty Gap (P1)

The poverty gap measures the aggregate shortfall of the income/consumption of the poor from the poverty line (the depth of poverty). With special case á= 1, the FGT index becomes the poverty gap (*P1*) and it can be written as:

$$P_1 = \frac{q}{n} \frac{z - \bar{y}^{p}}{z} \qquad (3)$$

where $\bar{y}_p$ stands for the mean value of *yi* among the poor. The poverty gap measure has an advantage over the headcount ratio in the sense that it will be increased when there is income transfer from poor to non-poor, or from poor to less poor who thereby become non-poor. Although the poverty gap index takes both the incidence and depth of poverty into account, it is insensitive to inequality amongst the poor. For instance, if a poor person consumes ten Nigerian Naira a day more but an even poorer person ten Naira fewer, both poverty incidence *(P0*) and poverty depth (*P1*) will not increase, and yet we know that poverty has got worse.

The Squared Poverty Gap (P2)

This measures the "severity" or "intensity" of poverty by giving more weight to the poorest. It does this by weighting each poor person by the square of his/her proportionate shortfall below the poverty line. With special case á= 2, the FGT index becomes the squared poverty gap (*P2*) and it can be written as:

$$P_2 = \frac{q}{n}\left[\left(\frac{z-\bar{y}_p}{z}\right)^2 + \left(\frac{\sigma_p}{z}\right)^2\right] \qquad (4)$$

where σ_p is the standard deviation of *yi* among the poor. This measure takes account of the incidence of poverty, the depth of poverty, and the inequality amongst the poor. It rises when the number of poor people increases, or the poor get poorer, or the poorest get poorer in comparison with other poor people. We might want to prefer the *P2* measure to others, but in practice it is of interest to look at all three measures. It should be noted that these poverty measures take values between 0 and 1, with numbers close to 0 indicating little poverty and those closer to 1 suggesting high poverty. Also, as the value of á increases for the FGT class, so does the (relative) weight placed on the poorest among the poor.

3. THE INCIDENCE AND SEVERITY OF POVERTY IN THE SUB-SAHARAN REGION: A COMPARATIVE ANALYSIS

Sub-Saharan Africa, Eastern Europe and Central Asia are the only regions in the world where the incidence and severity of poverty have worsened during 1981-2001 (Table 1). However, the incidence of poverty in Eastern Europe and Central Asia had been lower in 1981 (0.79%) and it still is lower as compared to the rest of the regions in 2001. On the other hand East Asia and the Pacific, Middle East and North Africa and South Asia have registered substantial reductions in the incidence and severity of poverty. The situation of Latin American and Caribbean regions is very interesting. These regions also experienced a general decline in the poverty incidence over 20 years; however, the fact that the poverty squared gap indicator has also increased over the same period means that the situation of the poorest has worsened.

The information contained in Table 1 may however mask the differential performance of regions within the African continent itself. Comparison of the different regions of Africa with respect to economic achievements and poverty reduction reveals that the Northern and the middle Africa regions have experienced reductions in poverty incidence and severity over 1981 to 2001 (Table 2). The western and southern Africa regions were not effective in fighting poverty or

Table 1. Changes in the incidence and severity of poverty

Geographic regions	Head count			Poverty gap			Squared Poverty Gap		
	1981	2001	% change	1981	2001	% change	1981	2001	% change
East Asia and Pacific	56.65	14.32	-74.7	19.8	3.23	-83.7	8.95	1.02	-88.6
East Europe and Central Asia	0.79	3.46	338.0	0.23	0.76	230.4	0.13	0.30	130.8
Latin America and Caribbean	10.05	9.91	-1.4	2.89	3.45	19.4	1.26	1.78	41.3
Middle east and North Africa	5.08	2.35	-53.7	1.0	0.45	-55.0	0.40	0.16	-60.0
South Asia	51.51	31.89	-38.1	16.06	7.39	-54.0	6.77	2.39	-64.7
Sub-Saharan Africa	41.62	46.38	11.4	17.03	20.53	20.6	9.47	11.98	26.5

Sources: Figures on Poverty from World Bank (2000, 2001).

Table 2. Changes in the incidence and severity of poverty across geographic regions of Africa

Geographic regions	Changes in poverty incidence 1981-2001(%)	Changes in poverty gap 1981-2001(%)	Changes in poverty squared gap 1981-2001 (%)	Irrigation Potential (ha)	Actual irrigated area as % of potential
Northern Africa	-69.1	-75.0	-80.0	7194300	86.0
Southern Africa	32.1	60.7	76.4	1607800 (162800)*	97.0 (37.8)*
Eastern Africa	3.7	4.8	2.9	14542896	21.2
Western Africa	16.3	31.7	45.2	8656909	11.9
Middle Africa	-11.9	-6.6	-2.4	9925000	0.6
Sub-Saharan Africa	7.1	15.4	20.8	35393305	16.3

* The figures in the bracket exclude the Republic of South Africa.

Sources: Figures on Poverty from the World Bank (2000, 2001); Figures on irrigation from FAO (2003) Statistical database: *www.apps.fao.org/default.htm.*

attaining economic progress. In general, the sub-Saharan African countries performed woefully with respect to poverty alleviation. World Bank projections indicate that, although the world as a whole is roughly on track to reach the Millennium Development Goal of eradicating extreme hunger and poverty, this may be beyond reach for sub-Saharan Africa. Indeed, the indications are that on present trends the absolute numbers of rural poor in the region will continue to increase above their present levels, in which case, close to half the world's poor will live in sub-Saharan Africa by 2015. Overall, rural poverty accounts for 83% of the total extreme poverty in the region and about 85% of the poor depend on agriculture to a greater or lesser extent for their livelihoods. It is therefore clear that agricultural growth is the key to poverty alleviation, though it is less clear how the required growth will be achieved.

4. WATER RESOURCES ENDOWMENT AND LEVEL OF INVESTMENT IN AGRICULTURAL WATER MANAGEMENT IN SUB-SAHARAN AFRICA

Is sub-Saharan Africa a peculiarly water scarce region? A close scrutiny of the data depicted in Table 3 reveals that the water resources endowment of sub-Saharan African countries as indicated by the per capita actual renewable water resources compares reasonably well with that of Asia, Central America, the Caribbean, Middle East and North Africa. However, the per capita total annual withdrawal is extremely low, indicating the alarmingly low level of investment in the sector. Although water withdrawals for agriculture amounted to approximately 88% of total withdrawals from the region's global renewable water resource, the total of these withdrawals represented only 3% of the total resource. Thus, although there may be some basin-specific water shortages in some countries, there appears to be ample scope for further development in sub-Saharan Africa as a whole.

Recent FAO projections assume that in sub-Saharan Africa, 73% of the growth expected by 2030 will come from intensification (in the form of yield increases and higher cropping intensities), with the remaining 27% coming from arable land expansion (Bruinsma 2003). But while some yield growth could be achieved through improved economic incentives, better market access and improved technology, and while some increase in cropping intensity could be achieved by reducing fallow periods, dependence on rainfall alone limits the potential for intensification. The corollary is that while rain-fed cropping will remain the main source of growth in the agricultural sector, investment in agricultural water development will become increasingly important in the coming years. Yet compared with other regions, there has been relatively little investment in agricultural water development in sub-Saharan Africa to date. Indeed while the irrigation potential for water management in Sub-Saharan Africa amounted to nearly 35 million ha, only about 16.3% of this has been put under irrigation. Moreover, the bulk of the water-managed area is located in few countries, namely South Africa, Madagascar and Sudan, which together account for about 60% of the actual irrigated area in sub-Saharan Africa.

The reasons for such low investment are thought to include perceptions of poor economic efficiency (compared with other uses of water), poor financial viability, high costs and poor sustainability (Inocencio et al. 2005). Concerns have also been expressed over increasing water scarcity in the region and the perceived relative wastefulness of irrigation. Obviously, investment will not increase until these negative perceptions are satisfactorily addressed. Yet, whilst it is

Table 3. Water resources and its level of utilization

Geographic regions		Water Withdrawals		
	Per capita actual renewable water resources (m3/person)	Per capita annual total (m3/person)	% used for agricultural purpose	Irrigated land (% of total crop land)
Asia (excluding Middle East)	4079	631	81	35.3
Central America and Caribbean	6924.4	603	75	19.3
Europe	10655.1	581	33	8.1
Middle East and North Africa	1505	807	86	28.5
North America	19992.5	1663	38	10.3
South America	47044	474	68	8.9
Oceania	54636.8	900	72	4.9
Sub-Saharan Africa	6322.5	173	88	3.8

Source: FAO (2003) Statistical database: *www.apps.fao.org/default.htm.*

acknowledged that past experiences have often provided grounds for such perceptions, there have been successes that could be built upon. For example, large-scale farmers in South Africa and Zimbabwe have developed and sustained significant areas of irrigation for non-rice cereals and fiber crops and have shown this to be commercially viable and sustainable; smallholders in Swaziland have, on their own initiative, taken advantage of market linkages and spontaneously developed irrigation for commercial sugarcane production. There have been successes with technology as well: in Tanzania, the area developed by smallholder farmers for rice production using traditional low-cost water management techniques far exceeds the total area under conventional irrigation systems; manual irrigation pumps have, furthermore, been successfully used for vegetable production throughout the region.

Up till the 1990s, there seemed to be a global consensus that governments are pivotal in facilitating investments in water development because most public investments in new water infrastructure are typically for groups and collectivities and are for multiple goals, larger areas, and multiple users. During the last decade, however, there was a heated debate about the role of the public and private sectors regarding investments in water resources infrastructure. Many efforts were made to decentralize and attract private investors with limited success. .Private investors are not likely to come forward, and even if they come forward, they entail the same risk of monopolization as state investments. Nevertheless, there are indications that the private sector played by far the major role in financing and developing controlled irrigation in countries such as South Africa, Swaziland, Zimbabwe and Zambia, mainly because of the colonial history of these countries. However, it is important to note that in these countries most of the larger scale private sector developments and some of the small to medium-size schemes have depended on public sector investment in large dams and subsidies for scheme infrastructure costs. Elsewhere in the region, most controlled irrigation has been financed and developed by the public sector. Thus, investing in water resources development and management is a proper function for governments – no one else is likely to do it otherwise, especially in poor rural areas (van Koppen and Safilios-Rothschild 2005, part 1 of this report).

In contrast, the substantial areas under ‘other forms of water management’, which include the areas referred to as ‘traditional irrigation’ by FAO and which probably amount to a considerable proportion of the total water-managed area in Sub-Saharan Africa have been financed and developed entirely by smallholders. For instance, since the mid-1970s and early 1980s, the Northern Nigerian states started the promotion of dry season small-scale irrigation investments in the fadamas by attempting to promote village perimeters using large diesel pump sets, harnessing surface and groundwater resources. This was primarily because the areas of land irrigated by farmers, without help from the Nigerian government and donor agencies using traditional systems of agricultural water management far surpassed those developed by the Nigerian government and its donors via large-scale irrigation schemes, and at much lower cost (Carter 2003). For instance, 75 percent of about 90,000 ha of irrigated land in Nigeria are believed to be under private small-scale fadama irrigation while the remaining 25 percent is under public large-scale irrigation schemes. In the remainder of this report we discuss the poverty impacts different forms of agricultural water management. Similarly, in eastern and southern Africa region there are indications that the traditional or informal irrigation systems are far more important than the formal irrigation systems in terms of area (Blank et al. 2002). However, the available statistics on irrigation potential and actual irrigated area in sub Saharan Africa are basically guesswork due to definitional problems and lack of common approach in the assessment (Habitu et al. 2002).

5. CASE STUDIES FROM EAST AND SOUTH AFRICA[7]

5.1 Irrigation investment projects

Description of the case study projects

Six case studies were carried out on irrigation investment projects in Madagascar, Tanzania and Zimbabwe. Three of these (Madagascar Upper Mandrare Development Project (Madagascar PHBM), Tanzania Mara Region Farmers' Initiative Project (Tanzania MaraFIP) and Tanzania Participatory Irrigation Development Project (Tanzania PIDP) considered the agricultural water development component as a whole within the respective projects. The other three considered a specific subproject within an overall project. Four of the projects (Madagascar PHBM, Tanzania MaraFIP and PIDP as well as Zimbabwe Smallholder Dry Areas Resource Management Project (Zimbabwe SDARMP) were IFAD-assisted. Maunganidze and Mutaradzi irrigation schemes in Zimbabwe were EU-assisted; Mupangwa Irrigation Scheme, also in Zimbabwe, was DANIDA-assisted. The six case studies covered a wide spectrum of agricultural water management types including partially-controlled medium-scale irrigation, fully-controlled small-scale irrigation, run-of-river irrigation, irrigation from dams, groundwater irrigation, surface irrigation, and sprinkler irrigation. Three of the projects/subprojects were intended for the production of rice crops; the other three for non-rice crops. The projects were selected because they had been recognized as successful by the respective financing or implementing entities and represent different approaches and technologies (Table 4).

The overall objectives of the projects were to increase incomes, reduce poverty, enhance food security and improve the quality of life. A range of activities to achieve the above objectives was intended for the various projects, including agricultural water development, access road improvements and institutional capacity building (Table 5).

Most of the case study projects had elaborate targeting intentions at least at the project appraisal stage (Table 6). Having defined the poor/poorest, the appraisal reports for MaraFIP, PIDP, and SDARMP, specified the proportion of beneficiaries to be drawn from the lower groups and made specific reference to women and/or female heads of households in the cases of PIDP and SDARMP. For PIDP, for example, the intention was not only that "about" 50% of beneficiaries would be from poor households (i.e., drawn from the lower and middle strata), but that at least 30% of the plots would be owned by women. In the case of SDARMP, the intentions were that 100% of the beneficiaries would be drawn from the poorest quintile of the rural populations in the selected districts, in the expectation that this would result in 75% of beneficiaries being female heads of households.

Poverty targeting achievements of the projects

In the case of PIDP, despite the intentions, the experience gained from the earlier SDPMA seems to have discouraged any further serious attempts at targeting the poorest stratum. Similarly, despite the intentions, no attempt to target the poor was made for the Mara Bunds subcomponent of MaraFIP and, once the decision had been made to finance the project, no attempt was made at targeting the poor at Dombolidenje. In some cases, the requirement of payment of a joining fee may have marginalized the poorest stratum, even where the fee was payable in kind because a family labor constraint is often a characteristic of poverty.

[7] This section is entirely based on the IFAD – IWMI poverty study 'Agricultural Water Development for Poverty Reduction in Eastern and Southern Africa' by Peacock (2005).

Table 4. Case study investment projects and external financiers

Case Study	Year Appraised/ Approved	Brief Description	Technology	Scale	Crop type	O&M Costs (USD/ha/year)	Capital cost (USD/ha)
Madagascar: Upper Mandrare Development Project (PHBM)	Phase I 1995; Phase II 2000	Rural development investment project with substantial agricultural water component for low cost improvements to 2 500 ha of small and medium-scale run-of-river surfaceirrigation schemes for intensified rice production. Phase I completed 2001; Phase II ongoing.	Run-of-river; concrete/masonry diversion structure; gravity-fed; partially lined main canal; unlined secondary canals; field to field distribution; basin irrigation.	Medium	Rice	4	440
Tanzania: Mara Region Farmers' Initiative Project (MaraFIP)	1996	Rural development investment project with component for small, low cost dams for 1 200 ha of new surface irrigation for rice cultivation. Completed in 2003.	Low, earth embankment dam storage; gravity-fed; lined main canal, unlined secondary canals; field to field distribution; basin irrigation.	Small	Rice	37	3679
Tanzania: Participatory Irrigation Development Project (PIDP)	1999	Agricultural water investment program to upgrade 3 850 ha in 16 existing run-of-river surface irrigation schemes, develop 1 520 ha in a further 7-8 new run-of-river surface irrigation schemes and to improve 6 080 ha in traditional advancing flood planting systems. Successor to a similar earlier project. Ongoing.	Run-of-river; gabion diversion structure; gravity-fed; unlined main canal; unlined secondary canals; field to field distribution; basin irrigation.	Medium	Rice	16	1066
Zimbabwe: Dombolidenje Dam & Irrigation Scheme	Overall project 1994	Subproject of Smallholder Dry Areas Resource Management Project (SDARMP), a rural development investment project. Subproject consisted of new large dam and 5 ha surface irrigation scheme for non-rice crops. Completed in 2001.	Large, earth embankment dam storage; gravity-fed piped main; lined secondary and tertiary canals; furrow irrigation.	Small	Non Rice	487	82400
Zimbabwe: Maunganidze Irrigation Scheme	EU project 1990; IFAD assistance 2001.	Investment subproject of Small-Scale Irrigation Programme (SSIP) consisting of 67 ha surface irrigation scheme supplied from groundwater. Completed in 1997.	Pumped groundwater from electrically powered boreholes; piped main; concrete lined secondary and tertiary canals; border strip irrigation.	Medium	Non Rice	95	10940

(Continued)

Table 4 (Continued).

Case Study	Year Appraised/ Approved	Brief Description	Technology	Scale	Crop type	O&M Costs (USD/ha/year)	Capital cost (USD/ha)
Zimbabwe: Mupangwa & Mutaradzi Irrigation Schemes	na	Investment subprojects of Support to Smallholder Irrigation Programme (SSHIP) and Microprojects Programme (MPP) respectively, completed in 1995 and 2000. Both are gravity-fed sprinkler irrigation schemes, of 22 ha and 24 ha respectively.	Run-of-river; gravity-fed piped main line; piped distribution; drag hose sprinkler irrigation	Small	Non Rice	98	7829

Na= Not available

Table 5. Intended water development and related activities of case study projects

Case Study	Intended Water Development and Related Activities[a]
Madagascar: Upper Mandrare Development Project (PHBM)	• Rehabilitate 2500 ha of existing rice irrigation schemes (1690 ha of former government sponsored schemes 810 ha of informal schemes) and expand by 900 ha. • Establish and train users' organizations. • Rehabilitate 80 km of trunk roads and 40 km of rural access roads/tracks. • Improve district level project implementation capacity.
Tanzania: Mara Region Farmers' Initiative Project (MaraFIP)	• Construct 11 small earth dams and irrigation systems for 1180 ha of rice cultivation.
Tanzania: Participatory Irrigation Development Project (PIDP)	• Rehabilitate/upgrade 16 existing rice irrigation schemes, comprising a total of 3850 ha, developed under earlier SDPMA. • Construct 36 new diversion schemes to supply 7600 ha of rice irrigation, of which 2280 ha was already being used for this purpose by traditional means. • Construct 8 new *charco* bunds to irrigate a total of 240 ha for rice cultivation. • Construct 108 new shallow wells for domestic water and vegetable irrigation.
Zimbabwe: Dombolidenje Dam & Irrigation Scheme	• Construct 600 garden-scale irrigation schemes covering 300 ha, of which 200 ha was to be based on shallow wells and 100 ha was to be based on deep wells, boreholes and small dams. • Training in participatory development for public sector service providers, district level staff and farmers.
Zimbabwe: Maunganidze Irrigation Scheme	• Institutional strengthening of government department responsible for planning and implementing smallholder irrigation schemes. • Training of irrigation farmers and their committees· • Construction of 700 ha Musikavanhu Irrigation Scheme (Maunganidze was added when it was found that surplus project funds were available).
Zimbabwe: Mupangwa & Mutaradzi Irrigation Schemes	• Not stated, but irrigation development and capacity building activities were clearly intended to be undertaken on both projects.

a/ In the case of subprojects, activities shown refer to those specified for the overall project.
Source: Project documents

Table 6. Targeting intentions for case study projects and subprojects

Case Study Project/Subproject	Targeting Intentions
Madagascar Upper Mandrare Development Project (PHBM – Phase I)	No specific targeting within project area: the whole population of the project area was considered poor and eligible for project assistance. Irrigation schemes, ownership of which was already established, were largely pre-selected (at formulation).
Mara Bunds subcomponent of Tanzania Mara Region Farmers' Initiative Project (MaraFIP)	Priority target groups for project assistance in general were the 'poorest' and the 'poor' as defined in appraisal report, which provided definitions according to agro-ecological zone. However, no minimum percentages of priority target group specified.
Tanzania Participatory Irrigation Development Project (PIDP)	"About" 50% of beneficiaries were to be poor households and at least 30% were to be women.
Zimbabwe: Dombolidenje Dam & Irrigation Scheme	Irrigation development under SDARMP was to be targeted at the poorest quintile of the rural populations in the selected districts – interpreted to mean that 100% of beneficiaries would be from the lower stratum – which was expected to result in 75% of beneficiaries being female-heads of households.
Zimbabwe: Maunganidze Irrigation Scheme	No specific targeting intended.
Zimbabwe: Mupangwa & Mutaradzi Irrigation Schemes	No specific targeting intended.

Source: Respective project documents

From the wealth ranking[8] exercise done to select sample farmers for interview, the impression was gained that, in terms of the poorest stratum in general, the targeting intentions were probably met at PIDP, since the lower group constituted more than 50% of total beneficiaries (Table 7). In contrast, it appears unlikely that the targeting intentions at Dombolidenje were met, since the beneficiaries were not drawn entirely from the poorest quintile of the population. However, the other schemes, including Maunganidze, generally included a large proportion of the poorest stratum – even if they were not specifically intended to. Overall, despite the apparent lack of systematic targeting, the indications are that the poorest stratum was reasonably well represented in scheme memberships, although the better off were represented too.

In terms of targeting women, for the 16 rehabilitated SDPMA schemes, 35% of the membership on average consisted of female heads of households, compared with 11% for the project area population as a whole. However, the impression gained was that the majority of women members of PIDP/SDPMA schemes were actually wives of male plot holders who had subdivided their irrigable land to assist the project in meeting its targeting obligations. A similar impression was gained at the MaraFIP subprojects. At the PHBM schemes visited, all of which involved rehabilitation and expansion of an existing scheme, where land ownership patterns had been well-established, less than 10% of plot holders were women, However, on the other projects, female-headed households made up 20%, 33%, 64% and 26% of the membership at Dombolidenje, Maunganidze, Mupangwa and Mutaradzi irrigation schemes respectively, all coincidentally or otherwise, non-rice schemes. The overall impression was that targeting intentions could have been better specified but that, even if they had been, targeting the poorest stratum was not easy to implement in practice.

For the IFAD-assisted projects at least, the poorer geographic areas within a country or regions were targeted at appraisal. At PIDP, which covered several regions of Tanzania, a screening process to select districts for inclusion was also carried out during the initial stages of implementation, based, *inter alia*, on poverty head counts. There was no indication that thereafter there had been any specific targeting of the poorest social stratum *per se* at any of the projects studied, despite intentions at appraisal. Nevertheless, project beneficiaries were typically extremely poor in terms of the poverty datum of USD1.00 per capita per day set by the Millennium Development Goals.

Table 7. Examples of irrigators' criteria and socio-economic stratification of scheme membership

Case study/ Sub Project	Wealth ranking distribution of beneficiary farmers (%)		
	Upper	Middle	Lower
Madagascar: Upper Mandrare Development Project (PHBM)	16	39	46
Tanzania: Participatory Irrigation Development Project (PIDP)	10	34	56
Zimbabwe: Dombolidenje	18	57	25
Zimbabwe: Maungaindze	57	29	14

Source: Case studies

[8] The criteria used for wealth ranking as elicited from the beneficiary farmers through group discussions include: size of irrigable land, size of arable land owned, number of cattle or livestock owned, type and quality of housing material, level of off-farm income, ownership of ox-cart and ploughs and food self-sufficiency status of the household.

Changes in gropping patterns and gropping intensity

The case studies indicated that current cropping patterns reflect a rational response to market access and food sufficiency status at each of the schemes. Rice was generally regarded by farmers on all three rice projects not only as a staple food – to supplement maize and cassava from rainfed lands – but also as an important source of cash income; hence, where water was available in the dry season farmers would use it to grow more rice in preference to other field crops. At PIDP, because of the lack of irrigation water for paddy, farmers had attempted to grow an off season crop of pulses on residual moisture. At Dombolidenje and Maunganidze, because of grain maize shortages in Zimbabwe over the past few seasons, irrigators had found it expedient to grow their own supplies. In contrast, at Mupangwa and Mutaradzi, where conditions were more favorable for rainfed maize, farmers found it more rational to reserve irrigation for other higher value crops – including green maize.

Comparison of cropping patterns and intensity without and with-project is shown in Table 8. On rehabilitated schemes at PHBM, the cropping intensity of paddy was typically increased with-project from 110% to 125%. At PIDP it was increased from 80% to 100%, while the intensity of other cropping on residual moisture increased from 5% to 10%. On all three rice projects the lands on which newly developed areas were located had without-project been only partly used for rainfed arable cropping, at an intensity of 25-50%. Without-project, the scheme areas at the three non-rice projects had been used for rainfed arable crops at an intensity of 50%. With-project, cropping intensity was increased to 130-200%.

Table 8. Cropping patterns and intensities without and with-project

Case Study/Subprojec	Cropping Pattern/Intensity	
	Without the project	With project
Madagascar Upper Mandrare Development Project (PHBM – Phase I)	50-110%	125%
Tanzania Mara Region Farmers' Initiative Project (MaraFIP – Mara Bunds subcomponent)	25%	100%
Tanzania Participatory Irrigation Development Project (PIDP)	50-85%	110%
Zimbabwe: Dombolidenje Dam & Irrigation Scheme	50%	200%
Zimbabwe: Maunganidze Irrigation Scheme	50%	200%
Zimbabwe: Mupangwa & Mutaradzi Irrigation Schemes	50%	130%

Source: project reports, interviews and field observations

Land productivity impacts

Documented data for actual without and with-project paddy yields was triangulated during household interviews, in time series form where possible and for each of the social strata. The results obtained for main and off-season crops at PHBM Phase I schemes displayed wide disparity between lower and upper stratum farmers in absolute terms, but less in incremental terms (Table 9). The weighted average was much lower than assumed at appraisal, although the weighted average incremental main season yield of 0.85 t/ha was reasonably close to expectations. Incremental yields achieved at MaraFIP were higher than assumed at appraisal because, contrary to expectation, the investment was for new development rather than rehabilitation. Yield increments were generally attributed to improved irrigation water supplies and crop husbandry practices, including line planting. However, despite these mostly positive results, with-project yields were far below potential in absolute terms, particularly at PHBM.

Table 9. Typical actual paddy yields achieved at rice schemes

Projects	Social	Share of stratum	season farmers	Paddy yields (t/ha)		
				without	with	incremental
PHBM Schemes	upper	15	Main	1.65	3.03	1.38
			off	1.40	2.18	0.78
	middle	40	main	0.86	1.81	0.95
			off	0.45	1.22	0.77
	lower	45	main	1.04	1.62	0.58
			off	1.20	1.00	-0.20
	Average	100	main	1.06	1.91	0.85
			off	0.93	1.27	0.34
	Yield assumed at appraisal		main	1.9	2.9	1.0
Tanzania Mara Region Farmers Initiative Project (MaraFIP-Mara Bunds Sub component)	Actual yield		main	0.0	3.3	3.3
Tanzania Participatory Irrigation Development Project (PIDP)	Actual yield		Main	1.6	3.3	1.7
	Yield assumed at appraisal			1.6	2.7	1.1

Source: project documents and interviews

The best estimates of average paddy yields at the three rice schemes were 1.9-3.3 t/ha. The higher end of the range represented yields at MaraFIP, where without-project production was negligible but with-project dams were provided to regulate irrigation water supplies. Incremental paddy yields at PHBM, PIDP and MaraFIP were 85%, 155% and 333% of appraisal targets respectively. However, in absolute terms these yields were low compared with reported yields in South Asia and even at Mwea in Kenya. Since the schemes at PHBM and PIDP were based on run-of-river supplies, it is possible that the developed area was periodically short of water, which would have adversely affected yields.

Estimated yields of grain maize at the three non-rice projects in Zimbabwe averaged 2.5-3.4 t/ha, which was considerably lower than the 5.5-6.0 t/ha assumed at appraisal. The average yield of canning tomatoes at Maunganidze was 20.6 t/ha, which was slightly higher than assumed at appraisal but considerably lower than the 60-70 t/ha achieved by large scale commercial farmers. However, yields of dry beans averaged 1.6 t/ha, reasonably close to the 1.7 t/ha assumed at appraisal.

Labor productivity and employment impacts

Whole farm labor requirements obviously vary from farm to farm depending on farm size, cropping pattern, cropping intensity and the degree of mechanization available. However, paddy is particularly labor intensive and the requirement for the whole farm with-project on the three rice projects varied from 278 labor-days per year at PIDP to 405 labor-days per year at PHBM, representing an increment of 65-140 labor-days per year per household. Since the typical household is only able to provide up to 360 labor-days per year household, the obvious shortfall at PHBM and MaraFIP would have had to be met from hired labor. Furthermore, the shortfall is likely to have been greater than indicated, since during periods of peak demand – for example during puddling and transplanting – the labor requirement would exceed 1.5 labor-days per household.

Most interviewees at PHBM, however, indicated that hired labor was infrequently used: instead tasks were shared between households. Obviously, this arrangement was more financially advantageous than direct hire. Overall, the indications at PHBM were that (a) middle and upper stratum farmers effectively hired labor to meet periods of peak demand, and (b) wage labor was generally obtained from the ranks of the lower stratum. The situation at MaraFIP was more straightforward: hired labor was used typically by middle and upper stratum households for puddling, transplanting and, occasionally, weeding. At PIDP, there was less use of hired labor, but even middle stratum households would occasionally sell their labor. In the case of the three rice projects, a typical household would hire at least 40 days of wage labor per year at approximately USD1.00 per labor-day.

At Dombolidenje, owing to the small size of the irrigated farm (0.1 ha) per household, incremental labor with-project was estimated at only 15 labor-days per household and no wage labor was employed. The same applied to some extent at Mupangwa/Mutaradzi, because whole farm size there was smaller than at Dombolidenje, although farmers from the upper stratum (which included most farmers at Mutaradzi) did hire in times of peak labor demand. Although the total labor requirement at Maunganidze was higher than at the other non-rice projects (because of the labor-intensiveness of tomatoes), it was less than that available from within the typical household and hired labor was unnecessary. However, farmers with less than average family labor resources would employ additional labor from within the extended family, paid in kind.

Income and poverty reduction impacts

Increasing the incomes of the target population was the explicit or implicit overall objective of at least five of the projects/subprojects studied. Changes in cropping pattern and intensity, and improved land and labor productivity, *ceteris paribus*, lead to increased income and hence reduced poverty. Increases in household and *per capita* incomes need to be put in perspective in terms of income from all sources, if their significance is to be understood. Apart from irrigation, these sources might include rainfed farming, livestock production, off-farm activities such as handicrafts, wage employment and business as well as remittances.

It was clear in most cases that farmers with non-farm business interests, such as trading and transport, were represented in beneficiary groups. It was also clear that in some cases (Dombolidenje, PIDP, Maunganidze) less well-off households were engaged in alternative off-farm income generating activities, such as gold-panning, mat-weaving and fuel wood collection. Vegetable growing, mainly for home consumption, was also important. But there was no indication anywhere that remittances typically formed a significant part of household income. Overall, the main source of income for the majority of beneficiaries was agriculture and livestock. In all cases, beneficiaries of irrigation interventions had already been engaged in agriculture under rainfed conditions and most continued these activities with-project – at a reduced scale if some of their rainfed arable land was absorbed into the new irrigable lands or otherwise, labor permitting, at the same scale as before.

Typical whole farm net income for each of the rice projects studied, without and with-project, assuming that all labor is provided by the family is estimated in Table 10. The area of irrigated farm considered takes account of the expansion of the scheme area in the cases of PHBM and PIDP, even though the typical household may or may not have benefited individually from expansion. Incremental income at the three rice projects ranged from only USD 0.11 to USD 0.18 per household member-day, which may seem very small. However, in terms of the US Dollar a day poverty datum it is put into perspective by income from rainfed farming without-project, which ranged from only USD 0.10 to USD 0.21 per household member-day. On the above basis, making some assumptions

Table 10. Summary of typical household members' income without and with-project at case study rice projects (mid-2003 USD/household member/day)

Income source	Madagascar PHBM		Tanzania MaraFIP		Tanzania PIDP	
	without	with	without	with	without	with
Irrigated farming	0.05	0.23	0.0	0.14	0.01	0.12
Rainfed farming	0.16	0.10	0.21	0.21	0.10	0.09
Livestock production	0.07	0.07	0.03	0.03	0.03	0.03
Vegetable gardening	0.04	0.04	0.04	0.04	0.04	0.04
Off-farm activities	0.02	0.00	0.02	0.00	0.02	0.00
Total	0.34	0.44	0.30	0.41	0.20	0.27
Increment (%)	29		36		38	

Source: Peacock 2005.

Table 11. Summary of typical household members' income without and with-project at case study non-rice projects in Zimbabwe (mid-2003 USD/household member/day)

Income source	Dombolidenje		Maunganidze		Mupangwa/Mutaradzi	
	without	with	without	with	without	with
Irrigated farming	0.0	0.01	0.00	0.16	0.0	0.20
Rainfed farming	0.04	0.04	0.06	0.04	0.03	0.00
Livestock production	0.08	0.08	0.04	0.04	0.00	0.00
Vegetable gardening	0.04	0.04	0.04	0.04	0.00	0.00
Off-farm activities	0.20	0.20	0.02	0.00	0.15	0.00
Total	0.36	0.37	0.15	0.28	0.18	0.20
Increment (%)	2		82		14	

Source: Peacock 2005.

with regard to off-farm income, it is estimated that at the three rice projects the total income from all sources of a member of a typical household without-project was USD 0.20-0.34 per day and that this increased by up to 38% to USD 0.30-0.45 with-project.

Similarly, it is estimated that at the three non-rice projects the total income from all sources of a member of a typical household without-project was USD 0.15-0.35 per day and that this increased by up to 80% to USD 0.20-0.35 with-project (Table 11).

Food self sufficiency impacts

Whole farm cereal and tuber balances for the three rice projects, without and with-project, are shown in Table 12. Not surprisingly, since they are rice projects, all of them produced a large surplus of cereals or tubers over the typical household requirements both without and with the project, with irrigation making a significant contribution. Although the incremental surplus at PHBM amounted to only a net 10% because of rainfed production foregone, it was more than 20% at MaraFIP and PIDP. At MaraFIP, where all paddy production was incremental, the surplus was sufficient to feed an additional 5.1 households over and above the producing household.

Table 12. Whole farm cereal and tuber balance at case study rice projects without and with-project

Parameters	Madagascar PHBM		Tanzania Mara FIP		Tanzania PIDP	
	Without	with	Without	with	Without	with
Household size	5.5	5.5	5.5	5.5	5.5	5.5
Adult Equivalent	4.3	4.3	4.3	4.3	4.3	4.3
Total Annual cereal and tuber production (t/household)	3.86	4.15	4.45	5.31	3.45	4.16
Contribution from Irrigation	0.27	2.05	0.00	1.03	0.06	1.29
Minimum Requirement (t/household)[a]	0.87	0.87	0.87	0.87	0.87	0.87
Surplus (t/household)	2.98	3.28	3.57	4.43	2.58	3.28
Incremental surplus (%)	10		24		27	
Equivalent surplus households	3.4	3.7	4.1	5.1	2.9	3.8

[a/] Based on minimum caloric equivalent to 203kg of cereal or tuber/adult/year.

Table 13. Whole farm cereal balance at case study non-rice projects without and with-project in Zimbabwe

Parameters	Dombolidenje		Mauganidze		Mupangwa/Mutaradzi	
	without	with	without	with	without	with
Household size	5.5	5.5	5.5	5.5	5.5	5.5
Adult equivalent	4.3	4.3	4.3	4.3	4.3	4.3
Total annual cereal and tuber production (t/household)	0.34	0.97	0.43	2.33	1.18	1.32
Contribution from Irrigation	0.00	0.65	0.00	2.00	0.00	0.82
Minimum requirement (t/household)[a]	0.87	0.87	0.87	0.87	0.87	0.87
Surplus (t/household)	(0.54)	0.10	(0.38)	1.52	0.30	0.44
Incremental surplus (%)	118		505		48	
Equivalent surplus households	(0.62)	0.1	(0.47)	1.9	0.3	0.5

In contrast, the typical household at two of the non-rice projects (Dombolidenje and Maunganidze) would have been seriously short of food in the without-project situation. The impact of the project on household food self-sufficiency in these two cases was very clear, since the previous deficit had been turned into a surplus with a swing of 120% at Dombolidenje and 505% at Maunganidze (Table 13). What is perhaps more significant is that at Maunganidze, the surplus cereal with-project was sufficient to feed two additional households, over and above the producing household. Interviews suggested that part of this surplus was used for in-kind payments to wage labor on either the irrigated or the rainfed farm or both, but that at least part of it was used to feed the extended family.

Other impacts

Of the three rice projects, the most striking impacts reported were at PIDP, where an increase of 86% in farm income with-project had, according to interviewees, enabled beneficiaries to enjoy a number of improvements to their material wellbeing. These included better quality housing, purchase of farm

and transporting assets (ox-ploughs and oxen, bicycles and carts, transistor), better access to health services; and ability to finance children's education (particularly secondary education). Changes in wealth indicators, reported in the *Mid-Term Socio-Economic Assessment* of PIDP for four representative upgraded SDPMA schemes (Bahi, Lusu, Igongwa, Choma and Nata) are shown in Table 14. According to this report, the injection of additional farm income had also had a positive impact on trade and business in the villages themselves as well as the market centers on which they bordered, as a result of scheme members investing their additional income in establishing businesses such as bars, kiosks, shops, flour mills, tailoring shops, furniture workshops and bicycle transport (ferrying people between bus stops and the villages). All this had also induced further investment by traders and transporters from outside the area and had generated its own second round of employment.

Table 14. Changes in wealth indicators at representative upgraded SDPMA schemes, PIDP, Tanzania

Type of Asset	Ownership by year		Increase(%)
	2000/01	2001/02	
Ox-plough	805	867	8
Ox-cart	38	89	134
Cattle (purchased)	15	154	927
House with corrugated metal roof	41	208	407
Bicycles	172	244	42
Transistor radio sets	172	1687	881
Grain milling machine	2	12	500
Small shops/kiosks	2	74	3600
Television sets	0	10	Na
Vehicles	0	2	Na
Motor cycles	1	2	100
Mobile phones	0	1	na

Source: Mid term Socio-Economic Assessment (July 2003).

Impacts other than increased incomes and food security were not obvious at Dombolidenje, probably because of its relatively small size. At Mupangwa/Mutaradzi farmers described the main benefits as increased ability to pay school fees and opportunities to participate in trade, as well as improved housing. Similarly, of the three non-rice projects, the most impressive direct impacts of irrigation investment were found at Maunganidze. The wellbeing improvements listed by farmers including those in the poorest stratum are improved housing, ability to accumulate assets (particularly livestock and ploughs), ability to pay school fees, improved diet and nutrition, and ability to afford better clothing.

Of the above benefits, the most visible and striking is improved housing. Without-project housing had generally been of mud/pole under thatch construction, but with-project, numerous new 2-3 roomed houses in concrete block under asbestos-cement sheet roof had been completed or were under active construction. Most of these were complete with their own ventilated improved pit latrines and, in some cases, a new water well. It was also obvious, from visits to a number of homesteads, that irrigators were accumulating new assets as a result of increased disposable income. There was no doubt that this had been the result of the investment in irrigation, since there was no other source of income in the area.

According to the final evaluation of Maunganidze, traders around the scheme had reported that business had increased as a result of the scheme. Apart from increased sales of agricultural inputs and implements, there was increased demand for groceries as well as for building materials (cement, asbestos sheeting and plumbing) and building construction services. There had also been a consequent growth in downstream industries, including the establishment of small-scale agro-processing plants (e.g., grinding mills) and workshops for manufacturing farming equipment (such as ox-carts), window frames, door frames, burglar bars and the like. Some of these industries had been able to take advantage of the electrical power network which was not only extended to the scheme to power the pumps but also to the village.

Health impacts

It was clear that HIV/AIDS had severely affected the availability of household labor and its productivity. However, in these same cases it was also clear that access to irrigation and resulting increased household income had greatly helped the affected households to cope. For example, it had enabled them to pay for clinic visits and drugs, to improve their nutrition, and in the case of Maunganidze to develop their own sources of clean drinking water and sanitation facilities, thus reducing the risk of infection.

Constraints and challenges

Inadequate access to complementary inputs: The recurring finding pertaining to the six irrigation investment projects has been that actual crop yields with-project have fallen far short of their commercial potential. The overwhelming observation was that this was because of a lack of support services, including credit and input supply, and technical advice. Farmers lacked access to credit and therefore the use of yield-enhancing inputs such as fertilizers and crop protection chemicals was negligible. Although the projects provided technical support services, these were not necessarily geared to maximizing profit, and mechanisms for their continued support once the project had withdrawn had not been established. The likelihood in all cases was that farmers would be left to fend for themselves, which they would be unable to do unless given support to organize for doing business with the market.

Marketing constraints: Farm gate prices for paddy showed wide variation between seasons – lower prices reflecting a relative abundance of the crop in the immediate post-harvest period, when most producers have to sell a large part of their crop to meet household cash requirements, and higher prices reflecting a relative scarcity in the immediate pre-harvest period. Often many of the same producers had to subsequently buy back a proportion of the crop at higher prices to meet household food requirements – after having sold their labor for cash. Despite government controls, grain maize produced on the three non-rice projects in Zimbabwe was generally traded on the parallel market at higher than the gazetted price. The case study on Maunganidze highlighted the low price paid to contract growers for canning tomatoes – equivalent to less than 2% of the current retail price for the canned product. Where projects had financed improvement of arterial and/or feeder roads, they appeared to have improved market access by encouraging more buyers and transporters into the areas. But, again, the mechanism for maintaining these roads once the project had withdrawn had not been established.

Organizational issues: It was found that WUAs remained poorly established and unlikely to be able to collect fees, manage their own financial affairs and operate as legal entities. They might provide labor for minor repairs and routine maintenance such as cleaning canals, but no more. In no case was it clear that the WUAs' responsibility for operation and maintenance extended to major repairs, for example reconstruction of a washed out diversion weir or head works. Furthermore, it was generally not always clear who owned the infrastructure, i.e., whether central government, local government or the communities themselves were the owners.

Usually insufficient funding is allocated to the organization of WUAs and even if formed, they were inherently weak in terms of autonomy and accountability, resulting in mistrust and fear among the membership. Where they appeared well-established and fully functional, this might be due to: (a) the high quality, focus and commitment of implementation staff, (b) the degree and type of farmer training, and (c) farmers' awareness of the importance of the irrigation scheme to their livelihoods. However, even so, it was doubtful that the membership would be able to raise sufficient cash to commission major maintenance and repairs.

Water and land right issues: There were incipient or potential water rights disputes at MaraFIP, PIDP and PHBM. At MaraFIP, the respective village authorities had encouraged expansion of some of the Mara Bund schemes to accommodate more members when it was clear that there was insufficient water for the existing area. At PIDP, whilst the spontaneous expansion of existing irrigable areas was a gratifying indication of demand, there were signs of potential tensions between expanded schemes and downstream users and even within the same scheme. The irrigable area in run-of-river rice schemes varies considerably from year to year, but the rules for allocation were unclear.

There had been a problem of insecure tenure at PIDP when the original users of Bahi Irrigation Scheme were evicted to make way for better-off, more productive farmers. Interviewees indicated that land markets operated on an informal basis in both Madagascar and Tanzania, with irrigated land (or the right to use it) being sold for up to USD 670/ha in Madagascar and leasing or sharecropping a common practice on all three rice schemes. At Maunganidze the total number of irrigators far exceeded the number of registered plot holders, as the latter lent or hired out land to members of the extended family and others.

Land distribution with-project at PHBM and PIDP was a 'grey' area. Both projects had been intended to improve and expand existing irrigation schemes, with the intention that the expansion would benefit additional households to those already holding plots in the existing area. At PIDP, land redistribution was specifically mentioned as a project objective to address the inequalities that were thought to be common in the traditional rice growing areas, where the majority of farmers own 1-2 ha of irrigated land while a minority owned as much as 10-20 ha each. The impression was gained, however, that project equity objectives were not being met. For example, there were obvious cases in which the project had enabled existing irrigator households to merely increase their irrigated land holdings, which they then hired out to sharecroppers. At MaraFIP, the proposed expansion appeared intended to benefit mainly the wives of existing plot holders.

The situation was clearer on the three non-rice projects in Zimbabwe, where land redistribution certainly did take place at Maunganidze, Dombolidenje and Mupangwa, and farmers were allocated uniform plot sizes, although the leasing of irrigated land is more common than officially recognized. At Mutaradzi, there were a number of 'absentee landlords' who either leased their land to others or did not use it at all.

Gender issues: Women were under-represented in scheme membership at the PHBM rice schemes, but better represented at PIDP and MaraFIP. However, female plot holders at these latter schemes were mostly married women whose husband also had a plot in the irrigation scheme and to some

extent were included to 'make up the numbers'. Woman-headed irrigator household appeared fewer in number than married women irrigators in all cases.

5.2 Alternative agricultural water development: Indigenous or introduced technologies

The literature suggests that a wide range of indigenous or improvised water harvesting technologies have been practiced in many countries of Africa. It is beyond the scope of this paper to review the entire spectrum. What follows are descriptions of a representative selection of some of those in use (Table 15).

With a few exceptions, water harvesting projects are still not systematically monitoring the impact of water harvesting on yields, they are promoting packages costing more than USD1000 per ha, and farmers are still not adopting them. There seems to have been a general lack of understanding on the part of researchers that the overall objective was to increase farming households' incomes and that interventions would be judged as successful only if they were physically functional for the purpose intended over their expected economic life. There is limited documented information on the actual costs and benefits for the various interventions presented in Table 15.

Nevertheless, by reference to various texts and design manuals, including FAO's 1991 publication on *Water Harvesting* as well as information on cropping patterns, yields and prices obtained during farmer interviews, estimates of earthworks quantities, labor outputs, costs and benefits for some of the interventions in mid-2003 USD were determined. A summary of the results

Table 15. Examples of indigenous or introduced soil and water management technologies

Technology	Description
Majaruba Basins (Tanzania)	Bunded basins with dimensions of 15m by 15m and a bund height of 200m. Permits storage of an average depth of water of 125 mm and allows the exploitation of valley bottoms and plains in the semi-arid areas
Planting pits (Kenya and Tanzania)	Holes of about 30 cm in diameter and 20 cm in depth excavated along the contour at a spacing of 0.5-1.0 m. The holes are filled with soil and compost. They trap runoff and hold moisture, silt and organic debris and are used to plant trees or field crops.
Contour barriers (Kenya and Tanzania)	Cross-slope barriers, which may be vegetative (grass strips, trash lines) or mechanical (stone lines, earth bunds). The barriers intercept runoff from upslope and promote infiltration in the cropped area.
Trapezoidal bunds (Kenya)	An earth bund with wing walls extending upslope at an angle of 45 degrees, resembling three sides of a trapezium in plan. The bunds are intended to collect and impound runoff from long slope catchments external to the cultivable areas
Deep tillage (Botswana and Zimbabwe)	Deeper ploughing to 20-25 cm using heavy equipment, which promotes deeper rooting and thus increasing access to water
Tied ridges (Zimbabwe)	Consists of a broad based ridge and furrow system, with a1.5 m spacing between ridges, which are formed by a tractor-drawn ridger.
Runoff capture & storage (Kenya, Burkina Faso)	Water harvesting systems that collect local surface runoff (sheet, rill and gully flow) in small, brickwork storage structures of 100-1000 m^3 capacity and used for supplementary irrigation of food crops
Conservation tillage (Zimbabwe, Tanzania, South Africa and Zambia)	Covers a spectrum of non-inversion practices from zero tillage to reduced tillage; it is intended to maximise soil infiltration and soil productivity as well as to minimise water losses, while conserving energy and labor.
RELMA subsurface storage tanks (Kenya)	Development of subsurface tanks to store rainwater from micro-catchments for dry season irrigation of vegetable gardens

Table 16. Overview of cost effectiveness of selected agricultural water development alternatives

System type	crops	Capital cost (USD$/ha)	Total annual costs (USD/ha)[a]	Net annual income (USD$/ha)	Benefit cost ratio
Majaruba basins	Paddy	94	14	8	0.6
Negarim micro-catchments (Kenya)	Fruit trees	500	77	0	0.0
Contour ridges	Field crops	369	57	19	0.3
Trapezoidal bunds (kenya)	Sorghum	750	116	(13)	(0.1)
Tied furrows (machine construction)	Field crops	Na[/b]	Na	na	na
RELMA sub-surface storage tanks	Vegetables	5000	659	330	0.5
Silanga storage tanks	Vegetables				
Tanks		667	103	0	
Treadle pumps		263	79	0	
Total Silanga plus pump		930	182	300	1.8

Notes: [a] Includes annualized capital and maintenance costs, [b] Not available
Source: Peacock 2005.

is presented in Table 16. Capital costs ranged from USD 94 per ha for *majaruba* basins, for paddy production in Tanzania, to USD 5000 per ha for what have been labeled 'RELMA' type sub-surface storage tanks for horticultural crop production in Kenya. Annual benefits (after labor costs) ranged from zero (*negarim* micro-catchments and trapezoidal bunds) to USD 330/ha (for *silanga* storages with treadle pump). Benefit-cost ratios ranged from minus 0.1 or less for *negarim* micro catchments and trapezoidal bunds to 1.8 for *silanga*/treadle pumps.

The most promising technology was the *silanga* tank (complete with treadle pumps) in Kenya, used for vegetable gardening by individual households, which showed a benefit-cost ratio of 1.8. It is worth noting that both of these are based on indigenous technologies.

The 'RELMA' tank technology could be viable if higher levels of productivity could be obtained than those of *silanga* tanks. However, like *silanga*, RELMA tanks would probably depend on manual/treadle pumping, which is likely to inhibit higher productivity, and the initial capital cost is likely to be beyond the reach of most smallholder households. Moreover, it should be noted that Machakos district, where both the RELMA and *silanga* tanks have been tried, receives relatively high and well distributed rainfall; the technology would obviously work less well in drier climates.

Tied ridges appear to be effective in enhancing rainfall infiltration on heavier soils, which results in significant yield increments of sorghum and cotton. However, research to date has not considered the costs, and the technology seems to depend on the availability of mechanized tillage. Hence, although the technology may be profitable for large scale farmers it is probably not feasible for small scale farmers. Similarly, research on conservation tillage seems to have ignored costs and benefits. Moreover, the technology appears to demand the use of herbicides for weed control, which may be feasible for large-scale farmers but not small-scale who might be averse to the financial risks involved. Of the other alternatives considered, the construction of trapezoidal bunds for sorghum production does not appear to be a viable proposition at all, owing to high capital costs and low incremental benefits. The development of contour barriers, micro-catchments and infiltration pits does not appear to result in any incremental benefit.

5.3 Treadle pumps

The promotion of treadle pumps over the past 7-8 years in Kenya and Tanzania by ApproTEC, supported mainly by the UK's DFID, was selected for case study because apparently (a) the NGO has created product awareness and sold almost 38 000 treadle pumps in these two countries, (b) has done so by facilitating the establishment of a commercial supply chain, and (c) the pumps produced had been purchased by farmers on their own account. The NGO received funding of approximately USD 9.7 million in the form of grants, most of which was intended and used for development of the treadle pump and establishment of the supply chain, initially in Kenya and later in Tanzania. The common overall objectives of the projects were to sell pumps, improve poor farmers' incomes, create employment, reduce poverty and contribute to economic growth. The intention was that the NGO would exit once a 'critical mass' had been achieved that would ensure that the supply chain continued without external support.

The NGO's first treadle pump for the East African market was the 'MoneyMaker', the design of which was inspired by a pump developed in Bangladesh. By end-1999, a total of 4050 of these pumps had been sold in Kenya and another 438 in Tanzania. By March 2001, at least 2835 were still in use. However, the MoneyMaker was discontinued in 2000 because it was not a commercial success. Like the Bangladeshi pump, the MoneyMaker could draw water from a depth of up to 6 m but it could not deliver it against a head, which was acceptable in Bangladesh, where the pumped water would typically be used for a rice paddy or nursery, but not in Kenya where the terrain is more undulating.

In 1998, therefore, the NGO developed the two-piston 'Super MoneyMaker' pump, which could not only draw water from a depth of 7 m but deliver it through a similar head above the pump. It was marketed in Kenya at USD 80 per unit. In 2001, in an effort to reduce costs, the single-piston 'MoneyMaker Plus' was introduced and marketed at a retail price of USD 38 per unit. Although the delivery rate from this pump was not as high as that of the 'Super MoneyMaker' it was still able to deliver water against a head of 6-7 m (Table 17). However, its discharge was pulsating rather than continuous. It was also somewhat difficult to balance on while pumping and it never sold as well as the more expensive Super MoneyMaker.

Remarkably, the Super MoneyMaker pump was 23% cheaper in Tanzania than in Kenya, apparently because of lower margins for each of the actors in the supply chain as well as lower manufacturing costs.

Table 17. Comparative features of super money maker and money maker plus pumps in Kenya

Pump	Retail Price (USD)	Total Sales (end-2003)	Maximum Suction Lift (m)	Maximum Total Dynamic Head (m)	Discharge (l/s)	Irrigation Potential (ha)
Super Money Maker	80	25,000	6	14	0.8-1.5	0.80/6 hours
Money Maker Plus	38	7,500	6	13	0.3-0.6	< 0.60

Source: ApproTEC.

Labor productivity and employment impacts

The second follow up survey in Tanzania found that the average value of non-family wage employment increased from USD 43 without the pump to USD 52 with pump. All evidence points to each productively used pump directly creating of the order of up to 200 additional labor-days

of wage employment per year, over and above that employed in manufacturing, distribution and sales, paid out in cash and kind. It is likely that this labor is provided mostly by the poorest stratum of society.

Income and poverty reduction impacts

At a unit cost of USD 326.5[9], the investment cost per hectare for the Super MoneyMaker pump, at an assumed irrigation capacity of 0.25 ha per unit, was USD 1306, excluding any other investment by the user. However, because most of the project costs were met by the donor, the investment cost to the end-user amounted to only USD 290 per ha. The estimated economic life of the Super MoneyMaker pump is three years, although most pumps marketed have already been in operation for considerably longer than this. If the cost of the pump was discounted at 8% over three years, the annualized cost at the project level including donors' contributions to pump development and farm level respectively would be USD 127 and USD28 per pump. Assuming a typical treadle pump operator's household size to be 5.5 persons and incremental annual income from pump irrigation of USD 665 per unit, the incremental income per household member-day equals USD 0.33.

A survey by Minja (2003) in Tanzania also recorded total household income, including that from rainfed farming, livestock and off-farm activities (Table 18). Without the pump, total household income amounted to USD 621, equivalent to USD 0.31 per household member-day. With the pump, total household income increased to USD 1 800, equivalent to USD 0.90 per household member-day. Of the total increment of USD 0.59 per household member-day, USD 0.33 was, as noted above, directly attributable to the pump. In other words, acquisition of a pump enabled the average owner to double his household income.

It is estimated that the 38000 pumps sold resulted in about 27000 households obtaining an incremental income of approximately USD 0.33 per household member-day, which when added to income from other sources (such as dry land farming and livestock) enabled them to achieve the target minimum per capita daily income of USD 1.00 set by the Millennium Development Goals. Direct income gains also extended to approximately 27000 additional households that were engaged in wage employment in treadle-pumped irrigated production.

Table 18. Other household income and sources for 64 treadle pump farmers in northern and lake zones of Tanzania (mid-2003 USD)

Item	Without pump [a]	After 9 months[b] (USD/treadle pump)	After 23 months[c] (USD/treadle pump)	Incremental value after 23 months
Irrigated farming	270	595	935	665
Rain-fed farming	38		61	24
Livestock	19	27	181	161
Off-farm income	294	642	623	329
Total	621	1264	1800	1179

[a] June 2001; [b] March 2002; [c] May 2003.
Source: Minja (2003) converted to USD and adjusted to mid 2003.

[9] As mentioned, the total grant assistance received by the NGO amounted to USD9.7 million, most of which had been used for treadle pump promotion. Since a total of 38 000 pumps had been sold by end-2003, the total donor contribution amounted to approximately USD 254 per unit[9]. Taking the Super Money Maker as the standard and taking the mean of the Tanzanian and Kenyan price for this pump as USD 72.50, the total investment cost at project level was therefore USD326.50 per pump, which also represents the cost per irrigating beneficiary household.

Other impacts

According to Minja (2003), after realizing income increases most farmers wished to build a modern house for their family, using burnt bricks and corrugated iron roofing. He reported a 38% increase in the number of respondents with this type of housing after 23 months of use compared with that after 9 months of use and a corresponding substantial decrease in the number living in mud houses (Table 19). Minja also found a considerable increase in other economic activities of households with pumps, including a significant increase in income from livestock, which was thought to be the result of investment of cash from irrigation. Whatever the case, ownership of livestock, notably sheep, pigs and cattle significantly increased with pumps, as did ownership of other assets, such as land and agricultural equipment.

Table 19. Characteristics of respondents' housing

Description	After 9 months	After 23 months	Change (%)
Burnt brick and corrugated iron sheets	21	29	38
Cement block and corrugated iron sheets	18	20	11
Mud walls and grass roof	12	4	(67)
Mud block and corrugated iron sheets	6	3	(50)
Mud block and grass roof	2	2	0
Mud, wattle and corrugated iron sheets	1	1	0

Source: Minja (2003)

Equity impacts

The NGO's strategy was to develop and promote technologies for small/medium-scale enterprises, in this case small-scale horticultural production enterprises, to achieve economic growth and create employment. The perception was that the early adopters would typically be the better-off farmers, who could access the necessary funding and afford to take risks. However, the distribution of pump purchasers by income category indicates that self-targeting by poorer farmers was probably more effective than supposed. The data show that a large majority of pump buyers (80%) had been surviving on less than a dollar a day (Table 20). Apparently, even very poor households had been able to access the new technology, possibly because the period required to gain sufficient income to repay the cost of the pump was suited to informal borrowing.

Table 20. Distribution of pump purchasers by income category (cumulative)

Daily Income (USD/household member-day)	Annual Household Income (USD)	Super MoneyMaker (%)	MoneyMaker Plus (%)
<1.00	2 008	73	80
<0.75	1 506	59	70
<0.50	1 004	48	54
<0.25	502	23	34

The survey by Minja (2003) in Tanzania found that 95% of pumps sold were bought by men. It is likely, however, that this percentage included cases in which women had actually purchased the pump but registered the pump in the husband's name, as head of household and controller of household assets. Pumps were initially mostly managed by the owner – i.e., the husband – but the survey found that, over a period of one year, there was an increase of 54% in the number of women managers, from 40% to 61%, indicating that women increasingly took over this responsibility. It was thought that this change had been brought about by men's job displacement, by which the former manager had moved on to other responsibilities for income generating activities that had resulted from investments made using the proceeds from pump irrigation. This seems likely since pump irrigation was accompanied by an increase in off-farm income. It was also thought that women were more likely to become engaged in pump irrigation than they had been in bucket irrigation, owing to the labor-saving nature of treadle pumps. The data suggested that women provided 41% of the family labor in irrigator households and also that women provided 42% of paid labor. It was also noted that, although woman managers were not necessarily the pump operators, they could sometimes be so.

Constraints and challenges

According to the interviewees in Tanzania, the main constraint to the adoption of the treadle pump was vegetable pests and diseases, for which they were unable to obtain technical advice, and as a result of which they had been considering abandoning production altogether. Thus, at the farm level, pests and diseases could become an important constraint and a challenge to sustainability. At the project level, there was no assurance that manufacturing and marketing of treadle pumps was sustainable without the continued presence in the supply chain of the NGO, since it was unlikely that the private sector was ready to take responsibility for pump promotion. This had been a point of concern to the various evaluations carried out on DFID's behalf. They considered that the involvement of an NGO in this way was a distortion that conflicted with objectives for private sector development. However, the arrangement would certainly meet poverty reduction objectives, provided donor funds continued to flow until 'critical mass' was achieved. Recently, ApproTEC changed its name to "Kickstart," and started collaborating with the John Deere Foundation from USA, a private sector company in agricultural implements who considers its grant to Kickstart as an investment in future African markets.

6. CASE STUDIES FROM WEST AFRICA

6.1 Nigeria case study: Low cost petrol pumps for fadama development[10]

Fadama utilization has been a major feature of the agricultural, food, economic and demographic experience of the Nigerian dry belt (Kolawole, 1991; Kolawole et al., 1994). In Nigerian fadama lands, the rationale for resource utilization hinges on the availability of valuable agricultural resources in zones where agricultural prospects are poor due to the low and erratic nature of rainfall, vagaries of weather and extended periods of drought. Food crop production in the fadamas has traditionally depended on rainfed agriculture during the wet season and on residual moisture after flood recession

[10] This sub-section is entirely based on Omilola, Babatunde (2005) 'Rapid Poverty Reduction Appraisal of the Impact of Small-scale Fadama Irrigation Investment in Nigeria'.

in the dry season. Investments in irrigation to support agriculture and food production in Nigeria started with the establishment of River Basin Development Authorities (RBDAs) in the arid North of the country with the central objective of developing large-scale irrigation schemes. About 160 dams were constructed via the RBDAs, with an estimated total reservoir capacity of 11 billion cubic meters to irrigate about 725,000 ha of farmland. However, the RBDAs generally performed woefully in developing and investing in agricultural water management, in that the large-scale irrigation schemes associated with them largely failed to meet the food production needs of Nigerians. The actual irrigated land under the RBDAs declined from 45,000 ha during 1990/91 to a meager 26,000 ha during 1999/2000. Their capital costs were also extremely high in relation to returns with associated technical and management problems (Adams, 1991; Carter, 1992). Consequently, investment in agricultural water management in Nigeria via large-scale irrigation schemes slumped dramatically due to a sharp decline in lending for large-scale irrigation by donor agencies.

Until the early 1980s, irrigation in Nigerian fadama lands was undeveloped and limited by available technology (the traditional water lifting devices, such as, the labor-intensive *shadoof,* calabash and bucket irrigation from channels, which are used to lift water onto the land). Water lifting by such devices can only irrigate about 0.1 ha per *shadoof.* The Fadama I project was implemented through the development of small-scale irrigation via the extraction of ground water, using low-cost petrol-driven pumps to improve the socio-economic welfare of the rural poor.

Before the introduction of technologies such as petrol pumps and tubewell drilling for irrigation, irrigated farming was practiced mainly through flood recession farming or the residual moisture cropping technique. Recession farming and flooded rice farming are practiced along major rivers such as the Hadejia River and the Jama'are River. But since the commencement of Fadama I, many farmers, though not all, have changed to low-cost gasoline or petrol-driven pumps for tubewells.

Impacts on the size of farm land

If we compare the average irrigated fadama land cultivated by the project beneficiaries before and after the project intervention, the project beneficiaries in Likori increased the cultivation of fadama irrigated land by 0.4 ha or 11.8 percent (Table 22). The corresponding figure for the project non-beneficiaries is a negative quantity of -0.3 ha, indicating that the average hectares of irrigated fadama land in the control group fell by about 9 percent[11].

Table 22. Land assets of Fadama I intervention and control groups in Likori, northern Nigeria

	Beneficiaries(N = 40)			Non-beneficiaries (N = 40)		
	Before Project	After Project	Change	Before Project	After Project	Change
Fadama irrigated land owned (ha)	3.8	4.2	0.4	3.9	3.6	-0.3
Fadama irrigated land cultivated (ha)	3.4	3.8	0.4	3.5	3.2	-0.3
Rainfed land owned (ha)	3.3	3.2	-0.1	3.2	3.5	0.3
Rainfed land cultivated (ha)	3.2	3.1	-0.1	3.2	3.4	0.2
Total land area owned (ha)	7.1	7.4	0.3	7.1	7.1	0.0
Total land area cultivated (ha)	6.6	6.9	0.3	6.7	6.6	-0.1

Source: Field Survey (September-October 2004).

[11] During focus group discussions, it was gathered that many of the non-beneficiaries diversified into non-agricultural activities, particularly fishing, due to increase in flood over the years.

Income and poverty impacts

The combination of "before-after" and "with-without" project comparisons showed that the project had a positive effect on its direct beneficiaries and slightly improved their situation in terms of income derived from irrigated fadama farming under the project in the case study village. Overall there was only a slight improvement in the poverty status and standard of living of the project beneficiaries in Likori village. The importance of combining both Fadama I beneficiaries (intervention group) and non-beneficiaries (control group) in the 'before-after' and 'with-without' project comparisons isolating farm income attributed to fadama irrigation from other sources of income can easily be observed in the results generated in Table 23 .

The change in income from irrigated fadama (before and after comparison) is 16613 Naira (or USD128). This is a positive quantity that shows that the situation of Fadama I beneficiaries in Likori village has *slightly* improved after the project intervention. However, when compared with benefits derived from rainfed agriculture (Table 23), Fadama I beneficiaries gained more from rainfed agriculture than irrigated fadama farming. This is because income from rainfed agriculture is 29950 Naira (or USD230).

Table 23. Incomes of Fadama I intervention and control groups in Likori, northern Nigeria

Incomes and(mean values for sample)	Beneficiaries(N = 40)			Non-beneficiaries(N = 40)		
	Before Project	After Project	Change	Before Project	After Project	Change
Absolute net income (Naira)	171074	226983	55909	182740	218650	35910
Income from irrigated Fadama (Naira)	61150	77763	16613	72450	62575	-9875
Income from rainfed agriculture (Naira)	57000	86950	29950	53988	78863	24875
Net farm income (Naira)	118150	164713	46563	126438	141438	15000
Non-farm income[12] (Naira)	52924	62270	9346	56303	77213	20910

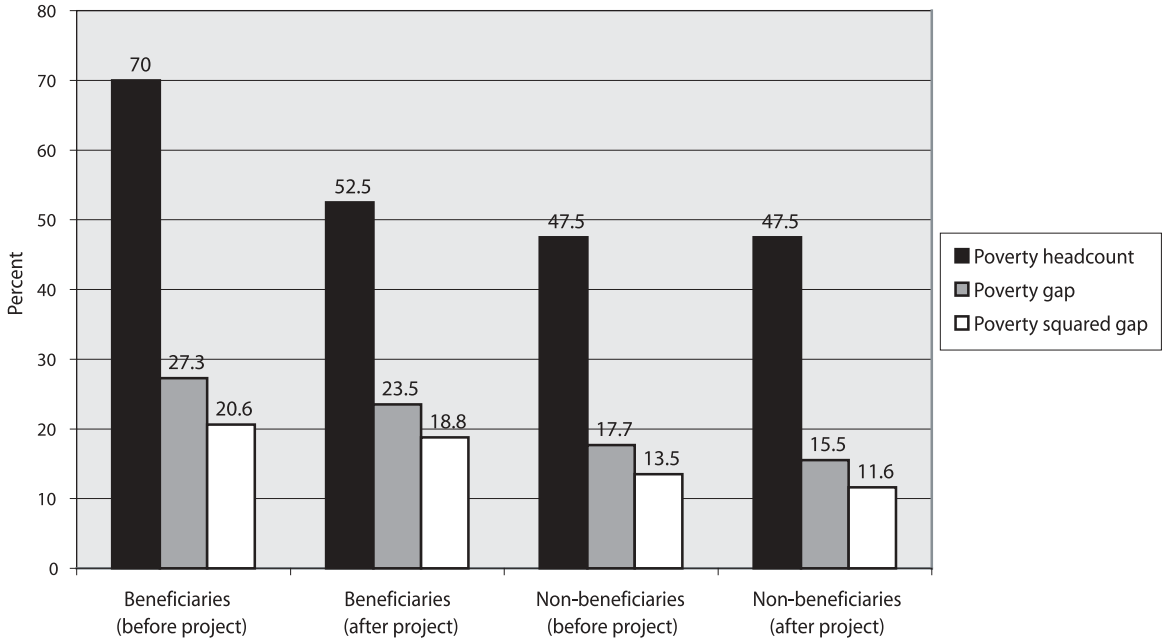
Source: Field Survey (September-October 2004), 130 Naira=USD1.

Based on before–after, and with and without comparison, the income effect of the Fadama I project in Likori is equal to 26488 Naira (or USD204), a 27 percent increase. Over the same period, average farm income from irrigated fadama agriculture in the control group fell by about 14 percent. However, this analysis does not specify whether the observed income increase in irrigated fadama agriculture under the Fadama I project accrued to the poor or the non-poor. Hence, 'before-after' and 'with-without' project comparison does not really deal with poverty reduction but with interesting changes in income, as it deals with both the well-off farmers and the poor farmers. The 'before-after' and 'with-without' project comparison concentrates mainly on farm income derived from irrigated fadama agriculture without combining all the incomes from other sources of livelihoods.

Based on income poverty measures derived from Foster, Greer and Thorbecke's (1984) indices, the project beneficiaries witnessed improvements in their poverty status in terms of all three income poverty measures used after the project intervention in comparison with the situation before the project intervention. On the other hand, over the same period the incidence of poverty remained the same among the non-beneficiary group, meaning that no one was lifted above the poverty line. However, the control group also witnessed a decline in the poverty squared gap meaning that the severity of poverty has eased.

[12] Non-farm income includes income from all other sources of livelihood apart from income from irrigated fadama agriculture and income from rainfed agriculture including salary and business income.

Figure 1. The poverty reduction impacts of Fadama I project in Nigeria



Food self-sufficiency impacts

During the semi-structured focus group discussions with both selected Fadama I project beneficiaries and non-beneficiaries in Likori village, having insecure access to food throughout the year was central to their well-being, rather than income *per se*. In light of the fact that food insecurity is regarded as the worst kind of poverty by the Likori villagers, the effect of access to motorized pump on the food self sufficiency status of the beneficiaries was assessed.

The poverty situation of both direct beneficiaries and non-beneficiaries of the Fadama I project can be compared by the percentage of beneficiaries/non-beneficiaries who classified themselves as food secure or insecure. Before the project intervention, 67.5 percent of the beneficiaries of the project in Likori could be categorized as food insecure, which fell to 42.5 percent after the project intervention. In contrast, the food insecurity level of non-beneficiaries of the project (control group) in Likori village rose from 65 percent prior to the project intervention to 75 percent after the project intervention (Table 24).

Table 24. Population share of poverty self-assessment categories of Fadama I intervention and control groups in Likori by wealth ranking (%)

Food self sufficiency	Beneficiaries(N = 40)		Non-beneficiaries(N = 40)	
Self-Assessment	Before Project	After Project	Before Project	After Project
Chronic food shortage	32.5	12.5	35.0	40.0
Occasional food shortage	35.0	30.0	30.0	35.0
Food self sufficient	30.0	42.5	30.0	25.0
Food surplus	2.5	15.0	5.0	0.0

Source: Field Survey (September 2004-October 2004).

Furthermore, the sum of the percentage of those who said they were food self-sufficient and those who said they were in a food "surplus" situation is taken as the percentage of people who identified themselves as food secure. Thus, before the project intervention, 32.5 percent of beneficiaries of the project in Likori could be described as food secure, which jumped to 57.5% after the project intervention. In contrast, the percentage of food secure among non-beneficiaries of Fadama I (control group) in Likori village declined from 35 percent just prior to the intervention of the project to 25 percent after the project intervention.

Other impacts

As the Fadama I project was implemented in two stages in Likori, the project beneficiaries in this village confirmed that the first stage of the project intervention yielded them some poverty dividends such as purchase of new bicycles, new motorcycles, marrying of new wives and building of new houses primarily because they were supplied with a 2-inch Robin pump which lasted for a longer period (2-3 years on average).

Constraints and challenges

Implementation problems: Despite the fact that some project beneficiaries derived some benefits from the project during its first stage of implementation in Likori, the general consensus of project beneficiaries was that the second stage of Fadama I project implementation was unfortunate, as the project implementers procured bad water pumps for them, which did not work well. The project beneficiaries were not allowed to select appropriate components suitable for them during project design and project implementation. The delay in procuring and distributing pumps and constructing tubewells for the beneficiary farmers, and the procurement of pumps that were poorly matched with constructed shallow tubewells are indications of implementation failures.

Lack of access to complementary inputs and services: The dearth of fuel and spare parts for the pumps procured resulted in beneficiaries not receiving enough benefits from the project intervention. The other problems faced include, cost and scarcity of farm inputs such as chemical fertilizers and pesticides and cost and availability of irrigation water pumps. In particular, the project beneficiaries revealed that the level of support for the irrigation pump technologies was inadequate. It was gathered that training of beneficiary fadama farmers in the repair of pumps and the supply of spare parts to replace those worn through use, received inadequate attention by the implementing agencies. The implication of the latter was that although some beneficiary fadama farmers received irrigation pumps, they could not use them because they could not obtain spare parts or make repairs to the pumps.

Pastoralist–farmer conflicts: The beneficiaries of the project intervention also reiterated that the Fulani pastoralists have not made things any better for them to derive tangible benefits from fadama irrigated agriculture. This is because of the increasing clashes and conflicts between nomadic pastoralists and farmers due to competition for land resources, leading to destruction of constructed tubewells. In most cases, the fadama irrigated farms are invaded by cattle herds. In many cases, the Fulanis attacked, damaged and destroyed facilities provided for irrigation on the farms leading to stoppage of fadama farming activities for a while.

Many of the pastoralists felt they had been denied access to dry season grazing resources due to the introduction of the dry season fadama irrigation project, particularly as wetland environments

in semi-arid zones such as the Hadejia-Nguru wetlands are widely regarded as key grazing and watering resources for pastoralist communities. In fact, the competitive uses to which fadama land was put under the project became the source of potential and actual conflicts amongst the various rural land users in Likori and other fadama lands. In a nutshell, conflict over natural resources, which frequently occurred between farmers and pastoralists in Likori village, was ranked by the respondents as one of the most important reason for not benefiting from implementation of the project.

Quelea quelea bird attack: The influx of one particularly pervasive pest, namely the *Quelea quelea,* a small and strongly gregarious bird found in flocks numbering over 1 million in size that feed on agricultural seeds and grains, is considered by both the project beneficiaries and non-beneficiaries as the single most important reason for not benefiting enough from both fadama irrigated farming in Likori.

Flooding problems: Flooding, which is so evident in the research site and other surrounding villages, was ranked by the project beneficiaries as another important reason for not benefiting enough from the Fadama I project intervention. The entire landmass used for farming in Likori is flooded. This had drastically affected the farming activities of farmers in this corner of Nigeria. The flood problem has, however, opened up another livelihood for the farmers, as most of them are now fully engaged in fishing activities.

The flood problem has its origin from the invasion of the water ways by the *Hyperrhanium* weeds called *Kachalla* locally. These grow inside of the Burum-Gana River, leading to obstruction of access of farmers to their farmlands. These weeds have succeeded in blocking the flow of water of the Burum-Gana River and this has resulted in flooding of surrounding farmlands. It continues to eat up more farmland everyday. Floods also spread the seeds of the *Kachalla* weeds. The *Kachalla* weeds have also provided a safe haven for the loquacious and destructive Quelea quelea birds. In areas where the growth of the *Kachalla* weeds is very dense, the birds build their nests and live. The uncontrollable birds invade and attack millet, sorghum and rice. This has been a big problem these people have had to live with.

Marketing constraints: The other important constraint preventing the project beneficiaries from realizing enough benefits from Fadama I project in Likori village is the deterioration in market access due to deteriorating public infrastructure such as roads and communications and poor access to farmlands. Access roads, though present, are in very poor condition, making farmers' access to their fields difficult. This is because the major bridge across the Burum-Gana River leading to the farmlands is always being washed away by torrents. The makeshift wooden bridge built over the Burum-Gana River towards the farmlands is known as the Atikrom Bridge. It is rickety and may not last long. The Atikrom Bridge is only pedestrian, bicycles and motorcycles cannot be ridden over it (Figure 2).

The absence of marketing and processing infrastructure implied that many beneficiary Fadama farmers were unable to make much gain from their farm produce, and to receive the best prices available in the markets for their food items since they were forced to sell at farm gate prices without adding value to the produce. 72.5 percent of the project beneficiaries interviewed indicated that they sold almost all their farm produce during the project intervention at the village market and within their farms. Most of the beneficiary Fadama farmers depended on middlemen who came to their largely inaccessible Fadama area to purchase their farm produce at very ridiculous prices. In some instances, perishable farm produce such as leafy vegetables, onions, water melons, tomatoes and peppers did not even get beyond their farms, as poor post-harvest handling made them lose quality. Hence, a whole crop of farm produce such as pepper or wheat is sold before it is harvested.

Lack of access to credit and information: About 27.5 percent of the non-beneficiaries said they could not afford to pay for the complete cost of shallow tubewells and pumps to be installed on their fadama farmland, as the conditions for participating in the project were too high for them.

6.2 Niger case study: Treadle pump promotion project[13]

Different water pumping technologies including treadle pumps are being promoted in West Africa by EnterpriseWorks (EW). There are no reliable data regarding the extent of utilization of different forms of water pump technologies in West Africa. However, EW monitors the outreach of treadle pump technology. Outreach across West Africa, at the moment, is mostly limited to countries directly reached by EW in its various promotion programs. This includes Senegal, Mali, Niger, Cote d'Ivoire, Burkina Faso, Ghana, and Benin (Table 21)[14].

At a cost of between US $50 to $100 per unit, EW's treadle pump helps farmers to increase annual income derived from vegetable production. EW's assessment reports mention that incomes of small scale farmers have doubled due to labor savings, expansion of farm sizes and economies of scale. The reports further state that about 2,000 irrigation pumps are currently sold yearly in EW' project countries in Africa.

*Table 21. Summary of impacts across west Africa **

Country	Year	Duration (yrs)	# of pumps Sold	annual income per pump (US $)	Total economic benefits (million $)
Senegal	1990 – 2001	12	3048	584	8.9
Mali	1995 – 2001	7	2311	542	6.3
Niger	1997 – 2001	5	1340	289	1.9
Benin	1998 – 2001	4	771	479	1.8
Burkina Faso	2000 – 2001	2	504	306	0.8
Cote d'Ivoire	2000 – 2001	2	495	479	1.2
Ghana	2002 – 2003	>1	630	822 [a]	Na
West Africa	1990 – 2003	13	8469 [b]	349 [b]	20.9 [b]

* = Estimated life span of the pump is five years; na = not yet available; [a] = for vegetable growers only in (2003); [b] = excluding Ghana.
Source: Enterprise Works, 2003.

In Niger, one of the driest countries in Africa, agricultural production is severely constrained not only by lack of cultivable land but primarily by lack of water to enhance agricultural production year round. Over 90 percent of the country's gardening population cultivate very small plots of land, and access to irrigation water through sustainable small-scale technologies is key to viable production.

Pump promotion starts with the identification and adaptation of the pump types to suit local conditions and the socio-economic circumstances of potential adopters. The identification of sites considers both technical attributes of the pumps, as well as the hydrological and agro-ecological characteristics of the potential sites. Key characteristics of identified sites included depth of the

[13] This sub-section is a synthesis of part of Kamara et al. (2004).

[14] Kickstart (formerly ApprotTECH) has recently initiated a donor-funded project in West Africa but it is too early to see results.

water table which has to be within 6m form the surface, recharge capacity of the aquifer (> 1 liter per second), concentration of market-oriented gardeners using traditional water-lifting technologies, and availability of adequate land for garden expansion (Naugle, 2000). For pump manufacture, skilled craftsmen were targeted, trained and encouraged to market their products. The training includes the choice of material, quality controls, installation and troubleshooting. After this basic training the manufacturer is set to producing the pumps and adjusting production (quantity) to local demand. Newly trained manufacturers are taken to gardening sites along with their pumps for field demonstrations and to develop direct contact with gardeners.

In some cases, incentives are given to buyers through a hire-purchase agreement between the manufacturer and the buyer. The contract agreed upon obliges the gardener to pay about 50% of the cost up-front, and to pay the balance on a mutually agreed date. This contract is concluded in the presence of a witness, usually the village chief, or other responsible member of the community. If the gardener fails to pay the remaining amount, the agreement empowers the manufacturer to repossess the pump while the deposit is withheld as a hire fee. After-sales support is also given as encouragement to the gardeners, which includes at least three visits by EW field staff, together with a representative of the manufacturer. After these visits, users are expected to make their own repairs, which may be supervised by field agents or manufacturer's representatives. Naugle (2000) reports that under the *Petite irrigation privée* (PIP), about 330 pumps were sold between 1997 and 1999, following 44 market demonstrations and 109 site demonstrations, attended by over seven thousand people.

Labor productivity and employment impacts

Adoption of the treadle pump improved the efficiency of labor by reducing both the number of required farm workers and working hours. In particular, labor time in lifting and distributing water decreased significantly. Before the pump, filling irrigation tanks required about 129 person-hours per week, which fell to about 76 after the pump, a reduction of 53 person hours per pump per week (Cambell and Hyman, 2000). This led to a 23% decrease of labor time for adults (men and women), and 25% and 29% for male and female youths respectively. Despite the decrease in labor requirements, daily wage rates for hired labor on the farms, which averaged at US $0.64 per person per day, did not change at all. This change in labor did not lead wage laborers to move away from the farms. The aggregate increases in farm sizes due to the pump created an avenue for absorbing the extra labor, which had an overall positive welfare effects both for the gardeners and for the laborers.

Land productivity impacts

Cambell and Hyman (2000) also assessed impacts in terms of changes in farm size, and recorded an increase of between 130% to over 200%. Despite the relatively small sizes of cultivated areas, these increases in cultivated area had significant positive impacts on farm income. The aggregate effects of the introduction of treadle pumps on farm size and labor as assessed by Cambell and Hyman (2000) is presented in Table 25. Input use was also reported to have increased significantly, in most cases by more than 100%. This is partly due to increased size of cultivated area which on the one hand raised the need for more fertilizer, and on the other hand increased farm income to facilitate application of more farm inputs. Another study also reported that farm sizes increased among treadle pump users in Niger by over 60% (Neighbor and Sellen, 2002).

Table 25. Garden size, labor force and hours of work before and after pump

Variable	Estimated averages values per pump*		
	Before the pump	After the pump	Percentage change (%)
Planted area (hectares)	0.067	0.180	168.7
Labor force (workers)	0.91	1.03	13.2
Labor (hours)	30.52	19.69	35.4

Source: Cambell and Hyman, 2000.
*Estimated form *33 market gardens and 36 pumps.*

Income and poverty reduction impacts

Adoption of treadle pumps by farmers in Niger has resulted in significant positive impacts, in terms of improvement of labor efficiency, increase in area under cultivation, cropping intensity and production volume, and increase in farm income. Cambell and Hyman (2000) found that about 18% of treadle pumps were used on market gardens where hired labor was employed, while the rest largely depended on unpaid family labor.

Overall, farmers' net income was reported to have increased by 130% to over 700% depending on whether or not the opportunity costs of family labor as well as other in-kind farm services were considered (Cambell and Hyman, 2000). That is, in all cases, farmers' incomes were found to have doubled as a result of adoption of the treadle pump. The total annual income for gardeners generally increased from about $200 per year before pump adoption, to about $500 per year after the pump. Similar results were also noted by others. For instance, Neighbor and Sellen (2002) report the introduction of treadle pumps enabled farmers to increase their annual income by over 250%, i.e., from US $170 to about US $440. This is three times more than the average annual per capita income of Nigeriens.

6.3 Ghana case study: Development of irrigated horticulture through utilization of the SOKA treadle pumps[15]

The goal of this irrigated horticulture project is to alleviate poverty by increasing the income of small-scale market gardeners and artisans. Local small-scale engineering/artisan shop owners are trained in the manufacture of the pumps which are designed to make use of local materials and fabrication techniques. Three water-lifting options are currently available to the Ghanaian dry season gardener – the traditional rope and bucket method, the motorized pump and the treadle pump (in particular the SOKA pump) (Table 26). Common water sources include wells, rivers and streams. The rope and bucket technique is very arduous and time consuming, allowing for a flow/distribution rate of only about 1000 liters of water per hour. A gasoline engine driven-pump of reasonable size (e.g., 4 HP) is currently sold commercially in Ghana at a price at USD500, excluding suction and distribution pipes (EnterpriseWorks, 2004).The high operational costs and small land sizes further compromise the financial viability of such pumps in irrigated vegetable production. Maintenance and repair of such pumps also sometimes require travel over considerable distances in search of expertise and spare parts, especially engine parts, which are not always readily available.

[15] This sub-section is a synthesis of part of the report by Kamara et al. (2004).

Table 26. Comparisons of alternative water lifting technologies

Water lifting device	Capacity at 4.5 m (l/sec)	Initial Cost (Cedis)	Depth range (m)
Rope and bucket	0.3	28000	Practical for only very small plots when depth is over 10m
SOKA pump	1.7	800000	0 – 7
Motorized pump	5.5	4500000	0 – 6

1USD = 9000 Cedis as of 2004.

Building on experiences elsewhere in West Africa, EW developed the local manufacturing capacity of low cost treadle pumps branded in Ghana as SOKA pump. Funds for the two-year project were provided by USAID and implementation activities commenced in early 2002. The SOKA pump has a number of features which make it more suitable to manual irrigation in Ghana. The standard version can lift 5,000 to 7,000 liters of water an hour from wells, boreholes or surface water sources up to 7 meters deep.

Initially the pumps were retailed at about USD67 per unit. However, increasing production costs have raised the unit costs considerably, to the extent that in early 2004, the SOKA pump was going for about USD88. In some cases however, middlemen are hired to assist in sales without further increases in retail price, while the manufacturers share their profit with the retailers. In certain areas, e.g., around Kumasi, some agro-chemical shops retail the pumps at prices that are as high as USD110.

An initial survey in 2003, a year after the start of the project, shows 42 % increase in labor use among 22 selected pump users out of 30 pump users interviewed (Enterprise Works, 2003). From the current study, it appears that the SOKA pump is making positive impacts on most of the indicators including labor savings; increasing farm sizes; changing cropping patterns, cropping intensity, production costs; and subsequently net farm revenue from irrigation. There is also evidence of increasing expenditures for food security, education and household improvements.

Changes in the cropping pattern

In the study regions, most farmers cultivate cash crops such as cocoa, staple food crops such as maize, cassava and plantain, and sometimes rear livestock, which is supplemented by vegetable gardening in the dry season to augment annual incomes, and also to keep them actively engaged in production activities, especially during the dry periods of the year when rainfed farming is not possible. Thus, the role of vegetable production in income generation is widely perceived as critical, since it facilitates a continuity of farm income generation all the year round. Treadle pumps in the area are used to produce conventional vegetables, with few instances of exotic crops, and sometimes livestock. Overall, about 16 different crops are cultivated by treadle pump-users in the area, including vegetables and tree nursery. Most of the vegetables are cultivated year round. In the dry season however, the production of most water intensive vegetables is severely constrained without access to efficient water procurement, lifting, and distribution technologies, such as the treadle pump, helping farmers to diversify crops and intensify production even in the dry season. Overall, 50% of the farmers now cultivate at least two crops in the dry season, which is facilitated by access to waste water with the pump. Cultivation practices have also improved (e.g., row planting is adopted) as a result of pump adoption.

Labor productivity impacts

The SOKA pump had a significant positive impact on improving the efficiency of labor use. In general, a 34% decrease in the total number of hours used in irrigation after the adoption of the SOKA pump is noted. Due to expansion of farm sizes and cultivated area, this reduction had an overall positive welfare effect since the labor saved could be used to increase other farming activities – increases in cultivated area and thus increase in the labor force required for irrigation. The dynamics of labor relations and requirements before and after the treadle pump, disaggregated by gender, are highlighted in Table 27.

Table 27. Change in average labor and farm size with and without treadle pump

Category	Averages before/after pump				Changes	
	before	N	after	N	actual	%
Farm size	1.07	87	1.79	77	0.72***	68
Labor for irrigation: men	2.0	86	3.0	82	1.0***	50
Labor for irrigation: women	2.26	47	2.06	39	0.20***	9
Labor: person hours per day	6.85	79	4.54	81	2.31***	34

N = number of respondents, ***= significant at 1% level.

Of the 77 pump users who cultivated vegetables during the year before they bought the pump, 67% actually expanded their farm sizes after purchasing a pump. The increase in farm size is what results in the increased demand for farm labor for irrigation and other activities such as land preparation, weeding and harvesting. Therefore an important income and poverty reduction impact of the adoption of the SOKA pump in Ghana has been recorded in increased farm sizes for farmers, reduction in total labor time for irrigation (more efficient utilization of labor), and an aggregate increase in the demand for hired farm labor which actually translates into job opportunities for landless laborers. That is, there is evidence of reallocation of saved time to other productive activities, and employment of more labor force in agriculture due to pump-enhanced production expansion. Hired labor use to operate pumps is very common. Overall, about 65% of pump users employed hired labor to operate the pumps, with an average wage of about USD2 a day.

Income and poverty reduction impacts

There was a substantial increase in income levels, enabling treadle pump users to improve their income situation. These improvements in labor, increases in farm size and improvements in income are generally also observed in other countries of intervention in West Africa. Total annual income of farmers also varies considerably across the sample, with an average of US $1,560 per household, a minimum of $16 and a maximum of $9,500. The data further show that most of the farmers earn above the poverty line, which is defined as US $400 per person per year. This implies that more than two thirds of those currently using and benefiting from the SOKA pump are above the poverty line. These people have the required initial financial capital or social capital to enhance access to and affordability of the pump. On average, most of the adopting farmers have farmed for about 13 years. It is assumed that these experienced farmers understand the advantages and risks involved in the use of treadle pump for dry season irrigated vegetable production, and hence have a good chance of succeeding to produce with the treadle pump on a profitable and sustainable basis.

Before the pump, the average total gross revenue generated by irrigated vegetable farmers was US $454. With the advent of the SOKA pump, average gross revenue increased significantly to US $882 (Table 28). This increase in farm income is seen as a direct opportunity for farmers to intensify production by investing in farm inputs, employ more labor for irrigation and land preparation, expand farm sizes, and realize profit-enhancing economies of scale. These effects have a considerable potential for creating avenues and opportunities for farmers to get out of poverty. Similar benefits have been reported in other countries where treadle pumps have been introduced (Polak et al.; 2000; Polak, 2003; Shah et al., 2002). In Senegal, Hyman et al. (1995) reported that expanded surface area under irrigation and greater yields have capacitated market-oriented Senegalese gardeners to realize net income gains of about US $850, a return of 750% on the original investment of US $100 in the treadle pump. The study on Senegal further indicated an increase in farm size of about 40% and a reduction in irrigation time from 12 person-hours per day to slightly more than 4 person-hours per day, which altogether had a remarkable impact on the profitability of more than 1,400 agricultural enterprises.

Although income increases reported in the current study are not as high as those reported in Niger and Senegal, increases in gross revenues of over 100% resulting from the adoption of treadle pumps are very reasonable to have significant income generating impacts.

Table 28. Net revenue change before and after adoption of treadle pump

	Before treadle pump adoption		After pump adoption	
Variable	Vegetables	Tree nursery	Vegetables	Tree nursery
Average gross revenues	454	1483	882	1606
Average total cost	273	239	439	477
Net revenues	181	1245	443	1128

The extra revenue was largely reinvested by farmers in various activities such as farm expansion, supporting family members and paying school fees for children. About 25% of the farmers invested in household improvements and assets, and some in the acquisition other farm assets. Usually, it is only after saving over and above subsistence requirements that investments in household improvement get prioritized. Investment in other farm assets is also a positive indicator of farm capital accumulation, which will also generate returns on the long-term. Investment in education is an investment in human capital creation, which in itself is an indicator of positive poverty impacts.

Gender impacts

Women are less often involved in SOKA pump operation, which was said to be due to the severity of work it requires. In the current survey, 70% of the farmers indicated that they did not involve women in irrigation because of the drudgery involved in SOKA pump operation, and found that pumping is too difficult for women. Female labor is mainly used for weeding and harvesting, and in general women receive a relatively lower daily wage than men. This may have important gender implications, both positive and negative: positive because the pump facilitates expansion of cropped areas and hence creates more jobs (weeding and harvesting) which is done mostly by women, and negative because men get higher daily wages than women since their work of pump operation is often thought to be more arduous. Some of the women farmers owning SOKA pumps do not operate it themselves, but use male family members or hired male labor to operate the pump instead.

Similarly in other West African countries, female participation is generally quite low. In Senegal, female participation in irrigation projects was not more than 4%, whereas in Niger women constitute less than 2%. A survey in Mali in 1997 revealed that less than 30% of pump owners were women. This implies that in most of West Africa, benefits from treadle pump utilization are accruing to men (Bishop, 2002).

Food security impacts

The impact of the treadle pump on poverty and wellbeing was also assessed in terms of its impact on basic household food security. Food insecurity, to a large extent goes hand in hand with poverty; the poor tiers of any society are likely to be the most food insecure. The dynamics of household food security were assessed for the two main seasons in Ghana, the rainy and dry seasons, which are normally characterized by different levels of food availability. The survey results indicate that 68% of farmers owning treadle pumps got their daily meals in both the rainy and dry seasons, and none recalled problems with food availability in either season. In contrast, 25% of the respondents reported they hardly had access to food in the dry season before the pump adoption. Although several differences were observed in the food security situation before and after the pump, the overall food security situation was claimed to have improved in the dry season with the advent of the treadle pump.

Constraints and challenges

Problems related to technology design: About 44% of respondents suggested that the treadle pump should be motorized at low cost in order to ease the drudgery involved and further decrease the labor requirement of manual operation. In fact, farmers indicated that diesel pumps would be most appropriate due to their relatively low operating cost.

Deficiencies in the support services: About 10% of the farmers reported that the SOKA pump should be promoted in its current state, but that cheap accessories, which are at the moment relatively difficult to get, should be made available. In particular, they expressed the wish for having durable PVC pipes available locally at affordable prices.

Lack of credit services: About 30% of the current users of the SOKA pump believe that lack of financial resources is the main reason why others are not adopting the pump. This view was strongly confirmed by several non-users interviewed, who emphasized lack of start-up capital as their major constraint. These responses further affirm the assertion that financial problems are major constraints in irrigated vegetable production. Over a quarter of respondents believe that those not adopting the pump are simply those that cannot afford to buy.

Lack of access to water: There are instances where farmers are not making efforts to acquire and use the pump simply because their farms are located too far away from water sources, while information on the dynamics of groundwater distribution in the area is lacking. Research on the distribution of groundwater or identification of suitable locations for groundwater development in these areas will encourage farmers to exploit the opportunities associated with the use of treadle pumps.

7. CONCLUSIONS

From the analyses of the case study investment projects, water harvesting technologies, and water pump technologies the following conclusions may be drawn:

1. It is erroneous to think that improving the access of a community to irrigation would automatically lead to better economic achievement, better quality of life or poverty reduction. Irrigation projects are operating within the context of multifarious factors that negatively or positively impinge on their performance. These factors can be biological, physical, institutional, economic, socio-cultural variables, etc. Since these circumstances are context-specific, they have to be analyzed, studied and addressed both during the appraisal and after completion of the projects. Therefore, it is unwise to fault the irrigation sector without considering the due share of other conditioning factors for the dismal performance of agricultural water management projects in sub-Saharan Africa. The case of Fadama I project in Nigeria is a classic example. The implementers expected miracles from the introduction of motorized pumps without understanding the limits set by the prevailing biophysical and socioeconomic circumstances of the area such as the problem of Quelea quelea bird, the flooding problem, the pastoralist-farmer conflicts for land resources during dry season, marketing problems, etc.

2. Some of the investment projects have tried to target the poor directly at the appraisal stage based on geographic locations or poverty head count data either maintained by the governmental institutions or determined through socioeconomic surveys done by the project implementers or financiers. The overall understanding was that targeting intentions could have been better specified but even if they had been, targeting the poorest stratum was not easy to implement in practice. For instance, the poor may not have the resources to effectively farm the irrigation plots allotted to them because they may lack oxen and ploughs and even labor, which they had to sell to satisfy their own food requirements. However, because of the pervasiveness of poverty in most of rural sub-Saharan Africa, some projects which did not intentionally target the poor may actually end-up reaching the poor if not the poorest.

3. Most of the agricultural water management interventions considered in this study, specifically irrigation investment projects and low cost water lifting technologies, have either eased the severity of poverty or lifted some of the target beneficiaries out of poverty for good. This might be an understatement of what was actually realized from the projects when one considers their multiplier effects due to employment, consumption, and investment linkages.

4. Water harvesting technologies/soil conservation technologies are usually proposed as an alternative to conventional irrigation projects. However, the performance of these technologies (except the use of *silanga* storage tanks in conjunction with treadle pumps), are often not satisfactory in an economic sense. Moreover, on a per hectare basis the cost of some these technologies are no less than the conventional irrigation projects (e.g., RELMA sub-surface storage tanks). This may also explain the dismal adoption rate of these technologies, particularly among poor farmers.

5. As has already been underlined, the main pathways and channels through which the impacts of investments in agricultural water management on poverty are transmitted is land and labor productivity. A closer scrutiny of the land productivity performance of the agricultural water management projects reveals that most of them have attained productivity levels much lower

than the level assumed at the appraisal stage. Even for those which have achieved the productivity level targeted at appraisal stage, the figures are still much below potential or below what are attainable in comparable regions of the world such as Asia or even below what large scale farmers in the region itself receive. Perhaps one of the important findings from the evaluation of the rice irrigation projects is that there is great land productivity variation within a scheme. For instance, in the Madagascar Upper Mandrare Development Project, the paddy yields realized by the farmers belonging to the lower social stratum (poorest) are about 50 percent below the paddy yield level obtained by farmers from the higher social stratum. Thus there is substantial room for improving the poverty impacts of irrigation projects through lifting land productivity.

6. Overall, the major constraints and challenges undermining the poverty reduction impacts of agricultural water management projects in the sub region in light of the findings from the case studies are: lack of access to complementary productivity-boosting inputs and technologies, marketing constraints, institutional and organizational problems, water and land rights issues, and planning and implementation problems.

8. RECOMMENDATIONS

From the understandings gained from the case studies and literature review, the following recommendations are derived:

1. The performance of irrigation water management with respect to economic growth and poverty reduction is great when complementary investments are made in related infrastructures and services. Thus, along with investments in water resources development, invest also in roads, education, agricultural related industries and services. This is consistent with the finding of the cost study (Inocencio et al. 2005) that integrated sector projects tend to have lower costs and higher performance.

2. Irrigation water, through critical, is only one of the factor inputs or services essential for enhancing farm productivity and income. Therefore, strengthen the support services such as agronomic research, extension system and financial services.

3. One of the glaring findings of this study is that access to irrigation by the poor or poorest does not automatically guarantee improvements in the wellbeing of the poor. Poor people with access to irrigation are found to operate at below half the productivity levels of better off farmers. Therefore, special consideration needs to be given to the poor in terms of training to upgrade their agronomic and others skills, credit provision, extension and access to inputs and other services.

4. Consider the special needs of women in irrigation technology design; and more generally, remove gender obstacles for women producers to promote agricultural growth at a potentially massive scale.

5. One of the most important problems raised consistently by farmers is the lack of markets or their inefficiency. Special institutional, organizational, legal, and regulatory mechanisms that enhance the functioning of markets are needed.

6. The adopters of water lifting pump should be given specific training on self-maintenance of the pumps rather than entirely relying on NGOs so that sustainability is ensured.

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