Working Paper

Pathways for irrigation development in Africa – insights from Ethiopia, Morocco and Mozambique

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ADLI	Agricultural development-led industrialisation
ARA-Sul	*Administração Regional de Águas – Sul* (Mozambique)
CAIL	Limpopo Agro-Industrial Complex (Mozambique)
CIS	Chókwè Irrigation Scheme (Mozambique)
EPRDF	Ethiopian People's Revolutionary Democratic Front
FDI	Foreign direct investment
FRELIMO	Mozambique Liberation Front
GDP	Gross domestic product
GTP	Growth and Transformation Plan (Ethiopia)
HICEP	*Hidraulica do Chókwè, Empresa Pública* (Mozambique)
IFI	International financial institution
IMF	International Monetary Fund
IMT	Irrigation management transfer
INIR	*Instituto Nacional de Irrigação* (Mozambique)
NGO	Non-governmental organisation
PIM	Participatory irrigation management
PPP	Public-private partnership
PROAGRI	National Programme for Agriculture Development (Mozambique)
RBA	River Basin Authority
SIREMO	*Sistema de Regadio Eduardo Mondlane* (Mozambique)
SSI	Small-scale irrigation
WUA	Water Users' Association

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Executive summary

Key Findings

1. Ethiopia, Morocco and Mozambique have followed unique political and developmental trajectories over the last five decades. However there are some striking similarities in irrigation policy and practice, in part a reflection of Africa-wide trends. Importantly, past legacies continue to shape the sector today.

2. Morocco has made the most progress in exploiting its irrigation potential, benefitting from early colonial investments followed by a strong, politically stable, centralised state with a commitment to further developing the irrigation sector. In contrast, Ethiopia and Mozambique have undergone several regime changes and social upheaval. Irrigation has not been a priority in agricultural policy until recently.

3. In the three case study countries irrigation policy has historically formed part of agricultural and/or water policy, in turn orientated towards a number of different social, economic and political goals. Contingent on the dynamics of the broader policy environment, objectives for irrigation have not always been coherent.

4. In Ethiopia, Morocco and Mozambique changes in policy have been driven to differing extents by political and ideological shifts; macro-economic conditions; donor agendas; political projects; and climate and environmental concerns.

5. The case studies have shown that changes in irrigation policy are mirrored in the histories of particular schemes, such as Chókwè Irrigation Scheme in Mozambique, and can result in the co-existence of multiple forms of irrigation, for example in the Awash Basin in Ethiopia or Souss Massa in Morocco. However, the causal relationships between irrigation policy and practice are difficult to determine due to feedback loops and confounding factors. Essentially the two have co-evolved in response to drivers at multiple levels.

6. The findings indicate that performance is often not evaluated objectively by scheme managers or other stakeholders. Instead, in the cases examined, management is primarily driven by narrow operational concerns with little opportunity for those engaged to draw strategic, system-wide lessons. This obscures understanding of potential trade-offs between different objectives, and how farmers attempt to maximise their returns and benefits.

7. Enduring challenges remain in managing irrigation to increase agricultural output and water productivity, ensure sustainability and contribute to poverty reduction and economic development. Many of these challenges pertain to wider issues in the agricultural sector or governance of land and water, rather than irrigation *per se*. Interventions in irrigation need to be based on a thorough understanding of activities in other water-using sectors and the implications of drivers of change, such as demographic pressures, for resource management.

8. Irrigation modernisation should be a process of continual adaptation to increase resource efficiency and improve services for users, in light of changing agricultural and socio-economic contexts. Ethiopia and Mozambique have ambitious plans for sector expansion. Tackling underlying constraints to performance will be essential to ensure returns on future investments.

9. Water scarcity is a key driver of irrigation policy in Morocco, and is likely to become an increasingly pertinent issue for Ethiopia and Mozambique in future. Beyond technological interventions, there is a need to account for water at multiple levels; improve monitoring and sector coordination; and manage trade-offs transparently. Legal safeguards would help to protect local communities and downstream water users.

10. Given the poor performance of state-managed irrigation, the private sector is often perceived as an attractive alternative. Nonetheless, the state has an important role to play in ensuring sustainable and equitable development of natural resources; an enabling environment for investment; and contributions from commercial agriculture to economic growth and poverty reduction.

1 Introduction

1.1 Renewed interest in irrigation

Amid global concerns over rising food and fuel prices, expanding populations, changing diets, a deepening water crisis and climate change, agriculture has appeared back on the development agenda. Irrigated agriculture, particularly, is thought to have an important role to play in increasing production of food (and biofuels) in an uncertain and resource constrained world. Yet calls for support to this sector, particularly large-scale irrigation systems, have met with scepticism in some quarters given the disappointments of past investments and lack of evidence regarding what works, why and where.

Over the last 50 years global agricultural production has almost tripled, in large part due to irrigation expansion (FAO 2011). Nevertheless, progress in raising productivity has slowed in recent years (Bruinsma 2009) and significant geographical disparities remain (FAO 2011). About 70 percent of the world area equipped for irrigation is in Asia (FAO 2011, citing FAO 2010a). Here agricultural production increased rapidly from the 1960s due to the introduction of new technologies, driving economic growth and poverty reduction (Hazell 2009). In the last five decades, a proliferation of groundwater-based irrigation in the private and informal sectors has benefitted millions of farmers and helped to fuel the agrarian boom. Yet unrestricted development has also led to rising environmental and economic costs in many areas as water levels drop (Giordano and Villholth 2007). Meanwhile large irrigation projects have largely failed to deliver the expected benefits, particularly to the poorest segments of the rural population, due to weak land and water rights and elite capture (Molden 2007).

In comparison to Asia, agricultural production has increased very slowly in Africa over the same period, barely keeping pace with population growth (Hanjra et al. 2009, Molden et al. 2007). For a number of reasons the irrigation sector has failed to take off and coverage remains low. Although there is great diversity both within and between African countries (Poulton 2012), positive examples in irrigation tend to be isolated and context-specific (Wiggins and Leturque 2010). The fact that so much has changed yet critical constraining factors have largely remained the same cannot simply be ignored. There is a need to examine cases where irrigation schemes have performed well over the long term and to understand why others continue to fail, to ensure that mistakes are not repeated. This entails further research to unravel the dynamic and inter-linked social, political and technological factors that have determined performance in different agro-ecological contexts.

Donors and policymakers are re-asserting a long-held view that sub-Saharan Africa has significant untapped potential and could be transformed to become a food surplus region, given the right investments, infrastructure and institutions (e.g. World Bank 2009). New initiatives for improved land and water management include the Partnership for Agricultural Water for Africa (AgWa) under the Comprehensive Africa Agriculture Development Programme (CAADP), and the New Alliance for Food Security and Nutrition. Countries such as Ethiopia and Kenya are pursuing ambitious plans to expand their irrigation sectors and investments in water resource development are accelerating, benefiting from new sources of finance and growing interest from the private sector. Informal groundwater-based agriculture is also beginning to take off as affordable pumps become locally available and urban markets expand (Calow and Mason 2014).

In the context of competing demands for water resources decision-makers need to tackle difficult question such as 'who benefits?' and 'what are the opportunity costs or trade-offs?'. There is a danger that accelerated, unconstrained development and weak regulation will result in forgone opportunities for broader-based transformative economic growth and loss of entitlements to resources for the poorest and most marginalised groups (Calow and Mason 2014). Indeed there are already concerns that land (and hence water) acquisitions by foreign investors serve to undermine the livelihoods of African communities (e.g. Bossio et al. 2012; Duvail et al. 2012). In short, there are a number of possible pathways for future irrigation development in the region. The challenge is to ensure that investments lead to equitable and sustainable benefits over the longer term.

1.2 Research questions and approach

This paper presents the findings of a rapid review to determine the policies and practices that have shaped irrigation performance in Africa over the last 50 years. The research was guided by the following questions:

1. How have national irrigation policies evolved over time?
2. What have been the internal and external factors driving policy change?
3. How have changing policies shaped irrigation practice?
4. What factors have shaped the performance of irrigation schemes?

To enable sufficient depth of analysis the scope of the study was limited to three countries – Ethiopia, Mozambique and Morocco (Map 1). Review of national/sector level trends was complemented with case studies looking at the history of specific irrigation areas or schemes. Although the study was predominantly literature-based, interviews with key informants

and short field visits to irrigation sites have provided supplementary information. One to two weeks was spent in each country during the March-June 2014 period in order to conduct these interviews. The study was commissioned by the Future Agricultures Consortium (FAC). Additional insights were drawn from previous research by the Overseas Development Institute (ODI) in Ethiopia and Mozambique under the programme 'European Union and African Union cooperative research to increase food production in irrigated farming systems in Africa' (EAU4Food [1]).

Ethiopia, Morocco and Mozambique were chosen, firstly, because they had potential to provide insights from different regions of Africa, capturing some of the diversity of irrigation policies and practices found across the continent. Secondly, countries were selected for which ample literature was available for review and of which the authors had prior knowledge.

The choice of case studies was constrained by the need to select examples in which it was possible to track change over several decades. A variety of scheme types were included in the analysis (Table 1), although contemporary forms of irrigation may be less well represented. The case studies are illustrative of how changing policies have shaped irrigation practice and performance in Ethiopia, Morocco and Mozambique, specifically. This selection of schemes is not a representative sample of irrigation practice across Africa. Nor is it claimed that the experiences of these three countries are synonymous with others in the region.

In Ethiopia the focus was on the upper-middle Awash River Basin due to the concentration of irrigation investments in the area; the legacy of schemes such as Wonji dating from the 1950s and 1960s; and recent expansion and diversification in the sector. Various examples are provided in the paper. In Morocco the research looked in more detail at the Souss Massa Basin, comparing the modern and traditional systems at Issen and the public-private irrigation scheme in Guerdane, and explored their significance in this water scarce context. Chókwè Irrigation Scheme was a natural choice for Mozambique given the long history of this irrigation system, its political importance and its sheer size. The changes in management over time and diversity of actors involved also made this an interesting scheme to study.

Map 1: Location of case study countries

Source: Authors' own.

Table 1: Case study characteristics

Country	Location	Scheme(s)	Vintage	Size	Irrigation method	Current Management
Ethiopia	Awash River Basin(upper-middle basin)	Wonji Sugar Estate	1954	10,000ha (including out-growers)	Mainly surface, some drip	Public agency
		Upper Awash Agro-Industry Enterprise	~1960s	1,200ha Merti-Jeju; 2,800ha Nura Era	Surface, with plans to introduce sprinklers	Private
		Genesis Farm	1996	40ha	Drip	Private
		Fentale Irrigation Based Integrated Development Project	2006/07	~3,000ha currently (construction ongoing)	Surface	Public agency and Water Users' Associations (WUAs)
		Melkayida	~1960s	200ha	Surface	WUA
Morocco	Souss Massa River Basin (Ouled Teima)	Issen Traditional	1986*	4,440ha	Surface	Public agency and WUAs
		Issen Modern	1981*	8,500ha	Sprinkler and conversions to drip	Public agency
		Guerdane	2009	10,000ha	Drip	Public-private partnership
Mozambique	Limpopo River Basin (Gaza Province)	Chókwè Irrigation Scheme	1950s	7,000ha (potentially 23,000ha)	Surface	Public agency

*These dates relate to the completion of a dam complex supplying the two schemes. Some irrigation was practiced in both areas prior to these developments.

Irrigation performance can be understood and measured in different ways. At scheme level common indicators include water productivity; cost recovery for operation and maintenance; and farmer incomes (see Boss et al. 2005 for a comprehensive list). However, despite efforts to standardise some of these key indicators, researchers and practitioners continue to use a variety of methods to assess performance, making comparisons difficult (Lankford 2012). The field has also broadened considerably in recent years to encompass new criteria and perspectives in the evaluation process, which can result in conflicting objectives (Chaponnière et al. 2012). Another issue is that evaluations of performance are often done at a different level to that in which decisions are being made. For example, policy objectives for irrigation tend to emphasise food security, rural poverty reduction, generating revenue through exports, environmental sustainability and climate resilience. However causal linkages between scheme level and higher-level indicators remain under-researched (Chaponnière et al. 2012).

Rather than apply a predetermined indicator framework, this study adopted an iterative approach to identify the factors which have shaped the performance of particular irrigation projects, practices or policies. The premise is that performance is best understood in relation to stated objectives, which may vary between schemes, among actors, and over time. The research also explored linkages across scales, and trade-offs between different objectives.

1.3 Definitions

Before proceeding, there are a number of terms used throughout this paper which should be defined. First, 'modern' irrigation is often equated with use of new technologies and/or management approaches. However, as Plusquellec et al. (1994) argue, modern irrigation systems should be designed based on the service concept rather than preferences for specific engineering options. Modernisation of the irrigation sector, moreover, can imply fundamental changes to the rules governing water resource management, including reforms to institutions, rights, incentives and accountability mechanisms. In this paper modernisation is understood as 'a process of technical and managerial upgrading (as opposed to mere rehabilitation) of irrigation schemes combined with institutional reforms', the objective being 'to improve resource utilization (labour, water, economic, environmental) and water delivery service to farms' (Renault 1999).

Second, methods used to account for water differ between disciplines and commonly used terms such as 'efficiency' are often poorly defined in the literature, causing confusion (Lankford 2012; Perry 2007). The framework provided by Perry (2007) for analysis of water resources management, and endorsed by the International Commission on Irrigation and Drainage, is applicable to any sector or scale of analysis. Perry defines water use as 'any deliberate application of water to a specified purpose' and withdrawal as 'water abstracted from streams, groundwater or storage for any use' (Ibid: 56). All water use goes to one of the following: 1) changes in storage; 2) the consumed fraction (evaporation and transpiration), comprising beneficial and non-beneficial consumption; and 3) the non-consumed fraction, which is either recoverable (i.e. can be captured and reused) or non-recoverable (e.g. lost to the sea). For irrigation specifically, the term water productivity is taken to mean the output of crop per unit of water consumed (Perry et al. 2009; see also Perry 2011). Where it has not possible to adhere to these definitions (i.e. in citing other authors) footnotes are provided.

Third, design and technology choice have implications for how an irrigation system is managed and performs. For the classification of irrigation systems this paper uses the categories and definitions provided by FAO AQUASTAT (see Frenken 2005; a glossary is available on AQUASTAT [2]). The area equipped for irrigation includes: 1) full or partial control irrigation, comprising surface irrigation systems which rely on gravity to convey water and sprinkler or localised (drip) irrigation systems which are pressurised; 2) equipped lowland areas; and 3) spate irrigation. Note that this categorisation does not distinguish between different water sources, scales or management types. However, these aspects are discussed in Section 2.1 below.

1.4 Paper outline

An overview of irrigation development in Africa is provided in Section 2, including a description of current patterns and trends, and the changing narratives and approaches that have shaped the sector over the last 50 years. Sections 3-5 present the findings from Ethiopia, Morocco and Mozambique in turn, addressing the research questions posed above. These are followed by a comparative discussion (Section 6) to identify similarities and differences between cases, and to draw lessons for irrigation policy and practice. Finally the paper identifies three inter-connected policy debates emerging from the literature and case studies, namely: 1) modernising irrigation systems; 2) governing increasingly scarce water resources; and 3) the role of the state versus the private sector. The conclusion (Section 7) summarises the main research findings and suggests areas for future research.

2 A short history of African irrigation

2.1 Current patterns and trends

Africa's total internal renewable water resources are estimated at 3,900km^3, less than ten percent of the global figure (FAO 2011; Table 2). The continent as a whole withdraws half as much water per capita as the world average, disproportionate to available resources (Svendsen et al. 2009), and therefore has significant untapped potential. Nevertheless water is distributed unevenly across the region, availability and access can be highly localised, and in many places water is scarce. Droughts, floods and seasonal variations in rainfall also pose considerable management challenges and constraints to development, particularly in the agricultural sector. It has been argued that irrigation provides a way to buffer against these uncertainties, reduce the impacts of climatic extremes and extend the growing season (Turral et al. 2010; Biswas 1986). You (2008) claims that irrigation could increase yields in sub-Saharan Africa by 50 percent.

Agriculture currently accounts for over 85 percent of Africa's freshwater withdrawals. However, irrigation has historically been little practiced in the region (Neumann et al. 2011). In the early 1960s there were 7.4m ha under cultivation (Table 3). Although this area nearly doubled over the next 40-50 years, in 2006 African countries irrigated just 5.4 percent of their collective cultivated land, compared with a global average of around 20 percent and almost 40 percent in Asia (FAO 2011, citing FAO 2010b). Hence the sector's contribution to agricultural output is relatively small. Coverage is also skewed. A large proportion of irrigated land is concentrated in five countries, namely South Africa, Egypt, Madagascar, Morocco and Sudan (Frenken 2005). African irrigation schemes are relatively small compared to those in Asia.

Table 2: African water resources and withdrawals

Region	Precipitation	Internal renewable water resources	Total freshwater withdrawal (2003)	Freshwater withdrawal as % of IRWR	Total withdrawal by sector (2003)					
					Municipal		Industrial		Agricultural	
	mm/year	km^3/year	km^3/year		km^3/year	%	km^3/year	%	km^3/year	%
North Africa	96	47	94	201	9	9	5	6	80	85
Sub-Saharan Africa	815	3 884	121	3	13	10	4	3	105	87
Total	**678**	**3 931**	**215**	**5**	**21**	**10**	**9**	**4**	**184**	**86**

Source: Adapted from FAO (2011, citing FAO 2010b)

Box 1: Classifying irrigation schemes by size and management type

Definitions of scheme sizes vary considerably from one country to the next. Many countries, including Mozambique, classify anything over 500ha as large-scale. Surface (gravity) and pressurised irrigation schemes of more than 1,000ha exist in about two-thirds of African countries, while schemes of more than 10,000ha exist in nearly a quarter. The largest scheme in Africa is the Gezira-Managil scheme in Sudan with an area of about 870,000ha. Several schemes of more than 100,000ha also exist in Egypt, Morocco and Sudan.

Rather than by its size, a scheme is often described by its type of management, for example: small private farms, commercial farms, communal (farmer-managed) schemes or public schemes. The management of irrigation systems is generally ensured jointly by government (primary infrastructure or public systems) and user associations (secondary and tertiary infrastructure) with the exception of private farms. A distinction is often made between 'small and medium' versus 'large-scale' irrigation, the latter primarily implemented by governments.

Source: Frenken (2005)

Schemes of less than 10,000ha represent nearly half of the former's irrigation area (Box 1).

Frenken (2005) estimates that Africa could irrigate 42.5m ha, based on available land and water resources, but is currently equipped to exploit around 30 percent of this potential (or 13.6m ha) (Table 3). Moreover, on average one fifth of the current equipped area is not operational at any one point in time (Svendsen et al. 2009). Projections to 2050 indicate that the equipped area could increase to 17m ha, or 40 percent of the potential (Table 3). This future expansion represents a 20 percent increase in total withdrawals by the agricultural sector by 2050. Most irrigation in Africa relies on surface water sources. Groundwater based irrigation is less extensive, representing a small percentage of total irrigation area.

Table 3: Irrigation expansion in Africa

Region	Equipped area (million ha)			As % of cultivated land		Of which groundwater irrigation (2006)		Projected increases in agricultural water withdrawals (2006-2050)	
	1961	2006	2050*	1961	2006	Area equipped (million ha)	% of total irrigated area	Withdrawals in 2050 (km^3/year)*	% change
North Africa	3.9	6.4	7.6	17.1	22.7	2.1	32.8	95	19
Sub-Saharan Africa	3.5	7.2	9.4	2.4	3.2	0.4	5.8	127	21
Total	**7.4**	**13.6**	**17**	**4.4**	**5.4**	**2.5**	**18.5**	**222**	**21**

*Projections
Source: Adapted from FAO (2011, citing FAO 2010a and 2010b)

However, groundwater is more heavily exploited in North Africa and Sudano-Sahelian regions where the climate is drier (Frenken 2005).

An analysis of AQUASTAT data indicates that a large proportion of Africa's irrigated land is used for cereal cultivation, including rice, representing nearly half (45 percent) of the total harvested area (Frenken 2005). The remaining area includes sugar cane, cotton and other industrial crops (15 percent), vegetables (12 percent), roots and tubers (3 percent), fruit trees (4 percent) and other annual or permanent crops (8 percent) (Ibid). Although there are notable regional variations in cropping patterns, cereals predominate in all cases except for the Gulf of Guinea, where vegetables are more commonly grown. However, vegetables are becoming increasingly important as an irrigated crop across Africa, accounting for almost the entire increase in irrigated area in recent years (Ibid).

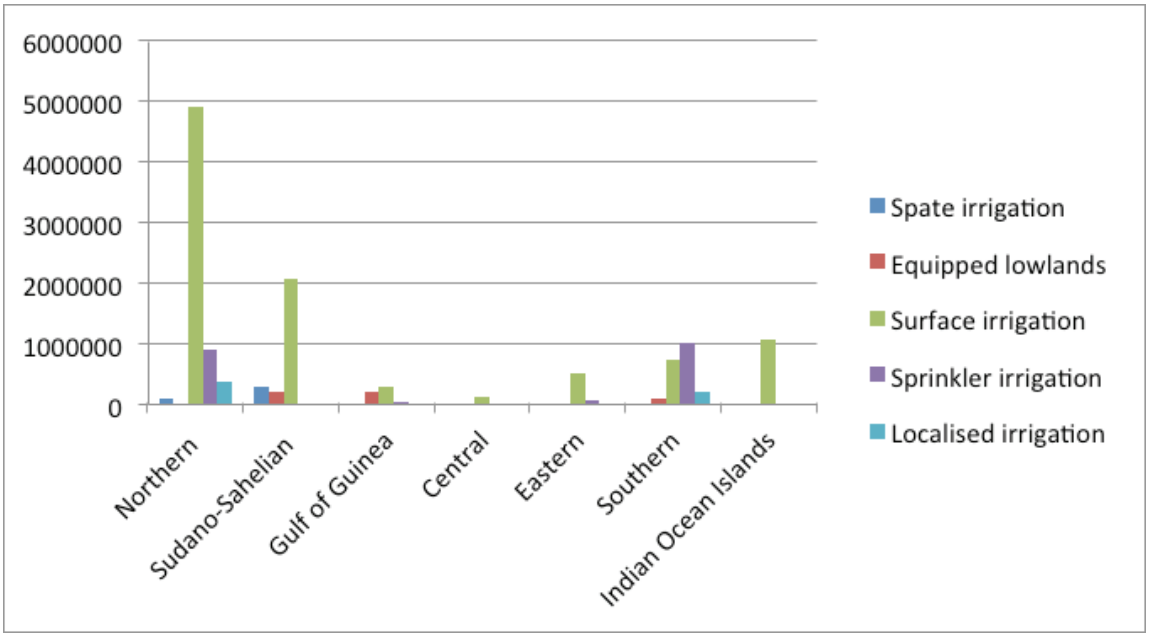
Over 90 percent of Africa's irrigated area is under full or partial control irrigation – surface, drip and sprinkler irrigation systems (Frenken 2005). The remaining 10 percent is spate irrigation and equipped lowlands. Although surface irrigation systems cover the largest land area there are notable regional differences in the use of different techniques. For example sprinkler and drip irrigation tend to be concentrated in the Northern and Southern parts of the continent (Figure 1).

2.2 *The Green Revolution (1950s-1960s)*

Efforts to boost agricultural production in Africa began as far back as the 1920s under colonial administrations, including large-scale irrigation developments in Sudan and Niger for cotton production (Woodhouse and Ganho 2011). Prior to this irrigation had been practiced on a

Figure 1: Distribution of irrigation techniques across African regions

Northern: Algeria, Egypt, Libya, Morocco, Tunisia
Sudano-Sahelian: Burkina Faso, Cape Verde, Chad, Djibouti, Eritrea, Gambia, Mali, Mauritania, Niger, Senegal, Somalia, Sudan (now Sudan and South Sudan)
Gulf of Guinea: Benin, Côte d'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Nigeria, Sierra Leone, Togo
Central: Angola, Cameroon, Central African Republic, Congo, Democratic Republic of the Congo, Equatorial Guinea, Gabon, São Tomé and Principe
Eastern: Burundi, Ethiopia, Kenya, Rwanda, Uganda, United Republic of Tanzania
Southern: Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe
Indian Ocean Islands: Comoros, Madagascar, Mauritius, Seychelles



Source: Adapted from Frenken (2005, based on AQUASTAT data)

relatively small scale, using traditional technologies and managed through customary institutions. In countries such as Morocco and Ethiopia these practices have evolved over several centuries.

In the second half of the twentieth century it was thought that an intensification of agricultural output was required in order to meet the challenge of feeding the growing world population (Turral et al. 2010; Molden et al. 2007). In conjunction with new seed varieties and fertilisers to boost yields, new irrigation technologies and management approaches were deployed worldwide and investments in the sector accelerated, particularly in developing countries where the area of land under irrigation increased significantly (Turral et al. 2010). Significant proportions of the donor community's agricultural budgets were being diverted to irrigation projects during this period (Rosegrant and Svendsen 1993). The result was that from 1963 to 2000 the world was able to respond to a doubling of its population by more than doubling food production.

This growth mostly occurred in the developing world, although Africa remained an important exception (Molden et al. 2007). In Asia especially, what became known as the Green Revolution was in a large part down to the boost that irrigation gave to agricultural output. For many people Asia's experience had thus become a benchmark of progress and what is achievable, and many considered whether Asian or Western formulas could be transposed to Africa (Nakano et al. 2013). Nonetheless, irrigation in Asia is diverse and should not be viewed as a uniform beacon of good practice, having its own particular set of problems.

From the 1950s to 1960s there were renewed attempts by African governments and their donors to invest in big infrastructure. Major river systems were equipped with dams to increase water storage, and expected to provide multiple benefits including stable water supply for food production (for food security and export earnings), domestic water services, increased resilience to drought and energy generation (hydropower) (Rahmato 1999). A number of ambitious irrigation projects were underway during this period. The Kenyan government, for example, was developing several irrigation schemes under the African Land Development Programme in the 1950s, including the Hola (1953) and Mwea (1956) irrigation and settlement projects in the Tana River Basin. The Chókwè Irrigation Scheme in Mozambique was also developed around this time for rice production.

Large water infrastructure development was part of the dominant development narrative at the time which emphasised technology and technological expertise. Engineering experts, often foreigners, were placed at the helm of large irrigation projects managed by the state (Faurès et al. 2007; Molden et al. 2007). Some viewed the state as the natural institution to drive the irrigation boom, responsible for national welfare (large-scale

irrigation arguably being a public good) and at that time having significant capacity for resource mobilisation (Merrey et al. 2007). Ostrom and Gardner (1993) argue that aid agencies helped to reinforce this image of the state as the 'owner' of irrigation by supporting costly public developments throughout the 1960s and 1970s.

By the mid-1970s evidence was emerging that although the Green Revolution had reduced food shortages globally, Africa was lagging behind. Reaching a peak at the end of this decade, donor spending on irrigated agriculture subsequently began to tail off rapidly. The literature identifies five main reasons for this trend:

1. Public irrigation systems were in most cases performing below expectations. Causes of poor performance in Africa included institutional inefficiencies, unreliable water supplies, low input use, and difficulties accessing profitable markets for agricultural produce (Peacock et al. 2007). Technical complexities were also a factor in some cases, such as the Limpopo scheme in Mozambique where engineers over-estimated the quality of the soil (Biswas 1986).

2. A sharp drop in the price of cereals throughout the 1980s meant that irrigated crops were unable to compete with subsidised foreign exports. Coupled with rising construction costs (point 3) benefit-cost ratios deteriorated (Molden et al. 2007).

3. African irrigation development has, for a variety of reasons, been marred by high costs in comparison to other regions and low cost recovery became a problem particularly for large schemes. For example, a review of six Kenyan schemes found that only one was delivering a net profit (Biswas 1986).

4. The non-governmental organisation (NGO) community was voicing concerns over negative environmental and social impacts. Loss of farming land, population displacement and environmental degradation were prices the poor often paid for poorly planned projects (Turral et al. 2010; Rahmato 1999). Participatory approaches were viewed as a means to empower water users and improve management of irrigation systems.

5. Neoliberal economists argued for the reduced role of the state and expansion of the private sector, policies which formed the foundation of structural adjustment programmes from the 1980s onwards and profoundly affected the agricultural sector (Bryceson et al. 2010).

The poor performance of irrigation investments highlighted some important governance challenges relating to the way in which schemes were developed, managed and financed. One reaction was to blame the farmers who were considered too traditional and in need of education in scientific methods. This was endemic in Nigeria, extending to major schemes built by the British in the 1940s and 1950s. The Edozhigi and Badeggi schemes, for example, were subject to multiple technical issues as a result of poor engineering and maintenance, but low yields were attributed to uncooperative farmers (Palmer-Jones 1987). This approach conveniently placed the responsibility for mismanagement of water at the farm level rather than with water agencies (Merrey et al. 2007). However, many of the agencies administering large schemes were established primarily to deal with construction. They were ill-equipped for ongoing management and incentives to provide reliable services to farmers were often absent.

An over-emphasis on the physical sciences also meant that planners largely ignored the social context in which these schemes would operate (Turral et al. 2010). Thus arrangements for scheme management were poorly matched to local institutional and social structures and disputes were difficult to resolve (Ward et al. 2006). Construction of the Nigerian Bakolori scheme in 1979 resulted in protests by local smallholders who lost their land to irrigation structures and were inadequately compensated and resettled; the uprising was violently suppressed by paramilitary forces (Yahaya 2002). Bakalori continues to underperform, and the economic cost of the loss of forests and fertile land to the scheme has outweighed marginal productivity benefits (Yahaya and Kamba 2003).

Local farmers were also reluctant (in some cases unable) to pay for services, which were often poor, and schemes had to be heavily subsidised (Biswas 1986). As the example of the Kano River irrigation project in Nigeria demonstrates, the promises made to communities and other stakeholders were dramatically different from the reality of irrigation construction and the serious underutilisation of developed irrigation infrastructure (Kadigi et al. 2013). At the same time, operation and maintenance aspects of projects were considerably less glamorous for donors and staff, and consequently received less funding and less experienced employees (Turral et al. 2010; Molden et al. 2007; Biswas 1986). In short, a downwards spiral of infrastructure degradation ensued in many schemes.

So where were the positive examples that served to reinforce the view that large-scale centralised irrigation could work in Africa? Cases such as the Gezira irrigation scheme, established in 1925 and still the largest scheme on the continent, suggested that such schemes would significantly contribute to agricultural production if proper management arrangements and technology were in place. At Gezira, both cropping intensity and cultivated areas increased steadily until the 1990s, thanks to a mix of favourable technological, policy and financial measures adopted by the Government of Sudan throughout the 1960s and 1970s. It is only in the 1990s

that the crop production declined significantly, due to weak institutional arrangements and deterioration of the infrastructure, as well as falling real world market prices in 1998 (Eldaw 2004).

Beyond the socio-economic benefits provided by Gezira, the scheme also enabled the state, colonial or otherwise, to establish political order and authority in the peasant hinterland (Bernal 1997). This model was undoubtedly appealing to colonial leaders up to the 1950s, and newly formed independence governments from the 1960s onwards. The proliferation of large scale schemes in Nigeria, despite consistent underperformance, has been described as an instrument by the elite, the same dominant class who worked in alliance with the British, to control competition for resources and maintain political power, justified by ideologies at the time of modernisation and nationalism (Palmer-Jones 1987).

2.3 Transferring management responsibilities to farmers (1970s onwards)

Given the disappointments of centrally managed irrigation, new ways of delivering irrigation were needed to address financial, social and environmental concerns. During the 1970s efforts were made to increase farmer participation and strengthen government agencies (Turral 1995). Macro-economic changes from the 1980s onwards provided impetus for further reform. Fiscal crises and structural adjustment policies served to reduce the role of African states in agriculture (Bryceson et al. 2010) and donor funding declined significantly, reaching a low in the mid-1990s to mid-2000s (ERD 2012). Market liberalisation was accompanied by a push towards decentralisation and privatisation of public systems (Cabral 2011) and a growing emphasis on good governance – principles such as inclusivity, transparency and accountability (see Franks 2004 on water governance). In this context irrigation management transfer (IMT), and the closely related concept of participatory irrigation management (PIM), became popular instruments for reform (Howarth et al. 2007; Merrey et al. 2007). Note, however, that IMT has been more prevalent in some African countries than others (see Garces-Restrepo et al. 2007).

Both IMT and PIM aim to increase the role and influence irrigation users have in developing, managing and financing irrigation systems. The process of devolving responsibilities from government agencies to farmers, particularly Water User Associations (WUAs), began in the mid-1970s and reached its peak in the early 1990s

Table 4: Evolution of public irrigation since the 1960s

Context	1960s to 1980s	1990s to present
Goals: drivers	Food security	Livelihood, income
Resources: land, water, labour	Abundant	Increased scarcity
Hydraulic development stages	Construction, utilisation	Utilisation, allocation
Dominant expertise	Hydraulic engineering, agronomy	Multidisciplinary, sociology, economics
Irrigation governance	Public	Mixed
Irrigation technology	Surface	Conjunctive use, pressurised
System management	Supply-driven	Farmer-orientated
Crops	Fixed, cereals and cotton	Diversified
Cropping intensity	1-1.5	1.5-2.5
Value of water	Low	Increasing
Concern for environment	Low	Increasing

Source: Turral et al. (2010, adapted from Barker and Molle 2004)

(Garces-Restrepo et al. 2007). Since the mid-1990s there have been further institutional and policy reforms in water resources management, subsuming irrigation (Turral 1995); however, the emphasis on participation and self-governance has remained (Abernethy 2010). These approaches have been advocated for a number of reasons. It is thought that:

- Farmers have a better understanding than external experts of local conditions, social context and their own needs, and thus their involvement in planning processes will ensure that interventions are appropriately designed.
- Involvement of farmers in decision-making fosters a sense of ownership, and hence water users will be more willing to invest in developing and maintaining irrigation schemes, relieving the burden on the state.
- Water User Associations can be held accountable by their members for the services they provide, whereas state agencies tend to primarily be accountable to higher authorities.

In reality, however, the main motivation for reducing the role of the state has been financial in most cases (Turral 1995). While governments have been willing to hand over management functions and costs to irrigation

users, they have been much slower in handing over ownership of infrastructure (Abernethy 2010) or devolve power through legal changes (Garces-Restrepo et al. 2007). Garces-Restrepo et al. argue for clearer legal status for WUAs and strengthening of farmers' water rights.

The ability of WUAs to operate and maintain modern systems without external support has also been questioned. Howarth et al. (2007) point to the lack of investment in developing the necessary skills and relationships for effective self-governance and tendency to rely on blueprints for institutional design. The result is that interventions are often poorly adapted to context and underperform.

It is often assumed that, if done well, farmer-run or jointly-managed schemes will perform better than centrally managed schemes. A review of the literature shows a mixture of positive and negative results, although the former tend to outweigh the latter (Vermillion 1997). Figure 2 presents a selection of IMT cases from Africa, showing that the pattern of outcomes and impacts has varied across countries (Garces-Restrepo et al. 2007). The area under cultivation, efficiency of fee collection and timeliness of water delivery have generally increased, whilst operation and maintenance costs to government have decreased, but this pattern is not universal.

The Office du Niger (Box 2) provides an interesting example of 'successful' IMT in a large irrigation scheme. This case illustrates that a series of small steps can work better than rapid reform, where government resources are limited (Garces-Restrepo et al. 2007). Starting with small, but politically feasible, changes and gradually building confidence in relationships and coalitions can allow for further reform later on. The iterative nature of the process and commitment to famer welfare were key characteristics of the Office du Niger experience. Meanwhile, broader changes in land tenure and market liberalisation provided additional incentives to farmers to increase production (Aw and Diemer 2005).

2.4 *Growth of the private sector (1980s onwards)*

Following structural adjustment in the 1980s and 1990s many African countries actively sought to encourage private sector investment, including agri-businesses and the food industry. Both local and foreign private investors are increasingly engaged in agricultural production, albeit representing a relatively small proportion of farm land at present, benefiting from favourable government policies and regulations (Locke and Henley 2014). Although only one percent of foreign direct investment (FDI) in developing countries goes to agriculture, investments in this sector tripled between 1990 and 2004 (FAO 2011, citing UNCTAD 2006). This has included conventional investors in production of food and agricultural commodities, as well as new investors from countries facing water constraints where opportunities to expand irrigated agriculture are limited (such as the Gulf States, India and China), or those interested in growing biofuels in light of climate change and rising energy prices (Woodhouse and Ganho 2011). Interestingly, most foreign investors in Africa are European and North American, contrary to popular belief (Locke and Henley 2014).

The heightened pace and scale of large-scale land acquisition in developing regions after the 2007-2008 spike in food prices (Locke and Henley 2014) has intensified debates around land and water acquisitions and the potential ramifications of commercial irrigation developments (Woodhouse and Ganho 2011). For example in Ethiopia there is evidence that, in the absence of strong regulation, private leases can serve to undermine local rights to resources (Tamrat 2010; Bossio et al. 2012). Moreover, irrigation developments in the past have displaced pastoral populations, reducing access to traditional grazing land and watering points, which has been an ongoing source of conflict in the Awash River Basin (Tiruneh 2013; Behnke and Kerven 2013).

Figure 2: Outcomes and impacts of irrigation management transfer (IMT) in Africa

	O & M costs to farmers	O & M costs to government	Efficiency of fee collection	Quality of maintenance	Timeless of water delivery	Equity of water delivery	Area irrigated	crop yields	Farm income	Soil salinity	Water Logging
Ghana	↑	↑	↑	↑	↔	↔	↓	↓	↓	▬	↔
Mali	↑	↓	↑	↑	↑	↑	↑	↑	↑	▬	↓
Morocco	?	?	↑	↓	↓	↔	↑	↑	↑	▬	▬
Niger	↑	?	↑	?	↑	↑	↑	?	?	▬	▬
Nigeria, Hadejia Valley	?	↓	↑	↑	↑	↑	↑	?	?	▬	▬
Senegal	↑	↓	↔	↓	↓	↔	↔	↔	?	?	↑
Sudan	↓	↓	↑	↑	↑	↑	↑	↑	↑	▬	▬
Tunisia	↑	↓	↔	↔	↑	↑	?	?	?	↔	↔
Zimbabwe	?	↓	↑	↓	↑	↓	↓	↔	↔	▬	▬

Legend				
	↑	Increased	↔	Remained about the same
	↓	Decreased	↕	Variable within systems
	?	Information not available	▬	Not applicable

Source: Garces-Restrepo et al. (2007)

Globally the growth of small private irrigation is the current defining trend for agricultural water management (Molden et al. 2007). In Asia the informal private sector has proliferated rapidly over the last thirty years or so based largely on groundwater abstractions (Giordano and Villholth 2007). The trend is more recent in Africa, but smallholder irrigation (both surface and groundwater based) is now growing faster than any other types, particularly in urban and peri-urban areas (Frenken 2005), partly driven by the availability of cheap technologies such as small pumps. It is difficult to find reliable data on the informal irrigation sector, as it is often excluded from official statistics.

Smallholder farmers are arguably the most important entrepreneurs in agricultural water management (Calow and Mason 2014). The trend towards small-scale irrigation (SSI) has a number of advantages. Individualisation of agricultural production and water management to some extent negates the need for large infrastructure investments and accompanying institutions (de Fraiture and Giordano 2014; Merrey et al. 2007). Small-scale systems that build on historical community relationships also avoid the need for a formal WUA and problems with collective action can largely be avoided. Nonetheless SSI has its drawbacks. It is very difficult to regulate the informal sector due to the large number of farmers involved and the nature of water as a common-property resource, as demonstrated by the Asian groundwater experience (Giordano and Villholth 2007). Many governments lack the regulatory capacity to monitor increasing abstractions, collect water charges and enforce environmental safeguards (Merrey et al. 2007).

2.5 Future prospects

In 2005 the Commission for Africa Report called for a doubling of Africa's irrigation area by 2015 (You 2008). Yet despite recent pledges from donors and governments, levels of public investment in agriculture have remained low (Akroyd and Smith 2007) and overseas development assistance to specific land and water sectors is declining (FAO 2011, citing OECD 2010). Spending needs for developing and sustaining irrigation schemes in Africa are estimated at US$3.4bn annually (Foster and Briceño-Garmendia 2010), yet the average actual spend in the 2001-2006 period was US$0.9bn (Briceño-Garmendia et al. 2008). Hence there is a notable funding gap. The public sector remains the dominant source of finance for irrigation (Foster and Briceño-Garmendia 2010).

The key principal underlying irrigation policy remains the need to mobilise water resources for food production, driven by population growth and compounded by changes in diets as global living standards increase (Turral et al. 2010). In the last decade or so climate change has also risen on the agenda, amid concerns that increasing variability will exacerbate existing vulnerabilities in Africa's agricultural sector (Ibid). At the same time, a large proportion of sub-Saharan Africa's population derives its livelihood from agriculture, and thus the sector remains a primary means of addressing the poverty challenge (You 2008). Under the right conditions irrigation can make a significant contribution to agricultural growth (Inocencio 2007), and for many developing countries irrigation will continue to represent a substantial share of agricultural investment (Faurès et al. 2007).

Box 2: Irrigation management transfer in the Office du Niger irrigation scheme, Mali

A commonly cited example of successful IMT and use of participatory approaches is that of Office du Niger irrigation scheme in Mali. In the early 1980s this 70,000ha scheme was characterised by low productivity and dissatisfied farmers. Only 1.5t/ha of paddy rice was produced from what was potentially the most productive site in West Africa, where heavy clay soils lie next to abundant freshwater low in salt. The scheme suffered from deficient drainage, limited field water management and the absence of specialised operation and maintenance personnel. Farmers cultivating plots in the scheme were heavily reliant on food rations provided by the agency, which were often insufficient to meet household needs.

Facing this difficult situation, donors declined to finance any further expansions until sustainability challenges had been adequately addressed. Small changes were implemented at first, including the establishment of village-level WUAs able to carry out operation and maintenance at the local level. By 1984, farmers had the agreement of the government to market their produce freely. Dependence of farmers on the Office du Niger for machinery was also removed and in 1987 farmers were offered permanent tenancies if they agreed to pay their water service charge and produce rice intensively. An act of parliament later allowed for partial authority of WUAs over scheme operation and maintenance. Managers of the scheme became accountable to elected farmers who sat on committees to agree changes. Farmers prioritised operation and maintenance works and agreed to sign three year, three way contracts (government, Office du Niger and farmers). Trust had developed between farmers and scheme managers such that they were able to agree a 50 percent service charge for water. As a result of these changes rice yields increased from 2t/ha in 1982 to 6t/ha in 1996.

Source: Garces-Restrepo et al. (2007); Aw and Diemer (2005)

Given Africa's growing population and expanding national economies, demands for water from the domestic, industrial and energy sectors are also increasing, coming into competition with agriculture (by far the largest consumer of water). Allocation of resources to irrigation therefore requires justification in terms of the expected economic and social return (Faurès et al. 2007). Reducing the costs and increasing productivity of irrigation schemes continues to be a priority, and indeed is necessary if the sector is to attract political support

and financial resources (Ibid). An emphasis on improved operation and maintenance, alongside rehabilitation, will also be key for long term viability of investments, while blueprints are one mistake that should not be repeated (Lankford 2009; Merrey et al. 2007). Future efforts are expected to focus on reforming existing irrigation systems, encompassing both managerial and technological change. At the same time, access to inputs and markets, soil fertility and local institutions remain equally important areas for investment for African irrigation (Faurès et al. 2007).

To conclude, irrigation development in Africa has had a chequered history. Approaches have evolved over time in response to technical, social and economic challenges, and have also been shaped by broader ideological shifts. There are clearly no one-size fits all solutions. However, renewed interest in the sector and calls for increased investment, both public and private, need to be matched by efforts to learn from past experiences and to critically assess options for future development.

3 Ethiopia

3.1 Introduction

Ethiopia has made impressive progress over the last decade, sustaining a high gross domestic product (GDP) growth rate of 11 percent under the 2005-2010 national development plan (MoARD 2010), and aspires to reach middle income status by 2025 (World Bank 2014a). Agriculture is central to the Ethiopian economy and hence to national policy. In 2006 agriculture's share of GDP was at 44 percent (Hagos et al. 2009, citing MoFED 2006), significantly higher than the average for sub-Saharan Africa of 20 percent (Cabral and Scoones 2007). Although the sector's contribution to GDP has since declined, recently overtaken by the service sector, it still accounts for most of the country's labour force (85 percent) and plays a key role in provision of raw materials for industry. In fact, commercial agriculture is thought to be on the verge of a growth spurt (Access Capital 2010).

Notwithstanding the progress made in recent years, Ethiopia still faces significant challenges in responding to its diverse and variable climate, particularly in the agricultural sector (Jones et al. 2013). National water resources are abundant and under-utilised, on average estimated at 1,900m^3 per capita per year, but are unevenly distributed in both space and time (Negash 2011). Many parts of the country experience considerable water stress as a result of complex interactions between various natural, socio-economic and political processes (Jones et al. 2013). In the past, droughts have had a heavy impact on the lives and livelihoods of rural populations as well as the national economy (World Bank 2006); future population growth and climate change are expected to place significant additional pressures on water resources, exacerbating existing vulnerabilities (Jones et al. 2013). In this context, irrigation is perceived as a means to better harness the country's water resources for human development and mitigate the impacts of climate variability, contributing both to poverty reduction and economic growth (World Bank 2006).

State interest in irrigation development first emerged in the 1950s during Ethiopia's modern Imperial era as part of a drive for agricultural modernisation and commercialisation, although traditional farmer-managed irrigation schemes had been in existence far longer (Rahmato 2008; Cherie 2006). In the intervening decades Ethiopia has undergone two significant political regime changes that have had profound implications for national economic development, the agricultural sector, and ultimately the lives of rural households. However, during much of this time irrigation has played a minor role due to limited policy interest and poor performance of investments.

More recently, interest has been rekindled in light of mounting concerns for national food security, the need to address vulnerability to climate change, and a desire to transform Ethiopia's economy. The national Growth and Transformation Plan (2010-2015) contains ambitious targets for irrigation expansion and investments appear to be accelerating in both the public and private sectors. Nonetheless, irrigation is no panacea and 'can only work if other components of the agricultural system are also effective' (Awulachew 2010: 5). Moreover, weak management and regulatory capacity, coupled with the lack of reliable data on changing land use and water abstractions, raises concerns regarding who is benefiting and whether irrigation developments are sustainable in the longer term.

3.2 The evolution of irrigation policy and institutions in Ethiopia

Three distinct political periods can be identified in Ethiopia's modern history. The 1950s to mid-1970s were the last decades of modern Imperial rule, during which a traditional feudal system of land ownership and agricultural production predominated (Rahmato 2008). Historically there had been very little state support for agriculture, public investment in the sector being less than five percent during the 1950s (Adams 1970), and rural livelihoods were undergoing a slow but steady decline in many parts of the country (Rahmato 2008). Recognising the need to stimulate growth, in 1957 the government launched the first of three five-year plans for national economic development, with the support of the World Bank and other donors (Rahmato 2008). These plans heavily emphasised accelerated modernisation and investments in scaling up commercial farming to increase agricultural production for export (Berhanu 2012; Adams 1970) and the government was keen to attract foreign capital (Rahmato 1999). By the third planning period (1968-1973) the government budget for agriculture had doubled to around 11 percent (Adams 1970).

Favourable policies during this era, including tax and financial incentives, attracted local and foreign private investments including for the development of irrigation schemes in the Awash Basin (Rahmato 2008). Meanwhile, significant donor support was provided to build hitherto nonexistent local capacities in agronomy and water resources management (Adams 1970) and a number of studies and surveys were undertaken for development of key river basins, including for irrigation (Rahmato 1999). During this period the first Water Resources Department was established under the Ministry of Public Works and Communications (1956) and the Awash Valley Authority[3] was born (1962), responsible for all water-related activities in the Awash River Basin (Tafesse 2008).

Although commercial agriculture remained the priority (Adams 1970), the 1960s was also a period when 'peasant agriculture became the object of state policy' for the first time in Ethiopia's history (Rahmato 2008: 27). Significantly, the second and third development plans included objectives to support modernisation of smallholder farming practices (Adams 1970). Various donor-funded package programmes for integrated rural development were implemented throughout the 1960s and 1970s to provide access to modern inputs, promote better farming techniques, organise farmers into cooperatives for credit access, improve market conditions and build rural public works (Rahmato 2008). However, these programmes had mixed results and development benefits were skewed towards the richer landed classes rather than poorer tenant farmers (Berhanu 2012; Rahmato 2008). Irrigation does not appear to have featured prominently.

Following a period of civil unrest the Imperial regime was overthrown in 1974 and the Provisional Military Administrative Council[4] was formed, popularly known as the *Derg* (Amharic for council or committee), embracing socialist ideologies and radical new agrarian policies (Lautze et al. 2009; see also GoE 1984). In the first few years of the new regime the government undertook extensive land reforms, arguably the greatest achievement during this period, abolishing the feudal system and transferring land ownership to the state (Lautze et al. 2009; Rahmato 2008). Aside from the larger farms, which became state-run enterprises, usufruct rights to land were allocated to rural households on the basis of equitable distribution (Rahmato 2008). Meanwhile key sectors of the economy were brought under state control and socio-economic planning became highly centralised (see GoE 1984). Significant changes were also made to administrative structures including the formation of politically-orientated Peasants Associations, which greatly increased the influence of the state at local level (Rahmato 2008).[5] Despite low levels of development, agriculture was central to the Ethiopia economy at this time and in the national plan of 1984 the sector was earmarked to receive 22.5 percent of total state investments over the next ten year period, including targets for irrigation developments (GoE 1984).

Derg policies focussed heavily on addressing rural poverty and food security (Lautze et al. 2009), combining socialist ideologies with a (Western) donor-driven emphasis on equitable and integrated rural development (Rahmato 2008). Nevertheless, until famine struck in the early 1980s, the government showed little interest in smallholder irrigation, instead favouring large complex water projects designed and developed by the National Water Resources Commission (established in 1971) (Rahmato 1999). Subsequent efforts to develop communal schemes, signified by the formation of the first Irrigation Department within the Ministry of Agriculture, were strongly top-down in nature and largely unsuccessful in transferring management to farmers (Rahmato 1999; Asfaw 1990).

Poor performance of communal irrigation can be attributed to agricultural policies of the time. Farmers were reluctant to join politically-orientated producer cooperatives (Kloos 1991; Asfaw 1990) in which they were forced to work collectively, pooling labour and sharing produce, which they deeply resented (Rahmato 2008). Moreover, market access was limited (Asfaw 1990) and the state imposed quotas for grain production and fixed prices well below the market rate. Coupled with restrictions on regional trade, this quashed any incentive to produce surplus (Rahmato 2008; Kuma 2000; Kloos 1991). Insecurity due to regular land redistribution, villagisation and civil war may also have played a role in stifling farmer investment (Rahmato 2008; Kloos 1991). Meanwhile, state farms were performing below expectations due to poor management, shortage of technical expertise, inadequate staff incentives and excessive red tape, among other factors (Eshete 1990; GoE 1984).

By early 1990 the *Derg* was forced to recognise the failures of its socialist policies and adopted a Mixed Economic Policy, including drastic reductions in public investments in state farms and encouragement of private farms, among other things (Awulachew et al. 2007). However, the regime fell shortly afterwards and many irrigation projects subsequently collapsed (Box 3).

In 1991 Ethiopia was facing political and economic crisis which ultimately resulted in a change in government (Cramer et al. 2004). During the next few years the centralised economy of the *Derg* was gradually replaced with a market-orientated system under a series of reforms supported by the World Bank and International Monetary Fund (IMF). Key policy changes included: a removal of restrictions on private sector activities; removal of subsidies and price controls; trade liberalisation; fiscal decentralisation and devolution of decision-making responsibilities to newly established regional governments; and adoption of Agricultural Development-Led Industrialisation (ADLI)[6] as a strategy for economic transformation (GDF 2011; Cramer et al. 2004). Following election in 1995, the Ethiopian People's Revolutionary Democratic Front (EPRDF) has continued to place an emphasis on pro-poor agriculture-led growth,

Box 3: The fate of irrigation schemes following the collapse of the *Derg* regime

Suspended (incomplete) schemes: A number of medium (500-3,000ha) and large (over 3,000ha) irrigation schemes under construction during the *Derg* were suspended, possibly because the new neoliberal policies of the mid-1990s limited government investment in such activities. Meanwhile, several private initiatives to take over and finish some of the schemes have been rejected or have failed of their own accord, whilst other schemes have been turned over to party-affiliated companies with limited success. More recently, in light of the government's emphasis on irrigation in the Growth and Transformation Plan, some projects have been reconsidered for development.

Transferred schemes: These were operative under public enterprises during the *Derg* and after 1991 were transferred to communities in the surrounding areas (or to private developers). Many of these schemes are located in the Awash Basin. In most cases transfer to local communities was unsuccessful and large tracts of land were left fallow due to: the lack of adequate capacity building and support for community management at the time of transfer; conflicts between different clans or tribes with competing claims to the land; and the lack of capacity in newly formed regional governments to draft and enforce policies for sustainable land use. Some investors have since made arrangements with communities or clan leaders and are currently operating the farms growing commercial crops such as cotton. However, much of the land has become overgrown and infrastructure has deteriorated, making it costly to bring these farms back into operation.

Source: Awulachew et al. (2007)

expansion of the private sector and strengthening public institutions for service delivery.

One noticeable change in agricultural policy since the 1990s has been a broadening in scope away from an exclusive focus on poverty reduction and food security in drought-prone areas, characteristic of the first national poverty reduction strategy, to include more productive areas and a greater push for agricultural commercialisation (Teshome 2006; see also MoFED 2006; 2002). The current Growth and Transformation Plan (GTP 2010-2015) is ambitious, aiming to sustain the high growth rates achieved during the late 2000s and for Ethiopia to reach middle income status by 2025. The plan stresses that 'smallholder agriculture will continue to be the source of growth' but that 'the private sector will be actively supported in large scale commercial farms and it is expected to show a major jump in the size of investment' (MoFED 2010: 19).

Irrigation is expected to play an important role in achieving GTP objectives. Moreover, as one key informant emphasised, well-designed irrigation could be a critical response for both subsistence and commercial farmers if the agricultural sector is to maintain growth under an increasingly variable and unpredictable climate. The Rural Development Policy and Strategy (MoFED 2003) promotes simple irrigation technologies, participatory labour-intensive approaches and farmer management of schemes. On the other hand, the Irrigation Development Investment Incentives regulation (2009) allows private companies to obtain permits which provide exemption from water use charges and privileged access to project studies, design and existing infrastructure to facilitate further development. Additional policy incentives for the private sector include low land rents, and various exemptions from import and incomes taxes (Bossio et al. 2012).

Sound water management has long been recognised as a prerequisite for sustainable agricultural development, but was not addressed comprehensively until the Water Resources Management Policy (1999) and Strategy (2001). Recognising water as a key but scarce resource, the Policy promotes integrated management across sectors, articulates the need for river basin organisations, and advocates for institutional stability and continuity (Tiruneh 2013). One notable omission, however, is the absence of any linkage between water and land management (Ibid). More recently the government has published a Strategic Framework for Managed Groundwater Development (2011) which focusses on policy adjustments and regulatory provisions required, given that investments in groundwater are expanding in agriculture and other sectors. However, despite these efforts to strengthen the policy base a number of bottlenecks remain, institutional fragmentation being a key challenge for effective natural resource management and hence irrigation development (Tiruneh 2013; Tamrat 2010; discussed further below). Interestingly, the Agriculture Sector Policy and Investment Plan (PIF) calls for 'a strategic review of agricultural water management to accompany the proposed major investments in irrigation development' (MoARD 2010: 10).

3.3 Drivers of policy change in Ethiopia

Processes driving policymaking and policy change are often highly complex and difficult to disentangle, and differentiating between drivers of change in irrigation policy as compared to other sectors of the economy would require a depth of analysis not possible here. Nevertheless, there are several factors worth mentioning that appear to have played an important role in shaping irrigation development in Ethiopia: politics and ideology;

foreign assistance; drought; and, perhaps to a lesser extent, markets.

Politics and ideology

Over the last sixty years Ethiopian politics has undergone two significant ideological shifts. In simple terms, the first was a change from a modern feudalist system to socialism in the early 1970s, largely triggered by internal pressures on government (exacerbated by drought) to take radical steps to tackle endemic rural poverty. The *Derg* effectively delivered the revolution that many had called for and, at least initially, tried to be responsive to the demands of the population (Lautze et al. 2009). Significantly, the land reforms and agricultural policies that followed precluded the involvement of the private sector (Asfaw 1990) and arguably stifled smallholder production and innovation (Rahmato 2008), thus indirectly impacting on growth in the irrigation sector. The second ideological shift was from socialism to a form of market-based capitalism, triggered by the economic and political crisis which came to a head in the early 1990s (Cramer et al. 2004). Upon ousting the *Derg*, the new government was similarly under pressure from both donors and the electorate to make significant changes and achieve demonstrable results. The neoliberal policies that followed have re-opened the door for private sector participation in irrigation, and the government actively encourages foreign investments. Nevertheless, the EPRDF's electoral base remains predominantly the rural poor (Brown and Teshome 2007). A tension therefore remains between the desire to promote large-scale commercial farming for macro-economic growth and the need to support the livelihoods of smallholder farmers (Teshome 2006).

Foreign assistance

Ethiopia prides itself on never having been colonised by a Western power. Nevertheless, policymaking has evidently been subject to numerous pressures from donors and multi-lateral financing institutions over the course of modern history, although this has caused less distortion at both macro and sectoral levels than in many other African countries (Brown and Teshome 2007). In the 1950s and 1960s the Imperial government was not only wholly dependent on the donor community for finance but, it is argued, also for the design and development of policies and programmes (Rahmato 2008). Given that this was 'the heyday of Modernization theory in the West' (Rahmato 2008: 31) the emphasis on large infrastructure, new technologies and modern management practices in Ethiopia's irrigation sector is therefore unsurprising. Nonetheless, donors had difficulty in influencing land reform, land being the foundation of the Imperial regime (Rahmato 2008).

During the 1970s and 1980s certain bilateral funders (notably the USA) gradually withdrew their support for the *Derg*, yet foreign assistance and loans actually increased, including from the European Economic Community (GoE 1984). Yet large infrastructure development became unpopular around this time. In Ethiopia the emphasis shifted towards farmer-managed irrigation and finance was limited (Kloos 1991). Today Ethiopia remains heavily dependent on external financial assistance and donors continue to play a role in shaping national and sectoral policies (Brown and Teshome 2007), for example through the Development Assistance Group[7]. Despite the growing emphasis on commercial irrigation expansion in government policy, however, traditional donors generally prefer to support smallholder irrigation, for example through the Agriculture Growth Programme[8].

Drought

The inability of the Imperial government to address the humanitarian crisis following severe droughts in the early 1970s is frequently cited as one of the reasons for the regime's downfall, and thus associated with revolutionary change. Famine became central to Ethiopian politics (Lautze et al. 2009). Having given food security a central place in national policy, the return of famine in the mid-1980s posed a threat to the *Derg*, particularly given mounting resistance to the regime from rebel groups who controlled some of the drought-stricken areas (Ibid). The government subsequently launched a campaign to use available water resources for developmental and agricultural purposes, including the first real attempt to develop irrigation for the benefit of smallholder farmers to increase food security (Kloos 1991; key informants). During the 1990s there were continued efforts by the government and NGOs to develop small-scale irrigation in drought-prone areas, and several regional bodies were established with a mandate to develop irrigation infrastructure in tandem with catchment protection efforts (Hagos 2005; Teshome 2002). More recently attention has also turned to investment in high productive areas, for example through the Agriculture Growth Programme (MoFED 2006).

Markets

Although it is difficult to link market drivers directly to policy change, markets have clearly played some role in determining the economic viability of irrigation development in Ethiopia. For example, during the 1950s and 1960s international markets were thought to have been particularly conducive for the development of export-orientated production of certain crops (Rahmato 2008), whilst in later years the fall in international market prices for primary agricultural products was considered disturbing for the financial sustainability of the irrigation sector (Asfaw 1990). More recently, farmers in proximity to growing urban centres and major regional highways have taken advantage of their location to access lucrative local markets. Demand for vegetables has increased rapidly and there is huge potential for expansion of commercial production (Gebreselassie 2010; Bekele et al. 2003). Larger commercial farms are also benefiting from

infrastructural links to reach regional and international markets for high-value vegetables, fruits, processed goods and cut flowers, and interest from foreign investors has grown (Bossio et al. 2012). Nevertheless, poor market access and lack of infrastructure for storage or processing remain key barriers to irrigation development in many parts of the country (AgWater 2010).

3.4 Implications for irrigation practice and sector performance

Although Ethiopia's irrigation sector is currently expanding, progress throughout its history has been rather slow. In 1984 a mere 100,000ha of irrigable land were estimated to be under production nationally (GoE 1984), half of which was located in the Awash River Basin (Rahmato 1999). Two decades later a total of 640,000ha was irrigated under the EPRDF's second poverty reduction plan (2005-2010) (Awulachew 2010). Meanwhile, potential irrigable land in Ethiopia is commonly cited at 3.7m ha based on river basin master plan studies (Awulachew 2010), although different numbers are often provided depending on estimations of available water and land, technology and finance (FAO 2014b). Coverage figures also vary between official sources and data is patchy (Box 4).

Box 4: Questioning the numbers

Despite efforts to compile comprehensive databases of irrigation schemes (e.g. Tiruneh 2013; Awulachew et al. 2007) establishing accurate figures of coverage in any period is extremely difficult due to the lack of clear baselines, inconsistencies in reporting and significant gaps in the data (Awulachew et al. 2007; Rahmato 1999). Capacities for monitoring changes in land and water resources and their use, let alone functionality and performance at scheme level, are severely limited (Tiruneh 2013). The statistics cited therefore vary considerably between official sources. Moreover, government targets heavily emphasise activities and outputs (such as area under study, or area under construction) over outcomes. A recent survey covering over 2,000 irrigation and water harvesting schemes in the Awash found that the total actual irrigation area was just over 88 percent of the area reported by regional bureaus and district offices and 94 percent of the area equipped for irrigation. The difference was attributed to infrastructural failures and water shortages, among other factors (Tiruneh 2013). On the other hand, in some modern schemes farmers are extending canal networks and can therefore irrigate more land than is reportedly equipped for irrigation (FAO 2014b).

Based on reported coverage in 2005/06, Hagos et al. (2009) state that 77 percent of the total area under irrigation is covered by traditional schemes[9], defined as small-scale schemes (under 200ha) with impermanent structures made from local materials, managed communally through customary arrangements. Modern small-scale irrigation accounts for 9 percent of the area. Modern implies fixed or improved water control and diversion structures managed by WUAs or farmer cooperatives. These schemes are largely developed by the government or NGOs. Another 14 percent of the area consists of medium (200ha to 3,000ha) and large-scale (over 3,000ha) irrigation, mostly public schemes (Ibid). The Water Sector Development Plan (2002) indicates that 4 percent of the irrigated area is privately owned (Awulachew et al. 2007). However, it is thought that private sector participation is on the increase, including foreign direct investments in production of biofuels, cotton, floriculture and horticulture (Bossio et al. 2012). Currently there is also an emphasis in the Ministry of Agriculture on household-based irrigation, defined as irrigation of under 5ha involving fewer than ten households, as a low-cost means to reach large numbers of farmers and catalyse growth (ATA 2014).

Water management technologies used in Ethiopia include: temporary or permanent river or stream diversions; spate irrigation; micro-dams; rain-water harvesting and ponds; and pumping systems (from groundwater, rivers or lakes), depending on geography and other factors (AgWater 2010). Surface (gravity-fed) canal systems are generally the most common irrigation techniques (Tiruneh 2013). Modern pressurised systems appear to be a relatively new phenomenon, with some uptake by the private sector and in new or expanding state schemes. Many communal irrigation schemes supplement rainfed agriculture. To date groundwater has been little exploited for agriculture, but abstractions are on the increase (MoWR 2011).

Irrigated agriculture accounts for a small proportion of food crops produced in Ethiopia, rainfed agriculture being predominant (FAO 2014b). Most export crops are also rainfed, but industrial crops such as sugarcane, cotton and fruit are irrigated on public and private schemes (Ibid). In small-scale irrigation schemes farmers primarily irrigate during the dry season, although some use supplementary irrigation in the rainy season (Hagos et al. 2009). Cereals are the dominant irrigated crop (over 50 percent of the area covered), followed by vegetables. Other crops include fruits, pulses, spices and oilseeds (Ibid). Although urban and peri-urban irrigation are not significant on a national scale, either in terms of area or production, irrigation is expanding around urban centres such as Addis Abba and plays an important role in supplying vegetables to these markets (FAO 2014b; key informants).

Considerable efforts have been made by the EPRDF to tackle some of the policy, institutional and financial challenges encountered by the *Derg* but many of these issues remain pertinent today (Table 5). Irrigation development continues to fall short of ambitious national

targets and fundamental challenges remain in sustaining high performance (Awulachew 2010).

One key factor undermining state investments in both eras has been institutional fragmentation. National and subnational institutions for land and water management have proliferated yet without clear delineation of responsibilities. Currently, the Ministry of Water, Irrigation and Energy (MoWIE) has a mandate to oversee water resources development, but in practice irrigation spans a number of government bodies including the Irrigation Department and Agriculture Investment Support Directorate in the Ministry of Agriculture, regional bureaus and district offices, river basin authorities and para-statals such as the Ethiopian Sugar Corporation. Horizontal and vertical coordination is frequently lacking, resulting in inefficient use of government resources, and disconnects in project planning and implementation (Tiruneh 2013; Tamrat 2010). Frequent re-structuring and high staff turnover exacerbate these problems and contribute to institutional instability (Negash 2011).

A second enduring institutional challenge has been the lack of adequate capacity to enforce land use and planning regulations, tackle widespread environmental degradation and regulate water abstractions effectively in the face of increasing demand. These risks can undermine the sustainability of irrigation schemes and may also deter private investment. Policies are now in place to tackle environmental problems such as water quality, salinisation, deforestation and soil erosion but implementation is weak. As discussed above, there are also disconnects between land and water policies, and a lack of clarity regarding customary rights, which makes it difficult to manage competing demands for resources (Tamrat 2010).

Third, the level of attention and resources given to construction and expansion of irrigation schemes, as opposed to management, maintenance and supporting services, is concerning. Awulachew (2010) estimates that many irrigation schemes are currently operating at 30 percent below design capacity. In government-built schemes managed communally by farmers, users often do not receive adequate training and support to operate and maintain systems effectively, contributing to low water productivity, conflicts and infrastructural decay. Financial sustainability is also remains a challenge, due to weak mechanisms for cost recovery. In some cases farmers simply lack the supporting infrastructure, inputs and services required to make irrigation a viable investment (ATA 2014). Meanwhile others have good access to inputs and markets but struggle with price fluctuations. Interestingly, Hagos et al. (2009) find that traditional irrigation schemes generate more income per hectare than modern small or medium scale schemes and suggest that they perform better because: 1) investment costs are lower; 2) farmers have more experience in managing the scheme; and 3) local water institutions are stronger. However, others argue that traditional schemes are characterised by poor agronomic and water management practices, lack of inputs, and low levels of productivity (van Halsema et al. 2011; Bekele et al. 2003).

Fortunately the Growth and Transformation Plan (MoFED 2010) recognises that a shift to higher-value agricultural production will require strengthening institutions for natural resources management, alongside investments in rural infrastructure and markets, and support to farmers through the extension system (ATA 2014; Tucker et al. 2013). There is also some recognition in national policy that strategies need to be differentiated according to the agro-ecology and other contextual factors (Teshome 2006).

Table 5: Constraints faced by the irrigation sector during the *Derg*

Policy	Institutional	Financial
• Restricted private sector participation which 'killed the spirit of entrepreneurship'	• Lack of coordination between government institutions	• Inability to mobilise funds (45% of budget spent)
• Lack of mechanisms for cost recovery and water charges	• Competing users of land and water, with no legal provisions (water code in draft)	• Increasing project costs
• Lack of land tenure security and fragmented land holdings	• Low capacity for study, design and implementation (shortage of skilled manpower)	• Fall in prices of agricultural products on the world market
• Lack of clarity of responsibility for irrigation scheme owners	• Inability to tackle environmental problems such as salinisation deforestation and water-borne diseases	• Poor financial management in existing irrigation projects
• Price control and pegged exchange rates		

Source: Summarised from Asfaw (1990), with additions from GoE (1984)

3.5 Case study: Awash River Basin

The Awash River Basin is considered to be the most heavily utilised river basin in Ethiopia, currently serving as home to 10.5m inhabitants, providing water to the growing capital city of Addis Ababa and containing a concentration of irrigation and industrial developments (Tiruneh 2013; Alemehayu et al. 2011; Tadesse et al. undated). Water scarcity and pollution are growing concerns (Tiruneh 2013). The Awash was also the site of the first large-scale irrigation developments in the 1950s and 1960s (Rahmato 2008), several of which function today, and still accounts for a significant proportion of Ethiopia's irrigation coverage in relation to potential (Alemehayu et al. 2011). The long history of irrigation in the area coupled with recent expansion and diversification makes the Awash River Basin an interesting case study. Here the focus is on the upper-middle basin[10] where most of the irrigation developments are concentrated, providing insights from a variety of schemes.

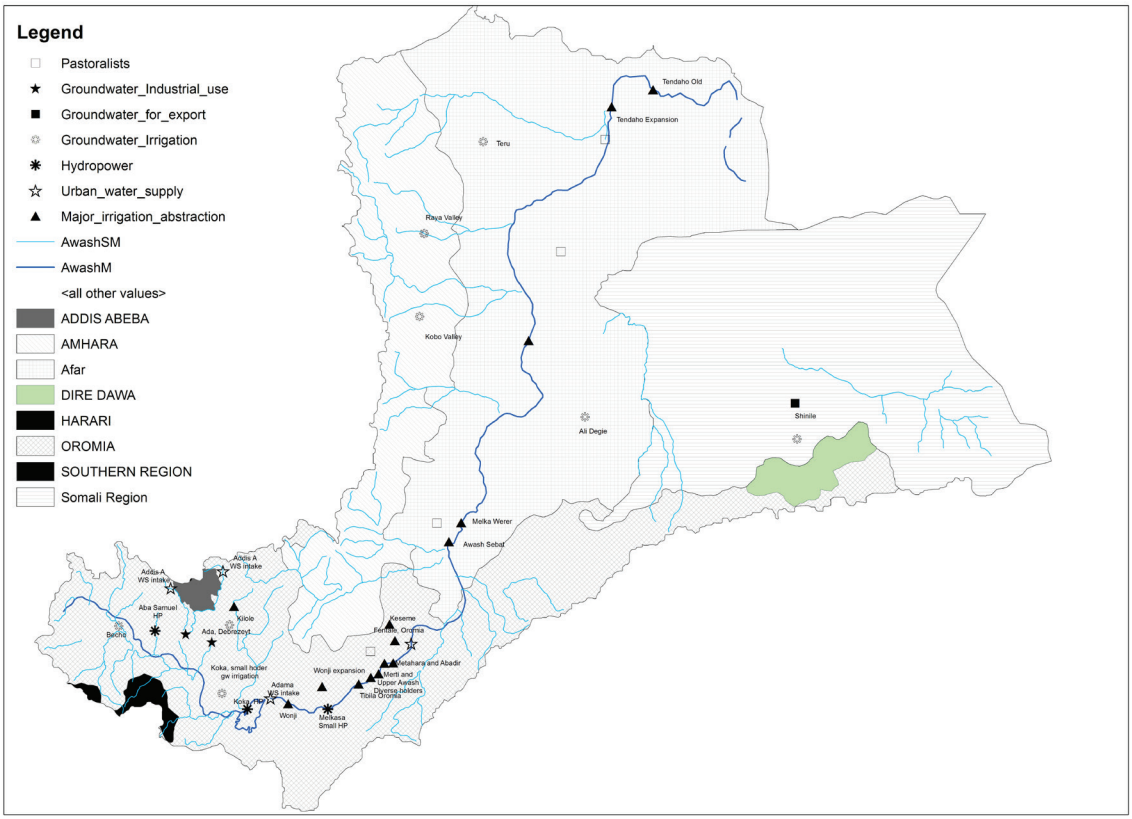
Background

The Awash River originates in the central western part of Ethiopia, flowing 1,200km from the highlands of Amhara and Oromia towards the eastern and north-eastern lowlands of Somali and Afar, terminating at Lake Abe (Tiruneh 2013; Awulachew et al. 2007) (Map 2). The river basin has a catchment area of around 110,000km^2 and a number of small and large tributaries, the Akaki River being the biggest single contributor to runoff (Berhe et al. 2013). Temperature and precipitation vary both spatially and temporally. The upper Awash, or Western catchment, is relatively cool and wet. Annual temperatures in the highlands average 12°C (Tiruneh 2013) and annual rainfall averages 850mm (Berhe et al. 2013), whilst the lowlands are semi-arid or arid areas with high temperatures and low rainfall.

Total mean annual river flow for the Awash is estimated at 4.9bn m^3 and groundwater potential at 0.14bn m^3 (Awulachew et al. 2007). Water resource availability per capita is less than 500m^3 per year (Tiruneh 2013); hence, the basin can be considered water scarce. Water distribution is also highly seasonal, many lowland tributaries only function during the rainy seasons, and evapotranspiration rates are high (Tadesse et al. undated). There are currently four storage reservoirs, three supplying water to Addis and the fourth (Koka dam) for hydropower generation and flow regulation. Another two are under construction for irrigation in the middle and lower parts of the basin (Tiruneh 2013). The Awash Basin Authority is responsible for coordinating developments in the basin, monitoring water abstractions and collecting water use fees, but has very limited capacity to implement its mandate and has limited influence over the activities of regional governments.

Due to the geographical distribution of natural resources and urbanisation trends the highlands of the western basin are relatively densely populated, reaching 270 people per km^2 in some areas (Tiruneh 2013). Agriculture is the dominant economic sector throughout the basin. In highland areas rainfed farming is the most common livelihood strategy, whereas pastoralism

Map 2: Water use in the Awash Basin



Source: Courtesy of Seifu Kebede (2014)

predominates in the lowlands. The highland population is mostly sedentary with mixed crop-livestock systems (Tiruneh 2013). Industry is another key sector in the upper and middle Awash, particularly in and around Addis, including tanning and leather manufacturing, breweries and distilleries, textiles and food processing (Ibid).

Tiruneh (2013) estimates that the Awash could sustain an irrigation area of about 338,300ha by 2030, but notes that this does not account for environmental water requirements or possible negative impacts on demand in other sectors. Meanwhile, potential for major groundwater development is thought to be limited due to low recharge (Tadesse et al. undated) although data is limited and abstractions appear to be on the rise (Tiruneh 2013). The water audit conducted by Tiruneh and his team (2013) concluded that the area under irrigation in 2010 was 160,000ha. Medium-large irrigation developments tend to be concentrated along the main Awash River while small communal schemes are also dispersed throughout its tributaries, particularly in the upper basin. The dominant irrigated crops are vegetables and cereals covering 31 and 29 percent of total cropped area, respectively, followed by cotton, sugarcane and fruits (Ibid).

History of irrigation in the Awash River Basin

Given that the Awash River Basin represents a large proportion of irrigation developments in Ethiopia and contains some of the oldest and largest schemes (Rahmato 2008), in many respects the history of irrigation in the area is synonymous with the national story depicted above. An emphasis on infrastructure development and agriculture modernisation under the Imperial government of the 1950s and 1960s played an important role in enabling commercial agriculture to take off, which included irrigation investments in the Awash (Rahmato 2008). The Koka dam was opened in 1960 which provided hydropower and helped regulate river flows for irrigation development downstream (Alemehayu et al. 2011) and construction of the tarmac Addis-Assab road opened the Awash Valley to markets in the hinterland as well as for export (Awulachew et al. 2007).

Aside from pre-existing traditional irrigation schemes managed through local customary institutions, irrigation development at this time was the domain of the private sector. Most of the larger schemes were built and owned by foreign companies, including the sugar estates at Wonji (Box 5) and Metahara; cotton production at Amibara and Tendaho; and horticultural farms around Merti-Jeju, Nura Era, Awara-Melka and Tibila (Behnke and Kerven 2013; Awulachew et al. 2007; Girma and Awulachew 2007). Local land owners also took an interest (Rahmato 2008) – for example, one key informant explained that the scheme at Melkayida (Table 6) was initially developed by a member of the royal family to supply fruits and vegetables to the palace.

Under the *Derg* most of the larger private schemes were confiscated and placed under centralised state management. Some attempts were made at further development in the Awash during this period. For example, Wonji expanded to incorporate an outgrowers' area of over 1,000ha (key informant) and the cotton farm at Amibara grew from 6,337ha to 12,318ha (Behnke and Kerven 2013, citing Said 1992). The government also constructed the Belbela-Wedecha dams and canal irrigation system, operated as a state farm (Girma and Awulachew 2007; key informants). However, profitability

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Genesis Farm, a small private enterprise in the upper-Awash Basin, is using ground-water based drip irrigation for vegetable production. This 40ha farm also produces flowers, dairy and poultry products, and has a small shop.

of commercially-orientated schemes was on the decline for a number of reasons, including low investment by the government (Kloos 1991). Meanwhile, the upper-middle Awash was largely neglected by the state in terms of smallholder irrigation development, the focus being on northern drought-prone regions of the country (Eshete 1990). According to key informants, some of the smaller farms were transferred to producers' cooperatives for management, including Melkayida, but this does not appear to have been a widespread trend.

Under the EPRDF many of the larger commercial irrigation schemes in the Awash have continued to function as state farms. There are ambitious plans to expand sugarcane estates in the middle and lower parts of the basin, including two new dams, conversion of Tendaho to sugar plantations and expansion of Wonji to 22,000ha through outgrowers' schemes (Tiruneh 2013; key informants). The fate of smaller farms has been mixed. Some of the smaller farms have been transferred to private ownership, including the recent sale of Merti-Jeju and Nura Era horticultural farms to MIDROC/ Horizon Plantations Plc (Table 6) and the privatisation of Amibara cotton farm in 2009. Attempts have also been made to transfer ownership of existing schemes to local communities (Awulachew et al. 2007), one of the few positive examples being the cotton plantation in Genawe District managed as a cooperative farm by a local clan, which is one of the best-run cotton farms in the Afar region (Behnke and Kerven 2013). Meanwhile the original Belbela-Wedecha farm was abandoned, although the reservoirs are now being used to irrigate a new area developed by the current government for smallholders, alongside traditional irrigation (Girma and Awulachew 2007; key informants).

In addition to these older schemes there are a number of interesting new developments in the Awash. Firstly, the Oromia Irrigation Department is developing Ethiopia's first large-scale irrigation schemes for smallholder production. The Fentale and Tibila projects are expected to cover a combined area of 25,000ha (command area under design) and benefit 30,000 households once completed (OWWDSE undated; key informants). It remains to be seen how effectively the government can hand over management of such large infrastructure to (previously pastoral) communities. Secondly, in the informal private sector a growing number of entrepreneurial farmers are

Box 5: Wonji Shoa Sugar Factory

Wonji irrigation scheme was developed in 1952 in the Awash by Dutch investors, about 100km from Addis. The scheme consists of a network of storage reservoirs (combined storage capacity of 268,000m^3) and conveyance canals, pumping water from the Awash River (Girma and Awulachew 2007). The Shoa factory was built in 1962 to process the sugar. At this time the estate was around 5,600ha and managed privately. As with all large farms, Wonji was confiscated by the *Derg* after 1974 and placed under state management, at that time operated by the Ethiopian Sugar Corporation (Sugar Corporation 2014). During the socialist era the scheme was expanded to include an outgrowing area and farmers were organised under producer's cooperatives, forming a union. However, key informants claimed that the union had been weak, lacking the necessary management skills and political clout to negotiate with the factory, and cooperatives accumulated significant debts. Sugarcane production was not profitable for outgrowers at that time. Households were heavily reliant on additional income from daily labour and credit provided by the factory (key informants). Meanwhile Ethiopia's sugar estates were suffering from declining profits and lack of adequate capacity (trained personnel, finance, machinery) for effective management and maintenance (see also Eshete 1990; GoE 1984).

In 1992 the state corporation was dissolved by law and the factories (including Wonji Shoa) became public enterprises. After a number of changes to the national supporting agency, a new Sugar Corporation was established in 2010 with a vision to create sugar industries that could compete internationally and ambitions to expand sugar production (Sugar Corporation 2014). According to the agronomist interviewed at Wonji, the estate has recently developed new outgrowing areas and has ambitions to increase the total outgrowing area to 18,000ha. The new plantations have sprinkler irrigation systems, but planting and weeding still requires hard labour (ploughing is generally done by machine). Meanwhile, older parts of the scheme remain in a worrying state of decay and reservoirs are in urgent need of rehabilitation. Power cuts are also a problem for Wonji's pump system, particularly in the dry season.

Discussions with outgrowers at Wonji revealed that the cooperative model imposed by the *Derg*, which was hastily abandoned by most Ethiopian farmers, has persisted in the older parts of the scheme. According to these farmers, they continue to own and cultivate land communally, sharing the profits. In newer areas farmers are also organised in cooperatives, but the nature and capacity of these institutions is different. Importantly, households retain ownership of their plots and receive harvest payments accordingly. The Wonji enterprise claims to be making a difference to the lives of local communities. Certainly, some of the farmers interviewed were very positive about the benefits they received. For example, they claimed that the factory provides households with a regular source of income and has even helped farmers to set up bank accounts. Nevertheless, discontent may linger in the older outgrowing areas, perhaps partly explained by historical grievances. Farmers here appear to have a poor relationship with scheme managers.

Table 6: A selection of irrigation schemes in the upper-middle Awash River Basin

	Wonji Shoa Sugar Factory	Upper Awash Agro-Industry Enterprise	Genesis Farm	Fentale Irrigation Based Integrated Development Project	Melkayida (Camp A) irrigation scheme
Location	Middle Awash (near Adama)	Upper and middle Awash	Upper Awash (in Debre Zeit)	Middle Awash (near Metahara)	Middle Awash (near Adama, close to Wonji)
Vintage	1954 (factory 1962)	~1960s	1996	2006/7	~1960s
Land area	6,000 ha + 4,000ha of out-growers (plans to expand outgrowing area by 12,000ha)	1,200ha Merti-Jeju; 2,800ha Nura Era	40ha, rented from local farmers (plans to expand if land is available)	~3,000ha under irrigation (construction ongoing – 18,000ha irrigable area)	200ha (1ha/ household)
Water source	Awash River – pumps and storage reservoirs	Awash River – diversion	Borehole – pumped	Awash River – diversion	Awash River – pump
Irrigation method	Surface irrigation (old areas); sprinkler system (new areas)	Surface irrigation (current efforts to modernise, including use of sprinklers)	Drip irrigation	Surface irrigation	Surface irrigation
Crops grown	Mainly sugarcane	Vegetables, fruit, cotton, maize (and processed goods)	Vegetables, salads, floriculture (plus dairy and poultry)	Mainly vegetables, possibly some cereals	Mainly vegetables (originally fruit)
Management and ownership	Owned by a Dutch company until transfer to the state in 1974; currently run by the Sugar Corporation (a public enterprise)	Initially privately owned; state-run then public enterprise from 1975-2013; now under Horizon Plantations Plc (affiliated to MIDROC)	Privately owned and run by an Ethiopian individual (previously joint-owned with two foreigners)	To be managed by various WUAs under an umbrella committee; government support to be withdrawn gradually	First owned by the royal family; state farm for ten years, then a producers' cooperative under the *Derg*; now managed by a WUA
Finance for infrastructure development	Originally Dutch investors; subsequent expansions funded by government	Originally built as a joint venture by local and foreign investors (used to include two other farms)	Originally mainly a foreign investment (Double Harvest Netherlands and America)	Government-funded project	Originally a private investment; the current WUA has inherited the pump, machinery and mill
Finance for current operation and maintenance	Government	Private	Private	Farmers/WUAs (possibly government support)	WUA
Other information	Objectives: help meet national demand for sugar; future export to generate revenue; provide social benefits (e.g. employment, service provision)	Commercial agro-processing enterprise (including for export); mission to introduce modern production and processing technologies to Ethiopia	For profit but also aims to benefit local community (e.g. free water supply, affordable produce, community centre); employs 500 staff and 300 daily labourers	Objective to settle pastoral communities, increase food security, increase incomes and reduce poverty; budget constraints currently slowing progress	Complicated history; local communities first given land on scheme around late 1980s; crops produced for both subsistence and sale
Source(s)	Rahmato (2008); key informants; Sugar Corporation (2014)	Key informant; Horizon Plantations (2014); Tiruneh (2013)	Key informants; Genesis Farm (2014)	Key informants: OWWDSE (undated)	Key informant

converting rainfed land to irrigation, where feasible, in order to produce vegetables for market. Although surface water remains the dominant source, groundwater exploitation also appears to be on the rise, particularly for horticulture production and the new floriculture industry in addition to domestic or industrial uses (Tiruneh 2013; key informants; authors' observations).

Scheme performance

The performance of Ethiopian irrigation schemes is difficult to assess quantitatively as the data required for scientific analysis is largely absent (Tiruneh 2013). The discussion here of water management, agricultural productivity and socio-economic benefits is primarily qualitative, drawing on evidence from different schemes. Performance is also analysed in terms of potential trade-offs between objectives, who is benefitting and in what ways.

Over 70 percent of communal and private irrigation schemes and nearly all large-scale public schemes (over 3,000ha) in the Awash Basin are surface systems (Tiruneh 2013; Table 7). Surface systems tend to be associated with high water losses from the network, for example through seepage and evaporation, and low water productivity, although performance will vary temporally and spatially, within and between schemes.[11] Some efforts are being made to modernise irrigation systems in public and private schemes. The new outgrowing areas at Wonji are pressurised sprinkler systems rather than surface systems. Mangers of the private Merti-Jeju farm are also planning to introduce sprinklers, whilst Genesis farm uses drip irrigation. One barrier to uptake of new technologies is the expense of buying and maintaining equipment, which is often not available locally (key informant). But perhaps the first step to improve water management is to incentivise better monitoring by farmers. Most interviewees did not know how much water they used.

Table 7: Estimated efficiencies[12] of irrigation systems in the Awash

Method of water abstraction	Irrigation system	Proportion (%)	Efficiency (%)
Community and private irrigation schemes			
Pump	Modern surface	18.8	50
Pump	Traditional surface	7.7	45
Diversion	Modern surface	29.9	40
Diversion	Traditional surface	35.9	37.5
Water harvesting	Sprinkler	0.0004	70
	Drip system	0.036	80
	Surface	7.5	65
Weighted average			**43.3**
Large-scale irrigation schemes			
Amibara (river diversion)	Surface		40
Metahara	Surface (hydroflume)		65
Wonji (pump)	Surface		45
Wonji (pump)	Sprinkler		70
Nura Era (pump)	Surface		40

Source: Tiruneh (2013: 31)

Technology is by no means the only factor determining scheme performance. Losses from the irrigation network are often associated with poor design, construction and maintenance of infrastructure (Berhe et al. 2013). At Wonji the siltation of reservoirs and canals due to catchment erosion over the last sixty years hinders water conveyance and reduces storage capacity (key informant). Rehabilitation would require a halt to production, which may not be feasible given the pressures to meet national demand for sugar and begin exporting. Other common problems include limited land levelling, leading to uneven water distribution on fields; lack of proper irrigation schedules, or adherence to these; and lack of equipment to measure or monitor water use (Berhe et al. 2013; Bekele et al. 2003). There are also differences among irrigators in terms of incentives to improve water management. For example, an agronomist at Wonji claimed that more water per day per hectare is applied to outgrowing areas compared to the land owned by the estate, overwatering being a result of payment arrangements for daily labourers and a lack of monitoring.

Water scarcity is likely to be a factor depressing yields in some areas of the Awash. According to key informants at Wonji and Merti-Jeju, these schemes experience shortages during the dry season when river flow is low. Increasing irrigation shortfalls in the basin are predicted with future expansions at Wonji and other new developments (Berhe et al. 2013). On the other hand, irrigation schemes, both large and small, are vulnerable to flooding during the rainy season which damages crops and infrastructure (key informants). Salinisation and waterlogging are also significant problems in parts of the middle and lower basin due to poor drainage and water management

practices (Tadesse et al. undated). The state-owned cotton farm in Amibara was losing 200-300ha of cultivated area annually from 1980-1990 due to salinisation (Behnke and Kerven 2013). Poor water quality due to human, industrial and agricultural pollutants, may pose a health risk in vegetable production, although the impacts have been little researched in Ethiopia.

Other reported challenges to production, particularly for smallholders, include pests and diseases; insufficient capital and lack of technological inputs; and weak management, inequitable water use and conflicts (Bekele et al. 2003; key informants). Farmers at Fentale and Melkayida cultivating plots also reported labour shortages. At Fentale some farmers are forming labour sharing arrangements whilst at Melkayida farmers hire daily labourers (key informants). For systems relying on pumping to abstract or convey water, the interruption of electricity supplies is an obvious drawback. Water stealing can also be a problem, including for commercial farms such as Merti-Jeju, and formal sanctions are difficult to enforce due to costs of policing abstractions. Finally, smallholders in peri-urban areas are at risk as agricultural land is converted to housing and industry.

Box 6: Crop yields at Wonji

Wonji is thought to produce around 150t/ha on average (Yirefu et al. 2007, citing Aregaw 2000), which is comparable to Metahara sugar estate where yields were around 156t/ha in 2000, having since risen (Behnke and Kerven 2013). However, the agronomist interviewed at Wonji reported variations in yields within the scheme. He claimed that production was higher under the sprinkler system as compared to the surface irrigation system, but cautioned against making simplistic comparisons based on technology alone. The latter area has been under cultivation for 60 years and consequently suffers from the cumulative effects of over-irrigation, compaction due to machinery, nutrient decrease and infrastructural decay. Interestingly, the outgrowers thought that yields had increased due to improved inputs, particularly new seed varieties. Technology upgrades at the factory have to some extent counter-balanced declines in yields in terms of economic return per hectare, according to the agronomist.

One of the main reasons why irrigation coverage is expanding in the Awash is that, despite the challenges noted above, irrigated agriculture is clearly profitable. In particular, domestic demand for vegetables has risen rapidly over the last few years due to population growth, increasing affluence and dietary changes. The upper-middle Awash basin is also relatively well connected to Addis and other nearby urban centres. A study by Bekele et al. (2003) shows average yearly net incomes of over 8,000 Birr (US$400)[13] per hectare for farmers on traditional schemes in the Akaki tributary, which is a considerable income as compared to ordinary Ethiopian farmers. Farmers interviewed at Fentale and Melkayida reported profits of 120,000 Birr (US$6,000) and 135,000 Birr (US$6,750) per hectare per year, respectively, in addition to nutritional benefits. Meanwhile, average income for households farming and working as labourers at Wonji is about 11,000 Birr (US$544) per year, representing 39 percent of average household income (Amrouk et al. 2013). Note, however, that the cost of water is not adequately accounted for in these figures, as most farmers are not currently paying charges to the Awash Basin Authority.

Decisions regarding the use of land and water resources often involve a level of risk as well as opportunity costs. Some of the farmers interviewed at Wonji in the old outgrowing area felt that sugar cane had only just become profitable for them, after years of debt, and turning their land to vegetable production would be far more lucrative. However, their land has remained under communal ownership and production since the *Derg,* therefore restricting individual decision-making and risk-taking. Amrouk et al. (2013) suggest that farmers are reluctant to leave the factory as fixed prices for sugar provide a degree of stability while revenues from other crops are more vulnerable to price shocks and manipulation by traders.

Irrigation developments are also likely to involve trade-offs between different objectives and benefits for different groups, which can be highly contentious. For example, conversion of pastoral grazing areas into irrigated cotton or sugar plantations has been a longstanding source of conflict in the Awash as pastoral livelihoods have been negatively affected by the loss of access to precious land and water resources (Behnke and Kerven 2013; Tiruneh 2013). Yet research by Behnke and Kerven (2013) indicates that pastoralism may in fact be a more economically productive use of land than, in this particular study, cotton farming. Increasing private investments in new irrigation developments need to be accompanied by stronger laws to protect local communities including safeguards for downstream water users (Bossio et al. 2012; Tamrat 2010).

3.6 Conclusions

In Ethiopia irrigation coverage has remained relatively low and the sector has generally occupied a marginal place in agricultural policy over the last forty years. Although ambitious new policies aim to accelerate expansion, particularly through private sector investment, a number of bottlenecks remain. Prioritisation of medium-large scale irrigation has persisted, despite significant challenges in developing and maintaining such schemes. Institutional fragmentation is a significant constraint to effective management of, and investment in, land

and water. In the irrigation sector technical problems are frequently underestimated and socio-economic dimensions neglected, manifested in disappointing performance such as low productivity, mismanagement and poor returns on investment. Meanwhile successful farmer initiatives are generally overlooked by the government, representing missed opportunities for learning and innovation.

Table 8: Factors influencing irrigation performance in the Awash River Basin

		Barriers	Enabling Factors
External	**Donors/ IFIs**	The withdrawal of external support for large scale infrastructure development (from the 1970s) contributed to declining public investments in irrigation; donors remain reluctant to support large projects such as Fentale	Since the 1960s donors have supported river basin surveys and other important studies (including in the Awash) which provide a basis for the government to plan irrigation and other water-related developments
	World markets	Fluctuating world prices can pose a significant risk for those farms reliant on exporting primary agriculture products (e.g. sugar); trade restrictions and high standards (e.g. European markets) are also a challenge	Some farms are exporting high-value goods to specialised markets, e.g. the floriculture industry; others have the infrastructure for agro-processing (e.g. Merti farm, Wonji sugar factory) targeting both local and international markets
	Climate and environment	Periodic droughts and floods pose a challenge, but are often not adequately factored into scheme design/ management resulting in water shortages or damage to crops/infrastructure; environmental degradation negatively impacts on scheme performance, e.g. siltation of reservoirs at Wonji due to catchment erosion	Irrigation could be a means to better mitigate the risks associated with climatic variability and change in some areas; the switch from rainfed agriculture to irrigation has allowed for year-round cultivation in certain parts of the Awash Basin; irrigation could be a means to expand production in marginal areas and relieve pressure on forests
National level	**Agricultural policy (and ideology)**	Irrigation has tended to play a fairly marginal role in agricultural policy; socialist models of production (1970s-1980s) performed poorly and regime change (coupled with structural adjustment measures) initially led to the collapse of many irrigation schemes in the early 1990s	Increasing emphasis on commercialisation coupled with tax (and other) incentives has enabled the private sector to re-enter the irrigation sector (under the EPRDF); irrigation is also promoted as a means to tackle food insecurity and provide incomes for smallholders
	Land rights (linked to water rights)	Successive land redistributions have led to fragmentation of holdings and insecurity of tenure, stifling innovation and investment by smallholders; unclear land policies, and disconnects between land and water regulations, may also deter private investments	Previous land reforms and the current land registration process are intended to strengthen the rights of poor smallholders to land; cheap land rates attract local and foreign investors in irrigation (although there are concerns over land acquisition)
	Institutions	Institutional fragmentation at national/regional level for land and water resources development; poor horizontal and vertical coordination; lack of staff/expertise and conflicting objectives; expensive and underperforming irrigation investments; lack of data also hinders effective planning	New institutions for irrigation development (e.g. Oromia Irrigation Department) signify an increase in government interest in the sub-sector and potential for increased allocation of resources; river basin authorities are mandated to coordinate Integrated Water Resources Management, including in the Awash
Sub-national / basin level	**Demand for water**	Uncoordinated developments and growing demand for water in the Awash Basin leading to increasing water scarcity, declining quality and shortages of surface water for irrigation, particularly in the dry season; upstream developments (e.g. Fentale, Wonji expansion) pose a risk to downstream irrigators (e.g. Merti farm)	Some farmers in the Awash are beginning to make use of groundwater for irrigation (e.g. Genesis farm) although this resource is also used for domestic and industrial purposes and may become more scarce in future
	Regulation	Weak capacity of the Awash Basin Authority to monitor and regulate water withdrawals and collect fees contributes to lack of coordination of developments and poor water management practices	Lack of regulation has perhaps enabled growth of the informal irrigation sector by entrepreneurial smallholder farmers
	Urban growth and markets	Expansion of urban and industrial areas prioritised over agricultural use of land – schemes such as Genesis Farm and Melkayida risk losing valuable irrigable land (and compensation is often inadequate)	Famers in the Awash benefit from their proximity to urban centres and transport networks (including for export); growing urban populations and lifestyle changes have resulted in increased demand for, e.g., vegetables, fruit, sugar (and related processed goods) and garden plants
Scheme / local level	**Technology**	Most irrigation schemes are surface water systems with low water productivity and high non-consumption due to seepage and evapo-transpiration; alternative technologies may be unaffordable for many smallholders and difficult to maintain	Availability of alternative technologies appears to have improved (with local suppliers and less 'red tape' on imports) – modern technologies have been introduced on some schemes, e.g. sprinklers at Wonji, drip irrigation at Genesis farm
	Finance and technical capacity	Lack of adequate finance and technical capacity is often a key challenge in operating and maintaining scheme effectively – this particularly applies to state farms such as Wonji as well as schemes managed by WUAs	Some schemes have benefitted from inherited infrastructure, machinery and/or technical know-how, e.g. Wonji was initially built by private investors before becoming a state farm; the current WUA at Melkayida has benefitted from skills and machinery passed on from the Derg period
	Social benefits	Displacement of local pastoral communities for irrigation developments (a source of conflict since the 1960s); potential negative impacts of more recent land acquisitions	Irrigation has become very profitable in the Awash for smallholders; larger schemes such as Wonji and Fentale seek to provide direct benefits to local communities in different ways

Drawing together findings from the national level analysis and Awash River Basin case study, it is possible to identify drivers operating at different scales that have impacted on the development and performance of irrigation schemes (Table 8). The Awash case mirrors the national story to an extent, but also remains an important exception in several respects. Unlike many other parts of the country, this area has been a focus for irrigation investments since the 1950s, benefiting from infrastructural linkages and access to urban markets.

The Awash is an interesting case because it reveals a number of emerging issues of pertinence to future irrigation policy in Ethiopia. Firstly, water scarcity and water quality are increasing concerns as demand from agricultural, industrial and domestic sectors grows. Although water scarcity has been a driver of national irrigation policies in the past, these have largely been centred on supply-side interventions (expanding irrigation to achieve food security). Demand-side policies and regulations do exist (e.g. rules for water allocation, user fees, pollution control) but are often not enforced effectively by the relevant institutions due to a lack of human and financial resources and political clout. Moreover, new irrigation developments need to be better coordinated and take proper account of existing water users. In addition to strengthening regulatory bodies, more could be done to incentivise farmers to monitor their water withdrawals and improve water management.

A second issue that requires attention from policymakers is the rise in groundwater abstractions for agricultural use, partly driven by the availability and affordability of cheap pumps. Fortunately the government is aware of this trend and has recently published a framework for development of groundwater resources. In the Awash groundwater abstractors include licensed private farms (including for floriculture) and informal irrigators. Few farms currently pay for the groundwater they abstract and the latter category of users are particularly difficult to monitor, whether using surface or groundwater. Nevertheless, the expansion of the informal irrigation sector is another trend that cannot simply be ignored by policymakers. In addition to posing a regulatory challenge, there may be opportunities to further support smallholders to raise productivity and incomes.

Finally, the push for private sector participation in agriculture raises important questions regarding land rights and who benefits from irrigation developments. The lack of clarity in implementation of land laws and policies, coupled with power imbalances, mean that local communities may lose out. Pastoral groups are particularly at risk in this regard, and in the past have lost access to valuable land and water resources to large irrigation developments. This issue is not unique to Ethiopia and private land acquisitions have been the subject of much debate in the wider literature.

4 Morocco

4.1 Introduction

Against a background of rapid urbanisation and successful programmes of economic diversification, agriculture remains a pillar of Morocco's society and economy. Less than five percent of agricultural land in Morocco is equipped for irrigation, but irrigation has been a significant area of investment and support from the state since the colonial era. Among other factors, irrigation policy and practice have been shaped by increased drought; increasing water scarcity and demand from other water uses; the needs of commercial versus subsistence agriculture; and changing public policy paradigms around the role and size of the state. These different drivers have resulted in some tensions in irrigation policy and practice between different scales.

Agriculture employs 40 percent of Morocco's workforce and accounts for approximately 15 percent of GDP on average (World Bank 2014c). In rural areas agriculture is the primary economic activity, providing livelihoods for up to 80 percent of the population (Van Cauwenbergh and Idllalene 2012). With a national agricultural strategy aimed at maximising the benefits of commercial agriculture, Morocco is now a leading supplier of early season vegetable and fruit crops to Europe and North America (Ibid).

The role of irrigation in Moroccan agriculture needs to be contextualised in terms of the climate and prevailing water scarcity. Morocco's climate is predominantly semi-arid, with uneven precipitation that ranges along the coast from 1,800mm per year in the north to less than 200mm per year in the south, with desert conditions inland. Most precipitation falls between October and April, and water supply is lowest when demand is highest during the hot summer months. The National Water Strategy has estimated that although long term average surface flows are 18bn m^3 per year, in practice annual flows range between 4 and 40bn m^3 (Departement de l'Environnement 2009). Annual renewable water resources per capita were estimated at 730m^3 in 2009 (Ibid). By 2025, it is estimated that 35 percent of the population will have less than 500m^3 per capita per year (Ouassou et al. 2007, citing Bzioui 2000). With high water scarcity and low supply, the Government of Morocco has long promoted a strategy of 'not one drop to the sea' (World Bank 1995).

Traditional rural livelihoods were predominantly based on agro-pastoralism and rainfed agriculture, although in some places traditional irrigation, including spate, *qanat* and *seguia* systems, existed from pre-colonial times. The French and Spanish colonial regimes invested in agricultural modernisation and irrigation, notably with projects in Sidi Slimane (52,000ha), Beni Moussa

(52,000ha) and Souss Massa (37,200ha). In 1954, shortly before independence, it was estimated that 355,800ha of Morocco's agricultural lands were under irrigation, around one-third of which was watered perennially (Houston 1954). By 2011 the area equipped for irrigation had grown to around 1,458,000ha by 2011 (FAO 2014a).

Reasons for increasing the area under irrigation have changed over time, and have included reducing rural poverty, increasing food supply, strengthening drought resilience and enhancing agricultural value. Over the years, different technologies and forms of organisation have emerged, with the government increasingly favouring pressurised drip irrigation systems over surface irrigation, and community and private sector schemes over centralised state schemes. Irrigation policy, and water and agricultural policies in general, are at a crucial juncture for Morocco as it attempts the transition to middle income status in conditions of increasing water scarcity and uncertainty. As in other parts of the world, increasing availability of cheap, small pumps and subsidised fuel have led to rapid depletion of aquifers (Faysse et al. 2012). Fragmentation of land and weak regimes of land tenure undermine attempts to achieve economies of scale in agriculture, inhibit organisation of irrigation and exacerbate poverty.

4.2 The evolution of irrigation policy and institutions in Morocco

There are three primary sources of water management institutions in Morocco: customary *(urfi)* arrangements, some of which have pre-Islamic roots; Islamic law *(Sharia)*; and the modern legislation from the French and Spanish protectorates and post-independence state. Prior to the colonial period, water and land institutions were diverse and localised, allowing water to be managed according to local environmental conditions. Typically these customary arrangements involved collective and communal forms of ownership, responsibilities for maintenance, and enforcement of rights (Keith and Ouattar 2004). At the time when *Sharia* was established in Morocco, the dominant interpretation of Islamic law forbade private ownership of water. According to Doukkali (2005), however, Islamic jurists compromised on this principal so that the native population would accept the new government's central power. The government instead set out moral principles for water management, but did little to enforce them. Many customary arrangements continue to operate in traditional spate and surface (gravity) irrigation networks.

The government of the French protectorate issued decrees in 1914 and 1919 placing all surface and sub-surface waters in the public domain, justifying this as being in accordance with Islamic law. Legislation in 1925 defined conditions for using irrigation water, and required revocable permits for withdrawals over 40m3 per day. The protectorate also permitted WUAs to develop private irrigation networks. As described by Doukkali (2005), this resulted in water rights being split between full property rights enjoyed by specific farms and irrigation schemes, and customary rights, either registered or unregistered. The development of irrigation and modernisation of agriculture became a key policy of the French, and to a lesser extent Spanish, colonial powers. Justifications included both improving the productivity of the modern farms of European settlers, and also for modernising and developing the countryside. Starting in the 1930s, but especially in the 1940s and 1950s, eight great barrage dams and ten diversionary dams were constructed for new irrigation schemes. Beginning in the 1920s there were also attempts to modernise traditional systems, and after 1938 the French increasingly used concrete to replace earth canals and wells (Houston 1954).

Upon independence the government kept the legal framework established by the protectorate, but developed more ambitious plans for water mobilisation and development of irrigation. The *Programme National d'Irrigation*, for example, established by Royal Decree in 1967, established the goal of irrigating a million hectares by 2000, and was later revised to 1.2m ha by 2010. Programmes of dam construction and large-scale centralised irrigation were developed to stimulate rural development and modernise agriculture. They also strengthened the strong social contract between a diverse people and the new state, which garnered loyalty through providing social welfare in the form of jobs, healthcare, education, subsidised food and utilities (El-Said and Harrigan 2014). In terms of irrigation, this led to further bureaucratisation of water. The 1969 *Code d'Investissement Agricole* (Agricultural Investment Code) became the primary legal instrument defining the government's role in mobilising, managing, allocating and collecting charges for irrigation waters, and also fixing cropping patterns, providing inputs, and guaranteeing the prices of certain crops (Doukkali 2005; Kadi 2002; Kuper et al. 2009b). The *Office de Mise en Valeur Agricole* (Office of Agricultural Development), or simply *l'Office*, became the ubiquitous government agency overseeing irrigation schemes.

This expansion of the government's role in development and the sheer size of the bureaucracy eventually contributed to the fiscal challenges which resulted in the 1983 World Bank structural adjustment programme. This included specific measures to reform the organisation and management of irrigation as part of a wider context of agricultural policy and fiscal reform, and had a significant impact on the established mode of integrated rural development (Van Vuren et al. 2004). The *Programme National d'Irrigation* was relaunched in 1993, reframed by structural adjustment and the global debate on transfer of irrigation schemes, emphasising increasing participation by water users in management (Kuper et al. 2009b; World Bank 1995). The complementary 1995 Water Law established eight sub-national *Agences de Bassin Hydraulique* (River Basin Agencies) responsible for integrated water resources planning across sectors (Keith and Ouattar 2004).

Recent years have seen key policy developments for agriculture and water. The National Water Strategy emphasises demand side management alongside mobilisation of resources, and lays plans to convert up to 800,000ha of traditionally irrigated lands to drip irrigation (Departement de l'Environnement 2009). Related initiatives include the *Programme National d'Economie d'Eau en Irrigation* (National Irrigation Water Saving Programme), continued efforts to transfer and reform irrigation management and a national groundwater action plan (El Haouari and van Steenbergen 2011; Kuper et al. 2009b). In agricultural policy, the *Plan Maroc Vert* (Green Morocco Plan), developed by the consulting firm McKinsey, shifts focus towards the role of the private sector. It aims to attract investments of 10bn Dirham (US$1.1bn)[14] per year, generate a million small companies and double agricultural production by 2020, largely by focusing on high value commercial crops for export and using private sector actors as 'aggregators' for small-scale farmers (Van Cauwenbergh and Idllalene 2012). The *Plan Maroc Vert* frames irrigation both in terms of drought resilience and for the production of value-added, water intensive crops, and increases the subsidy for drip irrigation to 80 percent (100 percent for farmers on less than 5ha of land). The Green Morocco Plan's decisive move away from agricultural policy that supports integrated rural development and towards a commercial programme is criticised by sceptics as ignoring the realities of Morocco's rural sector (Akesbi 2012).

The institutional and policy frameworks for water and agriculture in Morocco are complex. Considerable challenges remain in terms of centralisation of power; fragmentation of roles and responsibilities; and poor coordination (Keith and Ouattar 2004). Drought, for example, is increasingly recognised as a structural feature of the environment rather than an aberration, but integrating drought resilience into water management institutions remains a challenge (Ouassou et al. 2007). Current questions over the relative roles, responsibilities and rights of the state and farmers are in many ways continuations of the debates of the colonial period and the initial arrival of Islamic law in Morocco. As one key informant in Rabat reflected, if they are to be successful, central policy directives for irrigation always require adaptation to local social, environmental and institutional contexts, all of which have a rich and diverse history.

4.3 Drivers of policy change in Morocco

The literature identifies four key drivers of change with respect to irrigation policy in Morocco: increasing environmental constraints; the impacts of drought; macro-economic problems in the 1980s; and the opportunities afforded by global trade.

Impacts of drought

Drought has been a historical challenge for Moroccan agriculture. Up to 1.5m Berbers experienced famine resulting from drought in 1935/36, and only the rapid import of food prevented starvation of a million peasants in 1945 (Houston 1954). Although recent droughts have not resulted in widespread famine, they continue to have serious economic impacts at and national and household levels. In recent decades the intensity, persistence and frequency of droughts has increased to a level unprecedented in the last 500 years: 11 of the 22 drought years Morocco experienced in the twentieth century occurred in its last two decades, including a series of drought years between 1980 and 1985 (Touchan et al. 2008; Chbouki et al. 1995). In 1982, for example, Morocco received just 60 percent of the long term average precipitation, and the relatively low use of irrigation meant that agriculture was very sensitive to these impacts (Doukkali 2005). Morocco's social welfare programme was biased towards urban areas and elites, while rural areas did not have extensive rural services or markets, and ad hoc safety nets and drought response programmes failed to address the needs of the poor when impacted by shocks (El-Said and Harrigan 2014; Van de Walle 2004). The government's strategic responses to these impacts were to embark on a series of reforms around drought risk reduction and monitoring, and to increase resilience in water resources planning. This notably included the 1986 declaration to build one dam per year to enhance water storage, as well as other supply side policies such as inter-basin transfers (Keith and Ouattar 2004; Bazza 2002). The immediate effect, however, was for the government to liberalise private irrigation, and for farmers to sink both legal and illegal tubewells, encouraged by subsidised energy prices (Doukkali 2005).

Environmental constraints

Increased exploitation of groundwater has been driven not just by drought, but also by increasing water scarcity. The mobilisation of surface water contributed to the growth and resilience of Morocco's economy. However, limited options for further mobilisation, increased demographic and socio-economic water demand and the potential impacts of climate change have all increased concerns regarding water scarcity. In the Saiss Basin, for example, annual average precipitation has fallen 33 percent over the last 30 years while the number of private wells has grown from less than a dozen to over 9,000 (Kalpakian et al. 2014). The growth of Morocco's population, now more than 33m people, has seen average annual per capital renewable water resources fall from almost 1,900m^3 in 1960 to 660m^3 in 2014, with population projections implying declines to 535m^3 per capita per year by 2050 (Haut-Commissariat au Plan undated). Increased awareness of water scarcity and the need to reduce the consumption of water by the agriculture sector has been a key driver of demand

side policies, particularly those aimed at increasing water productivity and reducing losses from the conveyance network. This has manifested in policies and programmes supporting modernisation of irrigation, particularly encouraging and subsidising drip irrigation (Faysse et al. 2012; Doukkali 2005).

Macro-economic problems

The droughts of the early 1980s coincided with a collapse in the price of Morocco's key export, phosphate. The sudden decline in earnings led to a macro-economic crisis, and in 1983 Morocco became the first North African country to agree to a structural adjustment programme with the World Bank and IMF (El-Said and Harrigan 2014). Government expenditure fell by 50 percent between 1983 and 1986, with particularly severe impacts in rural areas where public investment in infrastructure and agricultural support underpinned the whole economy (El-Said and Harrigan 2014). By the mid-1980s cost benefit analyses of large scale irrigation projects around the world had revealed large inefficiencies, and the mood of donors was turning to small scale community-owned and private schemes (Turral 1995). Irrigation policy in Morocco consequently turned to transferring management to WUAs and greater community engagement, a programme which had mixed results (Kuper et al. 2009b).

Global trade opportunities

Structural adjustment also ushered in a period of rapid reforms in economic liberalisation and increasingly market-oriented policies (El-Said and Harrigan 2014). A reduction in investment and trade barriers, and increasing incentives for exports, opened opportunities for Morocco to supply early harvest products to European markets. Investors, including foreign investors, were quick to exploit these opportunities, and benefitted from lower labour, energy and water costs (Van Cauwenbergh and Idllalene 2012). The rapid expansion of commercial production, particularly in the Sebou and Souss Massa basins, has been a key driver for unsustainable groundwater extraction (Faysse et al. 2012). In the Lamzoudia District of Tensift, for example, aquifers have fallen over four metres a year as commercial farmers, purchasing land from destitute agro-pastoralists, have converted land to water intensive horticulture (Chriyaa pers. comm. 2014). This has contributed to broader problems of water scarcity and encouraged the government to look for alternative sources of irrigation water for high value crops, such as desalination.

4.4 Implications for irrigation practice and sector performance

Irrigation has become much more prevalent in Morocco over the last half century. In 1954 Houston estimated that the irrigated schemes totalled 355,800ha. By 2011 the total area equipped for irrigation had reached 1,458,000ha, although the area actually irrigated each year varied between 1,224,000ha and 1,387,000ha between 2004 and 2011 (FAO 2014a).

In terms of technology, there has been a continued programme of modernisation, beginning with the replacement of earth canals with concrete in the 1930s. Modern pressurised systems are now favoured over gravity systems; spate and surface irrigation infrastructure is gradually being replaced by drip irrigation. Spate irrigation declined from 165,000ha in 1989 to 26,000ha in 2004 (FAO 2014b). Meanwhile, drip irrigation has increased from 4,000ha in 1989 to 142,000ha by 2009, and ambitious plans to implement a further 800,000ha, mainly converted from traditional irrigation schemes (FAO 2014b; Departement de l'Environnement 2009; Kuper et al. 2009b). The growth in drip irrigation technology has been facilitated by non-technical factors including the availability and price of energy; subsidies; and land tenure and permitting systems (Kuper et al. 2009a). The government has attempted to reduce both financial and administrative barriers to accessing drip irrigation technology by small, poor farmers.

Prior to the colonial period irrigation schemes – either spate or gravity fed from springs – were primarily instituted at the level of tribes and communities, and managed in accordance with customary rules. The colonial and post-independence periods both concentrated on large irrigation schemes in which farmers were expected to comply with technocratic management regimes. Since the 1980s the government has attempted to transfer management to WUAs and community schemes, and has also tried to manage the explosion of private irrigation. The former have been mostly disappointing. Although initial plans in 1990 were to create 3,442 WUAs, of which 2,900 were to be in small and medium [15] schemes, by 2001 only 1,045 had been established, with just 600 in small and medium schemes (Doukkali 2005). Even in places where WUAs are active, the government remains heavily engaged in operations, maintenance and cost recovery (Kuper et al. 2009b).

Far more successful in organisational terms has been private irrigation, which grew from between 60,000 and 170,000ha in 1991, to 583,000ha in 2003, with 481,000ha irrigated either entirely or partially from groundwater (Doukkali 2005). However, while the investment efficiency of private irrigation has been high, its reliance on groundwater has caused unsustainable groundwater exploitation. Doukkali (2005) estimated that the decline of aquifers due to groundwater over-extraction has contributed to the abandonment of 150,000 to 200,000ha of formerly irrigated land. Moreover, although on paper a progression from traditional to central to community to private irrigation might appear linear, in practice it

has been mixed, and with chequered results (Kadiri et al. 2009; Kuper et al. 2009a).

Sources of investment and funding have also changed along with forms of organisation. In some areas equipped for traditional *seguia* and spate irrigation customary institutions still mobilise contributions towards operation and maintenance costs. The role of the central government, which for much of the last century eclipsed other sources of funding, has declined since the 1980s, although it remains the principal actor in large scale irrigation projects. The government still plays an important role in irrigation finance, such as through financing dam construction and subsidising the adoption of drip irrigation. However, the role of individual farmers and companies in investment has certainly increased in recent decades, with WUAs engaged in management and private expansion of groundwater irrigation. The increased role of the private sector is exemplified by the new public-private partnership (PPP) for irrigation in Guerdane, in the Souss Massa Basin.

4.5 Case study: Souss Massa Basin

The Souss Massa Basin, inland of Agadir in southern Morocco (Map 3), has a year round growing season. It covers an area of 28,000km2, of which approximately

Map 3: The irrigation areas of Morocco, including Souss Massa

MAROC

FAO - AQUASTAT, 2015

Source: FAO (2015)

250,000ha is suitable for irrigation (Dolcine et al. 2010). It is one of Morocco's most important agricultural areas, significant for commercial production since the colonial period. Exports have accelerated since the liberalisation programmes of the 1980s, and the area now produces 65 percent of national orange exports and 98 percent of tomato exports (Chati 2012). During this period demand for irrigation water has also increased from tourism on the coast and urban population growth, particularly in Agadir. This case study focusses on three irrigation schemes in the Souss Massa – the modern and traditional systems at Issen, and the public-private irrigation scheme in Guerdane – and explores their significance in this water scarce context.

Background

The long term average rainfall in the Souss Massa is around 220mm per year, although since the 1970s this has declined 20 percent while variability has increased (Agence du Bassin Hydraulique du Souss Massa 2005; key informants). Eight dams, with a total capacity of 764m m^3, regularise flows and provide a buffer against drought, and the Souss and Chtouka large aquifers have an additional storage capacity of 468m m^3 (Agence du Bassin Hydraulique du Souss Massa 2007; Dolcine et al. 2010). Total water use in the basin is approximately 1,100m m^3 per year, up to 95 percent of which is consumed by agriculture, and 71 percent of which is supplied from groundwater in both public schemes and private tubewells (Tagma et al. 2009a; Agence du Bassin Hydraulique du Souss Massa 2007).

With limited options for increasing supply, the basin is effectively closed and under increasing water stress. The Souss aquifer currently has a deficit of 360m m^3 per year: groundwater levels have fallen at rates of up to 2m per year, and in some places wells are now at depths of 200m by comparison to depths of 25m in the 1960s (Van Cauwenbergh and Idllalene 2012; Houdret 2008). The critical groundwater situation is viewed as a strategic issue by the government, not least because of the region's importance to national agricultural exports. It has responded with a range of efforts to conserve water resources and stabilise the aquifer, including the promotion of drip irrigation, the development of a social contract between large groundwater users and investigation of desalination potential to balance coastal aquifers and supply commercial farms (Faysse et al. 2012; key informants).

In 2002 the 105,000ha of irrigated land in Souss-Massa included 28,000ha of citrus, 17,700ha of horticulture, 18,200ha of cereals, 17,800ha of olives, 10,400ha of fodder and feed crops and 2,360ha of bananas, with citrus accounting for around 40 percent of total irrigation demand (Baround 2002). Traditional production of olives, barley and almonds continues in rainfed farms, and in the watershed's uplands, forests of argan trees facilitate agro-pastoralist livelihoods and provide ecosystem services by retaining precipitation and reducing soil erosion. The majority of farms (estimated at 75-90 percent by key informants) in the Souss Massa are less than 5ha in size. However, particularly in coastal areas of Souss Mass, farm size is not necessarily the indicator of poverty that it is elsewhere in Morocco, with some small farms producing 450t of tomatoes per year for export under plastic greenhouses (key informant).

History of irrigation in the Souss Massa

Irrigation has a long history in the Souss Massa, with both traditional systems and agricultural modernisation since the start of the colonial period. By 1950 around 15,000ha of the area had been irrigated, and the colonial government had plans to increase this to 20,000ha (Houston 1954). Of this area, 13,000ha was irrigated using traditional techniques: 10,750ha was under spate irrigation, the remainder using groundwater. Technologies included animal-powered lift irrigation *(neora)* and gravity irrigation in canals *(seguia*) and *qanats (rhettara)* to tap groundwater (Popp 1986). During the colonial period, large harvests in citrus, potatoes and bananas of early French settlers led to a rush of agricultural investment. Considerable areas were cleared of traditional crops (notably olives), equipped for irrigation and planted with citrus. Citrus production in Souss increased from 100ha in 1940 to 2,200ha in 1950, and reached 5,300ha in 1955 (Popp 1986). The trend continued after independence, reaching 28,000ha in 2002 (Baround 2002).

This development of agriculture and the expansion of irrigation was accompanied by rapid increases in groundwater abstractions, which rose from an estimated 8m m^3 per year in the 1940s to 22.6m m^3 in 1956, and reached 124m m^3 in 1969 (Agence du Bassin Hydraulique du Souss Massa 2007). Groundwater abstraction occurred both through centralised schemes under state control, such as the 6,300ha irrigated near Oued Teima by 1962, and through private abstraction, for example the 23,800ha irrigated near Taroudant by 1975 (Popp 1986). This contrasts with most other areas in Morocco, where private groundwater abstraction did not become a phenomenon until after the 1980s.

In addition to the expansion of groundwater abstraction, the government also invested in eight dams between 1972 and 2004 to mobilise surface waters for irrigation, drinking water and the recharge of aquifers. Early dams often provided supply to existing canal networks for surface irrigation. Increasingly, however, scheme design was modernised. First sprinklers, and then drip irrigation, became the standard. There have also been efforts to convert, or encourage conversion of, traditional to modern systems. As a result, there is considerable diversity in the irrigation systems and schemes in the Souss Massa. One estimate is that 54 percent of the irrigated area remains gravity based, while 15 percent is sprinkler and 31 percent is drip irrigated (Tagma et al. 2009b).

The Issen irrigation area is subdivided into traditional and modern sections, developed simultaneously. A complex of two dams, the larger Abdelmoumen and the smaller Dkhila, were finished in 1981 and 1986 respectively with a total storage capacity of 215m m^3 to provide 80m m^3 each year for irrigation. A key driver for this development was a water shortage jeopardising 2,700ha of citrus plantations resulting from over-pumping of the aquifer (Popp 1986). As the scheme relied on damming a key source used for traditional *seguia* irrigation, the scheme also channelled water from the dam to the existing *seguia* network. These two areas became the Issen Modern and Issen Traditional sections. Approximately 80 percent of the farms in this area are smaller than 5ha, although a relatively high proportion (60 percent) is private property *(melk)* (Chati 2012).

In the Issen Modern area, 8,560ha receive pressurised water supply in pipes via an on-demand system. Prior to the scheme, this area had been rainfed, although a significant area used groundwater for private irrigation of citrus. Supply from the irrigation scheme encouraged further conversion from olive and cereal production to emphasis on horticulture crops using sprinkler and drip irrigation. The irrigation scheme is managed by the *Office Regional de Mise en Valeur Agricole* (ORMVA): water is metered at each delivery point, and the farmer receives quarterly bills. Water is priced at 0.9 Dirham (US$0.1) per m^3, including a tax of 0.2 Dirham per m^3 which goes to the *Agence de Bassin* for maintaining the dam complex.

In the Issen Traditional section water is distributed in a canal network originally used for spate irrigation and *seguia* irrigation from a spring. A total of 867 farms and 4,440ha are serviced. Between 2005 and 2010 the government encouraged the formation of 12 WUAs called *Association des Usagers des Eaux d'Agricole* to manage the canal network. Some WUAs are engaged in managing multiple canals, and several canals have more than one WUA (ORMVA 2013). In addition to the WUAs are customary institutions for monitoring and control of the waters, based on groupings of settlements called *kabila*. Each has an elected individual, the *amazal,* who maintains a communally agreed irrigation schedule, and controls water flow into the canals for the specified length of time for each farmer on the schedule. The *amazal* is now generally an elected official representing the WUA to ORMVA. However, despite the apparent popularity and persistence of customary *kabila* institutions, just 36 percent of farmers on the canals have joined a WUA (ORMVA 2013). According to key informants, the most common barriers and objections to the WUA include the constraints and conditions imposed by the laws for civil associations, which require payment of membership fees and adherence to regulations for management and governance.

Based on the hours each farmer receives through the schedule, ORMVA issues a bill which charges 0.3 Dirham (US$0.03) per m^3. The farmer also pays towards the cost of a community guard, usually 2.5 Dirham (US$0.27) per hour, who is responsible for ensuring that no-one else uses water during the rotation. Typical schedules have farmers on a rotation every ten days, which has implications for the types of crops grown – usually olive trees due to their ability to last long periods without irrigation. Although subsidies for conversion to drip irrigation are available, rates of adoption are low and the majority of farmers in the Issen Traditional section continue to use surface irrigation. Most areas in the network use supplementary irrigation from groundwater for 5-10 percent of their water needs (ORMVA 2013).

Bordering on the Issen area is the Guerdane irrigation scheme, an area with the largest concentration of citrus production in the Soussa Massa, and one of the first PPP for irrigation in the world. The on-demand network irrigates 10,000ha in 576 farms in an area of 30,000ha, conveying water over 90km from the Mokhtar Soussi and Aoulouz dams (Houdret 2012). Prior to the scheme the area was primarily irrigated from private groundwater pumping, and groundwater overexploitation had led to the abandonment of 11,900ha (Faysse et al. 2012). Public participation in the scheme was justified in terms of reducing unsustainable aquifer abstraction and to maintain citrus production, viewed as a strategic economic activity.

The Guerdane scheme requires participating users to use drip irrigation and to purchase a minimum of 4,000m^3 per hectare per year. Based on the assumption that use of drip irrigation for citrus requires 6,000m^3 per hectare per year, the scheme is designed to set groundwater pumping at 2,000m^3 per hectare per year. This would be a significant reduction on the reported pre-scheme average abstraction of 10,000m^3 per hectare per year. The scheme is managed on a build-operate-transfer basis by the private sector partners, Amensous, who collect fees and ensure maintenance. A project management committee includes two farmers and representatives of government, and water is charged at 1.74 Dirham (US$0.19) per m^3 including a 0.2 Dirham tax for dam maintenance. Drought risk is shared between the management company and farmers, with Amensous absorbing the first 15 percent of losses before sharing costs with farmers. The farmers in this area are generally wealthy, with 67 percent of farms being 20ha or larger, and there are a number of foreign investors renting land in the area specifically to produce citrus for export (Chati 2012).

Both Issen and Guerdane schemes, therefore, were primarily driven by concerns with protecting commercial plantations of citrus in the face of increasing water stress, particularly declining groundwater levels.

Scheme performance

A challenge in assessing performance at the scheme level is the absence of public datasets, and fragmented institutional responsibilities for holding data. ORMVA, for example, collects data on network efficiency[16] and

Table 9: Key characteristics of the three Moroccan irrigation schemes

	Issen Traditional	Issen Modern	Guerdane
Location	Ouled Teima	Ouled Teima	Ouled Teima
Vintage	1986*	1981*	2009
Land area	4,440ha	8,500ha	10,000ha
Water source	Abdelmoumen and Dkhila Dam Complex (Oued Issen)	Abdelmoumen and Dkhila Dam Complex	Mokhtar Soussi (Oued Ouzioua) and Aoulouz (Oued Souss) Dams, with conjunctive use of groundwater
Irrigation method	Surface irrigation	Modern pressurised delivery, initially sprinkler but increasingly converted to drip irrigation	Drip irrigation
Crops grown	Olives, cereals, fodder, horticulture	Primarily citrus, also horticulture, cereals	Primarily citrus, also horticulture, cereals, bananas, fodder
Management and ownership	Farms are private, irrigation infrastructure and dams are public, WUAs involved in management of individual canals	Farms are private, irrigation infrastructure and dams managed by public organisations	Farms are private, management company of the irrigation network (Amensouss) is private, dams are public
Finance for infrastructure development	Public, with loans from international donors	Public, with loans from international donors	PPP: 987m Dirham (US$109m) total investment, 25% as a concessional loan, 25% as a grant from the Social and Economic Development Foundation of Hassan II, 5% participation from farmers and 45% from the Amensouss management company. This covered the cost of the irrigation network; dams were prior state investments.
Finance for current operation and maintenance	Cost recovery from farmers, possibly supplemented by the government	Cost recovery from farmers, possibly supplemented by the government	Recovered from user fees
Other information	867 farms supplied	More than 1,700 properties supplied	576 farms supplied
Source(s)	Chati (2012); ORMVA (2013)	Chati (2012)	Chati (2012); Houdret (2012)

*These dates relate to the completion of the dam complex. Irrigation was practiced in the area prior to these developments.

recovery of fees from farmers in both Issen schemes, while data on yields is held by other agencies. Similarly, Amensouss monitors network efficiency, but does not collect data on the yields or profitability of its clients.

A recent study of Issen Traditional conducted by ORMVA noted that average yields were below potential due to a combination of limited water availability, relatively low-tech approaches to agriculture and the degraded state of irrigation networks and systems (ORMVA 2013). The study also calculated the gross margins of each crop (Table 10), accounting for production costs, with labour contributing 20-50 percent of all productions costs. These yields are well below the maximum reported in the Souss Massa by Chati (2012), who noted significant differences in yields and water productivity between low-tech traditional agriculture and modernised commercial farms oriented for export. For example, yields of vegetables grown in greenhouses could reach up to 110t/ha with significant water 'savings' (Chati 2012).

Figures were not available for yields from the Issen Modern or Guerdane perimeters. Key informants from Issen Modern indicated that their yields were substantially above those of Issen Traditional, although interruptions in supply did have significant impacts on production. An official of Amensous reported that land prices for farms supplied by the scheme were ten times higher than surrounding land (250,000 compared to 25,000 Dirham per hectare), and that a waiting list of 700 farmers also demonstrated the scheme's value to production.

Network efficiency and consistency of supply were also markedly different between the three schemes. A key issue for farmers in the Issen Traditional section has been the maintenance of consistent flows, particularly

Table 10: Average yields and gross margins of key crops in Issen Traditional			
Crop	**Area of production (ha)[17]**	**Average yield (t/ha)**	**Gross margin (Dirham/ ha)***
Olives	2687	3.5	8140
Fallow	1054	-	-
Wheat	331	1.5	2745
Pomegranate	191	17.5	22960
Barley	189	1.4	2335
Citrus	136	22	24850
Alfalfa	135	24.5	9725
Spring horticulture	86	12	23735
Maize fodder	73	22.5	10090

*1 Dirham = 0.11 USD (OANDA, 23/01/15)

Source: (ORMVA 2013)

during and after periods of drought. The Dkhila dam, which services Issen Traditional, is prioritised for potable water and in drought years allocations to the irrigation network are reduced. Between 1986 and 1999 allocations for irrigation from Dkhila increased from 14 to 70m m^3. However, during a series of droughts between 2001 and 2008 the highest annual irrigation allocation was 8.5m m^3, and no water at all was released for irrigation in Issen Traditional in the peak drought years of 2001-2003 (ORMVA 2013). The canal network, although concretised, still experiences leakage of approximately 60 percent, and the system of allocation and control means most farmers are on an irrigation schedule with an average of ten day intervals (key informants).

By contrast, Issen Modern and Guerdane are on-demand systems. Amensous report Guerdane's network efficiency to be 97 percent, and compensate farmers for interruptions in service. They are also contractually obligated to hold back 24 percent of their income from user fees as a reserve to invest in planned network rehabilitation. By contrast, key informants reported that Issen Modern experiences regular delays in supply, although recovered fees are intended to meet the costs of maintenance. One farmer interviewed for this study estimated that she had experienced five service interruptions in eight months, each of which had lasted for 10-15 days and had implications for both yields and crop selection.

In addition to questions of performance at the scheme and farm level, the question also arises of performance against broader societal goals. For example, the rapid increase in land prices for farms supplied by the Guerdane scheme has been accompanied by destabilising land speculation (Houdret 2012). The Guerdane scheme has also been criticised by several authors on grounds of both governance and sustainability. Concerns for sustainability question the rationale for subsidising water intensive citrus production in a water scarce area, and the economic and social returns on this investment by comparison to alternatives (Elame and Doukkali 2012; Doukkali 2005). Governance concerns reflect the complex relationships between the royal family; the Social and Economic Development Foundation of Hassan II, which provided the public financing; the owners of the Amensous management company; and the owners of the large citrus plantations (Houdret 2012; Van Cauwenbergh and Idllalene 2012). Limited consultation with local small farmers in decision-making and dispossession of customary users of the scheme's source waters have also been raised as issues (Faysse et al. 2010; Houdret 2012). These all reflect concerns that the benefits of public investment are being captured by wealthier landowners at the expense of poorer, more vulnerable farmers.

Key informants noted that a key value of drip irrigation systems to farmers was their ability to reduce labour costs associated with surface irrigation. One farmer at Issen Traditional reported that he had been able to reduce his labour costs by over 60 percent following the adoption of new technologies. This was, indeed, his principal reason for adopting drip irrigation, due to the relatively marginal cost of water and energy. Other key informants agreed that individual large farmers also benefitted from reduced labour costs, but had no incentive to reduce their total water withdrawals. Water 'saved' through the use of new technologies was invested in expanding the irrigated area or increasing production of water intensive crops. These findings resonate with other studies that conclude that, whilst introduction of modern irrigation technologies may reduce the fraction of water going to non-beneficial consumption and non-consumption, this does not necessarily reduce total agricultural consumption of water (e.g. Pfeiffer and Lin 2010).

Table 11: Factors influencing performance of Issen and Guerdane irrigation schemes

		Barriers	Enabling factors
External	**Donors/IFIs**	Structural adjustment and donor-influenced neoliberal policies had significant impacts on rural poverty; budget cut-backs affected the government's capacity to deliver and maintain services	Provision of loans for infrastructure projects; technical assistance including scoping of Guerdane PPP scheme; promotion of participatory irrigation management
	World markets	Farmers are not always able to control for quality of produce and negotiate at a disadvantage; increased dependence on exports; increasing groundwater abstractions	European Union market opportunities and foreign investment opportunities have opened up potential for development of the agricultural sector, although these are not always exploited
	Climate change and drought	Increasing frequency of droughts; climate change has also contributed to water stress	Irrigation offers resilience against drought, at least in the short term, but its long term proposition as an adaptation to climate change is not clear
National level	**Agricultural policy**	Irrigation has been a major part of agricultural modernisation, but has not reached all players; problems in coordinating small farmers	Increasing focus on commercial agriculture, tax breaks and investments, and modernised systems play a big role in supporting this
	Land rights (linked to water rights)	Land fragmentation and informal tenure systems have been barriers to access of subsidies, credit and permissions for groundwater abstraction; informal and customary water rights not always recognised, with cases of water mobilisation investments diverting waters away from customary users	Reforms in the law have been introduced to permit foreign investors, and also to improve the access of small farmers to subsidies and credit
	Institutions	Fragmentation; conflicts between uses; choices becoming harder and more politicised as water becomes scarcer; questions about transparency, objectivity and favouring of certain stakeholder groups	Increasing attempts to integrate policy between water, agriculture and energy, with introduction of River Basin Authorities (RBAs), but coordination and decision-making not strong, and not necessarily transparent; attempts to make institutions inclusive have been partially successful
Sub-national / basin level	**Water stress**	Rapid expansion of groundwater abstraction and increased demand from urban growth and tourism has resulted in closed system in significant deficit; few sources can still be mobilised, and there is increased variability in supply; competition over water between sectors and users; many farmers on rotation systems with up to ten day gaps	Focus now is on increasing water productivity, recycling and demand management; interest in novel forms of supply including desalination for ultra-high value crops; policy focus on water scarcity has incentivised drip irrigation with the availability of subsidies and credit, but there are challenges in incentivising water conservation by individual farmers
	Regulation	Small farmers have found it difficult to meet requirements to obtain permissions for groundwater abstraction, access to government support, etc.; difficult to enforce rules at a farm level, particularly in terms of controlling unpermitted groundwater abstraction; collecting fees still problematic in areas using gravity systems and for groundwater abstraction	Lack of enforcement presents an opportunity to some farmers who have used the space to sink tube wells; however, individual rational decisions have led to an unsustainable situation at the basin level
	Planning	At the basin level, irrigation allocations appear to have largely benefited the rich and contributed to inequalities (with public funds subsidising the rich); ground water abstractions driven by large scale commercial production; tax holidays mean benefits are not shared with wider society	Introduction of RBAs has in principal decentralised integrated planning, but coordination and decision-making is not strong, and not necessarily transparent; attempts to make institutions inclusive have been partially successful
Scheme / local level	**Technology**	Surface irrigation results in a smaller fraction of water used for beneficial consumption; drip irrigation can lead to salinisation, reduces the fraction of recoverable losses that other users may rely on and is highly expensive for small farmers without access to pressurised supply	Public and PPP investments in modern pressurised systems have reduced costs to farmers of investment in drip irrigation; drip irrigation has increased water productivity and 'dollar per drop' as well as 'crop per drop'
	Finance and management capacity	Operation and maintenance often insufficient, with long interruptions in service; WUAs have limited capacity to invest; PPP schemes aimed at 'profitable' (e.g. large commercial) sectors; difficulties in getting access to subsidies for smallholders	Mobilisation of private sector funding has improved services – the question is how this model might be applied to the benefit of poor farmers; WUAs have not been highly successful, perhaps due to constraints on forms of organisation, despite a legacy of customary institutions
	Benefits	Customary water rights not always recognised, and some schemes have overridden customary rights; problems of elite capture at basin level (see above)	Expansion of irrigation has benefited farmers by increasing drought resilience, although it may also have increased water demand and be unsustainable

4.6 Conclusions

The experience of the Issen and Guerdane perimeters mirrors the evolution of national irrigation policy in Moorocco over the last three decades. Key factors have been the expansion of irrigation provision to support both commercial agriculture and small farmers; the impacts of drought; the constraints of increasing water stress that have driven the uptake of new technologies; and efforts to develop civil and private alternatives to management by the government. Factors from different scales, from the international to the local, have influenced the design and performance of these schemes (Table 11).

Officially covering less than 5 percent of agricultural land, irrigation plays a relatively small but important role in Souss Massa and Morocco. It has been crucial to developing commercial opportunities for water intensive crops since the colonial period, and droughts since the 1980s have provided an additional impetus. In addition to the provision of irrigation schemes, increasing numbers of farmers have relied on private irrigation drawn from groundwater. However, increasing agricultural water use, alongside increasing demand from other sectors, has resulted in water stress. Few sources for mobilisation remain, and the Souss Massa Basin's deficit has led to substantial declines in aquifers.

The government has responded by promoting technologies such as sprinkler and drip irrigation to increase water productivity and restore balance at the basin level. However, it is not clear that these technologies have contributed greatly to water conservation. Incentives for individual farmers to adopt drip irrigation appear to lie more in their potential to reduce labour costs, while the unit costs of water and energy can be offset by producing high value crops. In both the Guerdane and Issen perimeters, the provision of drip irrigation has facilitated at least some farmers to either increase the irrigated area or cultivate water intensive crops. Indeed, the provision of irrigation to Guerdane and Issen Modern was specifically to support commercial orange growers, disproportionately high users of water. Uptake of drip irrigation also presumably reduces return flows to groundwater, which would challenge the intended benefits for aquifer restoration. These conclusions mirror those of other studies in Morocco (e.g. Kuper et al. 2012).

The question of allocation of, and access to, irrigation in the Souss Massa has been raised as problematic by several authors (including Houdret 2012; Van Cauwenbergh and Idllalene 2012; Faysse et al. 2010). Key concerns are that participation by water users in water resource planning has been limited; that beneficial allocations of irrigation water have disproportionately accrued to a minority of wealthy and politically connected landowners; and that some communities have been dispossessed of usufruct rights as water resources have been mobilised. This is aside from a more general concern that the poorest farmers experience barriers in accessing state credit and subsidies (e.g. Kalpakian et al. 2014). These issues mirror widespread observations about elite capture of benefits from irrigation and water resource mobilisation (Molden 2007). Although the results of the Guerdane scheme are impressive, and the government is looking to replicate the model elsewhere in Morocco, it is not clear how the benefits of public-private investments could be made more accessible to the poor.

Several different objectives for irrigation exist at both national and scheme scales, and these are sometimes contradictory – for example, commercial development, poverty reduction, drought resilience and water conservation. Questions of performance are therefore difficult to untangle, and depend on who is making the judgement. While the government highlights impressive results such as commercial production or improved water management in the Guerdane perimeter, critics highlight issues of governance, including equity and transparency, and sustainability, and individual farmers are immediately concerned by issues of yield and profitability.

To conclude, the experience of Morocco is striking in that it encapsulates the challenges of balancing agricultural modernisation and commercialisation with pro-poor rural development in a water scarce environment. Morocco and Moroccan farmers have deployed irrigation to good effect. The key concerns that emerge are questions about how to rationalise agricultural water use in a context of increasing water scarcity, and how to ensure that water use is socially equitable. Morocco therefore offers a useful reference case from which the future development of other semi-arid African countries may benefit.

5 Mozambique

5.1 Introduction

With an impressive growth rate of 7.7 percent per year (World Bank 2014b), today Mozambique is considered one of Africa's best-performing economies (do Rosario 2012, citing Mosca 2011). However, despite its wealth of natural resources and agricultural potential, Mozambique remains one of the 20 poorest countries in the world (World Bank 2013). Agriculture is important to the country's economy, contributing around 30 percent to GDP, versus 23 percent for industry and 47 percent for the service sectors (2012 data) (FAO 2014b). In 2003, 80 percent of Mozambicans, the majority of whom were living in rural areas, were employed in the primary sector. Smallholder farmers cultivate 95 percent of agricultural land, and 70 percent of the population is still dependent on subsistence agriculture (World Bank 2007a). Unsurprisingly, agriculture has occupied a prominent position in the government's poverty reduction and development policies since the country's independence in 1975, although these have not always translated into action.

Mozambique has plentiful land and water resources, with renewable freshwater resources per capita estimated at 8,404 m^3 per year (FAO 2014b), but high climate variability results in frequent and recurrent droughts and floods. Performance of the agricultural sector over the longer term depends greatly on the extent to which water resources can be managed in an effective and productive way (World Bank 2007a). Nevertheless, as in Ethiopia, irrigation has tended to occupy only a marginal position in Mozambique's national agricultural policies and sectoral development strategies, leaving farmers vulnerable to variable, and often extreme, weather conditions.

Portuguese colonisers were the first to exploit Mozambique's irrigation potential. By 1973, 100,000ha of irrigated lands had been developed for rice and sugar cane production, especially in the southern provinces of Maputo and Gaza and in Cabo Delgado (N'guri) (Mosca 2011). After independence in 1975, however, the expansion of irrigation slowed down significantly, hampered partly by the civil war. Only 20,000ha were added to the equipped area in the Maputo and Gaza provinces, and a few water development works took place, including the construction of the Massingir Dam on the Elephant River (World Bank 2007a). Currently, 118,120ha are equipped for irrigation, of which 40,063 are actually irrigated, consisting mainly of large schemes (over 500ha). According to the 2002 agricultural census a large proportion (around 65 percent) of Mozambique's irrigated area is found in the southern regions of the country, while the central and northern regions only host 33 percent and 3 percent of irrigated lands respectively (FAO 2014b).

Food security and rural poverty continue to represent critical development challenges for Mozambique. It is important to understand how irrigation systems can be developed and operated effectively and sustainably to ensure that these investments provide benefits to the Mozambican economy and people. While technology and infrastructure will be important in this sense, the importance of having good policies and effective institutions in place should not be underestimated. This case study explores the changing priorities, policies and strategies that have shaped irrigation practice over time, in order to identify the factors that have shaped the performance of irrigation schemes in Mozambique.

5.2 The evolution of irrigation policy and institutions in Mozambique

Under Portuguese rule in the 1950s and 1960s Mozambique experienced a sustained period of economic expansion, with important investments in the agricultural sector aimed at exporting cotton, cashew nuts, sugar and rice to Portugal. Especially in the Southern provinces (Maputo and Gaza), the Portuguese settlers developed irrigation infrastructure to cultivate sugar and rice – efforts culminating in the construction of the Massingir Dam in 1971. After the declaration of independence in 1975, agricultural policy in Mozambique went through four distinct phases (do Rosario 2012; Tarp et al. 2002), discussed here in turn.

The first phase, from 1975 to 1986, was dominated by a Soviet-style socialist model of strong state intervention. The Mozambican government viewed state farms, and especially irrigation schemes, as the nodes for increasing agricultural production. Between 1978 and 1982, 90 percent of agricultural investments went to state farms while only 10 percent went to the smallholder sector (do Rosario 2012). The government also prioritised the rehabilitation and expansion of large irrigation infrastructure, particularly in the Limpopo and Incomáti river basins, in line with the 1976 *Plano General do Aproveitamento de Recursos Hidráulicos* (General Plan for Water Resources Use) (MoA 2013). Meanwhile, the lack of support for smallholder irrigation led to a significant decline in this sector (do Rosario 2012).

By 1983 the failures of centralised planning had become apparent and as in many other African countries, the government faced significant debts. A structural adjustment programme (1986-1992) was subsequently agreed, introducing a series of measures aimed at the establishment of a market economy in Mozambique (do Rosario 2012). These included the withdrawal of the state from direct engagement in agricultural production, restrictions on public expenditure in agriculture (and other sectors) and market liberalisation (do Rosario 2012; IMF 2011). State enterprises were dismantled, farms often privatised, and collective land reallocated to individual farmers (Ganho 2013; Pellizzoli 2010). Meanwhile there were increased investments in infrastructure, capacity building and administrative reforms, including new decentralised systems of governance (Mosca 2011). In the irrigation sector, this phase was characterised by the establishment of independent Units of Irrigated Agriculture in some provinces at the end of the 1980s, mandated with the development of small-scale irrigation systems and the provision of extension services for producers. But the precarious security situation of many rural areas as a consequence of the civil war constituted a strong limit to the effective performance of these units, and consequently of irrigation systems (MoA 2013; Silva et al. 2010).

Following the General Peace Agreement in 1992, and in the context of a post-war collapsed state, the main concern of the Mozambican government in this third phase was to promote cash crops for export (in particular cotton, tobacco and sugar) as a source of revenue. This was facilitated by privatisation measures adopted during the structural adjustment period and the availability of foreign capital (Mosca 2011) and resulted in new alliances, as well as reinforced old ones, between foreign

investors and the elites in power, therefore consolidating the Mozambique Liberation Front (FRELIMO) party's control over the economy, state and rural space (Mosca 2011, citing Pitcher 2002). FRELIMO also allowed the re-establishment of traditional authorities (Ducrot 2011). As a result, today there is a diversity of local authorities and leaders that co-exist in rural areas and often compete for the control of natural resources (Ducrot 2011).

During the 1990s a number of reforms were also implemented in the water sector, such as the 1991 Water Law and the 1995 Water Policy, anchored in the principles of decentralisation and participation. In the agricultural sector the government launched a two-phase National Programme for Agriculture Development (PROAGRI 1 from 1999 to 2004 and PROAGRI 2 from 2005 to 2009) aimed at building a common vision for national agricultural development by coordinating interventions in critical areas outside of the mandate of the Ministry of Agriculture (such as markets, rural infrastructure, water resources and financial services). Despite the support of international donors, however, little progress was made. Strategies that followed, including the Poverty Reduction Action Plan (2011-2014), heavily focussed on the promotion of food security and the smallholder sector (see Pellizzoli 2010), but there was little emphasis on irrigation until fairly recently.

Over the last decade (the fourth phase) irrigation seems to have appeared back on Mozambique's development agenda. The National Water Policy of 2006 envisaged the full utilisation of existing irrigation infrastructure, including through the promotion of private investment and PPPs (GoM 2006). The Strategic Plan for the Development of the Agricultural Sector (PEDSA, 2010-2019), anchored in the Green Revolution Strategy (2008), also encouraged investments in irrigation infrastructure as a means to boost agricultural productivity (GoM 2010). Between 2004 and 2009 a number of irrigation areas totalling 13,400ha were built or rehabilitated, especially in the Gaza, Maputo, Zambézia and Inhambane provinces (Table 12) (see also Cunguara et al. 2011). According to one key informant, the government sought to consolidate these investments under a coherent government-backed plan in an attempt to regain ownership. This resulted in a new *Estratégia de Irrigação* (Irrigation Strategy), approved in 2012, to 'contribute to the growth of agricultural production and productivity in order to ensure food security, generate surplus for export, increase job opportunities in the rural and peri-urban areas, and raise farmers' incomes' (MoA 2013).

Table 12: Rehabilitated or new irrigation areas in Mozambique (2001-2009)

Province	Area (ha) in 2001-2003 (according to 2002 inventory)	Total area (ha) as of 2010	Total area (ha) developed between 2002 and 2010
Maputo	908	3,747	2,839
Gaza	7,895	15,175	7,280
Inhambane	47	1,164	1,117
Tete	373	416	43
Sofala	176	573	397
Manica	1,126	1,671	545
Zambézia	2,708	3,070	362
Nampula	352	619	267
Niassa	7	490	483
Cabo Delgado	84	107	23
National total	**13,676**	**27,032**	**13,356**

This resuscitation of the irrigation sector has also been reflected in institutional changes. Despite government restructuring in the late 2000s, it was clear that existing arrangements were inadequate to support and coordinate the large donor and private investments aimed at re-launching irrigated agriculture in Mozambique (MoA 2013). Thus an *Instituto Nacional de Irrigação* (INIR, National Irrigation Institute) was established in 2012 to plan, develop and manage the country's resources for irrigated agriculture. Acting as an independent body under the Ministry of Agriculture, the INIR reaffirms and strengthens the Government's renewed commitment to the sector.

5.3 Drivers of policy change in Mozambique

Agriculture clearly occupies a central place in Mozambique's development agenda and irrigation has been invoked multiple times throughout the country's turbulent history as a means to increase agricultural productivity, and hence feed the Mozambican population. The raft of policy and institutional reforms in the Mozambican agricultural and water sectors, and in the irrigation sub-sector, over the last forty years or more have been shaped by a number of internal and external factors. The following have emerged from the literature

and key informant interviews: historical legacies; politics and ideology; foreign assistance; and new interests.

Historical legacies, politics and ideology

Centuries of colonial exploitation; the civil war between FRELIMO and the Mozambican National Resistance movement/party (RENAMO) that ravaged the country for more than 15 years; and the neoliberal adjustments imposed by the international financial institutions (IFIs) in the 1990s have all left their mark in Mozambique. After independence, exceptionally few Mozambicans had received adequate university training, and the majority of the existing managerial class (all Portuguese) had left the country (Tarp et al. 2002). According to key informants, in the irrigation sector this translated into a lack of capacity to maintain the schemes constructed by the Portuguese, which were either abandoned (e.g. on the Sabie and Umbeluzi rivers) or fell into disrepair. Post-independence, the Soviet Bloc provided technical assistance to Mozambique and thus could exercise political influence over the FRELIMO government. This had important repercussions in the agricultural sector. As indicated above, the latter was reorganised into state farms with centrally-set production targets. Nevertheless, Mozambique lacked the necessary human and capital resources to achieve the targets for agricultural growth envisioned in national development plans.[18] Moreover, investments did not yield the expected economic return, and foreign debt accumulated (Tarp et al. 2002, citing FAO 1982).

After the civil war, the FRELIMO elites moved from socialist to more neoliberal positions. Simultaneously the party's decision-making apparatus was decentralised in order to reassert FRELIMO's pivotal role and electoral base at the village and provincial levels (key informant). In the agricultural sector, such ideological and structural shifts put poverty reduction and food security at the heart of the government's mission. Encouraged by the IFIs, Mozambique's poverty reduction strategies highlighted the role of smallholder farmers (which still constitute the majority of the Mozambican population) and introduced market-oriented reforms to, *inter alia*, attract private sector investments. The importance of rice production was also emphasised as a response to the needs of a growing population and increase of international food prices in 2008/09. In turn, this called for substantial investments in irrigation infrastructure. Interestingly, rice was by far the least consumed cereal up until 1990, but became the third most consumed, behind sorghum and wheat, in fewer than 15 years (Kajisa and Payongayong 2011).

Foreign assistance

Donors have had considerable influence on government policies and priorities, including in the irrigation sector, since independence in 1975. At this time investments in the form of technical assistance came particularly from the Soviet Union and satellite countries in an attempt to consolidate their presence in this region. Since then a reliance on largely Western donor support has been reinforced by the civil war and is evident in the various reforms undertaken throughout the 1990s and 2000s. The emphasis in international irrigation discourse on cost recovery, decentralisation of water management, setting up associations for water users, promotion of commercial agriculture and increased participation of the private sector resonates in Mozambique's agricultural and water sector strategies.

Not only have donors exercised a strong influence over policy, they have also intervened directly by implementing irrigation projects on the ground. Indeed, key informants confirmed that the majority of irrigation schemes in the country have been rehabilitated or funded through donor-led interventions, following a piecemeal approach that lacks programmatic consistency. In theory this will change with the new irrigation strategy, which establishes clear guidelines for reforming the sector. However, without serious investment and leadership through the INIR, it is likely that implementation will be entirely contingent upon external funding without really taking account of the interests of local producers.

New interests

The emergence of new foreign investors in the Mozambican agricultural sector is a more recent trend. The government has made concerted efforts to attract private companies, particularly in the area of biofuel production (key informants; see also Fairbairn 2011; Ribeiro and Macavel 2009). This included the enactment of new laws and regulations to provide financial incentives for companies investing in technology, infrastructure and capacity-building (Nhantumbo and Salomão 2010). Between January 2004 and June 2009, Mozambique transferred 2.67m ha of land to investors for a total of 405 projects. About half of this land went to foreign-owned projects, of an average size of 1,500ha, primarily for timber and jatropha (Deininger and Byerlee 2010). Some of these interventions have included the rehabilitation of irrigation infrastructure, but on a very ad hoc basis, thus reinforcing the piecemeal nature and regional disparity of irrigation development in the country. Moreover, the traditional agricultural sector remains unattractive for private companies. Accessing national and international markets is problematic as Mozambique is characterised by poor transport infrastructure, particularly in rural areas (Domínguez-Torres and Briceño-Garmendia 2011).

5.4 Implications for irrigation practice and sector performance

Mozambique is thought to have great potential for irrigation development (about 3.3m ha), but only 50,000ha are currently being used. Moreover, 60 percent of irrigated land is used for commercial production of

sugarcane. Only 8.8 percent of farmers in the smallholder sector use any type of irrigation system (GoM 2010; key informants). In the north of the country, class A (less than 50ha) and B (between 50 and 500ha) irrigation schemes prevail, while class C schemes (over 500ha) account for approximately 80 percent of the equipped area in the southern part of Mozambique (Table 13). Small schemes (class A) are mostly operated by farmers, individually or communally – they are based on treadle pumps and other manual methods, and tend to have very low efficiency[19] rates (25 to 50 percent). Class B and C schemes are for industrial exploitation, mainly for sugar cane and rice, and use sprinkler irrigation with efficiency rates of up to 70 percent (World Bank 2007b).

According to INIR and other key informants, large schemes are no longer promoted because of their relatively high costs and poor performance, with the notable exception of the Chókwè Irrigation Scheme (CIS) (more below) and the Regadio do Baixo Limpopo in the Gaza Province (key informant). However, despite an increasing focus on smallholder irrigation, public expenditure remains skewed towards large projects. Between 2002 and 2007, investments in large-scale irrigation rose from 81 to 92 percent (World Bank 2014b). The costs for surface irrigation range from US$1,500 to US$2,000 per hectare, whilst maintenance costs can vary between US$500 and US$1,500 per hectare depending on the condition of the system (FAO 2014b; Mosca 2011). Most irrigation schemes use water from rivers,

Table 13: Types of irrigation schemes in Mozambique (2002 data)

Class of irrigation scheme (ha)	Area		Utilised area (%)	Rehabilitated area (ha)
	Equipped (ha)	Utilised (ha)		
<50	6,389	3,276	51	3,113
50-500	19,547	4,680	24	14,967
>500	92,084	32,107	35	59,977
Total	118,120	40,063	34	78,057

Source: FAO (2014b, based on data from Instituto Nacional de Estatística – Censo Agro-Pecuário 2008)

while groundwater is used only to a limited extent and prevalently by the smallholder sector. Irrigated crops are poorly diversified, consisting of more than 50 percent of sugar cane (cultivated in medium-large schemes). The remainder is rice, citrus fruits and vegetables, particularly tomatoes and lettuce.

In short, the irrigation sector in Mozambique appears to be characterised by: poor coverage, especially in drier areas where the probability of crop failure is high; prevalence of surface irrigation technologies, often associated with high network losses and low water productivity; and high costs, both of installing new schemes and operating and maintaining existing ones.

The slow and lopsided development of irrigation in Mozambique cannot be attributed to biophysical conditions, such as distribution of land and water resources, alone. Socio-economic and governance factors also need to be taken into account (Neumann et al. 2011). Irrigation development and agriculture in general are highly politicised endeavours. Key informants highlighted the fact that policy decisions on resource allocation have been (and still are) shaped by a double set of concerns: the practical ones linked to the imperative of boosting productivity, and the strictly political ones aimed at reaffirming the position of the FRELIMO-led government at the national and local levels (see also Mogues and Benin 2012).

Frequent changes in the institutional and administrative make-up of the agricultural sector have also contributed to poor performance in irrigation. In an effort to address institutional constraints the Ministry of Agriculture, whose budget heavily depends on funding from international development partners (59 percent in 2007), has gone through four restructurings between 2005 and 2010 alone (do Rosario 2012) and numerous other replacements of personnel. This, coupled with the ousting of competent managers and technicians (at both central and local levels) for ideological and political reasons, has resulted in a lack of continuity for policy implementation and a gradual erosion of the Ministry's technical expertise (do Rosario 2012, citing Mosca 2011; see also Pauw et al. 2012).

Key informants highlighted a number of additional challenges, particularly for smallholders (see also Cunguara et al. 2011). Firstly, farmers often do not have the skills and expertise required to manage and operate irrigation infrastructure, or to re-build schemes destroyed during the civil war. This situation is worsened by the lack of access to key agricultural inputs and technical support. The extension service has very limited capacity in respect to irrigated agriculture. Secondly, unclear property rights in some irrigated areas, especially schemes funded and managed by state enterprises, further reduce incentives for farmers to dedicate time and resources to use and maintain the irrigation infrastructure. Finally, some of the older large-scale irrigation schemes have been divided into smaller plots assigned to households for cultivation. Fragmentation has had negative implications for agricultural productivity and water resources management.

5.5 Case study: Chókwè Irrigation Scheme

The Chókwè Irrigation Scheme (CIS), also known as *Eduardo Mondlane*, is one of the most important (if not the most important) irrigation developments in Mozambique, dating back to the colonial period. Once considered 'the silo of the nation' and expected to produce enough rice to satisfy the needs of the entire country, today the CIS is rather described as a 'sleeping giant' because of its decaying infrastructure and low productivity (AllAfrica 2011). The history of the CIS provides interesting insights into changing policies and approaches to irrigation in Mozambique, the interplay between higher-level processes and on-the-ground realities, and challenges to sustaining high performance over the long term in a large scheme such as this.

Map 4: The location of Chókwè Irrigation Scheme in Gaza Province, Mozambique

FAO - AQUASTAT, 2005

MOZAMBIQUE

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Source: FAO (2005), available from FAO (2014b)

The CIS is located northwest of XaiXai, marked by a green triangle.

Background

The CIS, located in the Chókwè District of Gaza Province (Map 4), lies within the lower part of the Limpopo River Basin, which is characterised by a semi-arid climate and extreme seasonal and inter-annual variation in flow (Brito et al. 2009). The average annual rainfall is 622mm, falling mainly during the wet season from October to April (Munguambe et al. 2009). Further, the area is a low-lying flood plain, generally less than 100m above sea level, and subject to water discharges/withholding in dams in upstream riparian countries (South Africa and Botswana) (Carmo Vaz 2000). The wet conditions of the lower Limpopo Valley are particularly suitable for rice cultivation, which is why the Portuguese regarded Chókwè and the surrounding area as the granaries of the country, and were hoping for the scheme to produce half of the national rice output (Kajisa and Payongayong 2011).

The main sources of water in the lower Limpopo River Basin are two main branches flowing into Mozambique, namely the Elephant River and the main stem of the Limpopo, as well as some local tributaries, including the Changane and Sangutane Rivers. Originally a perennial river, the Limpopo now remains dry for eight months of the year as a consequence of the increasing abstractions of upstream countries (Brito et al. 2009). The Limpopo River Basin has an average annual runoff estimated at 5,200mm^3, but patterns of rainfall, and consequently the river's flow regime, are highly variable, and the basin is vulnerable to both flooding and droughts (Brito et al. 2009; UN-HABITAT and UNEP 2007).

The CIS and the Macarretane dam were designed and built in the 1950s and extended in 1979 under Portuguese rule, with the objective of delivering water through gravity systems to boost vegetable and rice production in the region. In the 1970s the Massingir dam was built on the Elephant River to guarantee the supply of water for irrigation in the middle and lower Limpopo basin all the way to Xai-Xai, where another irrigation scheme, the *Regadio do Baixo Limpopo*, was present. The CIS stretches over a length of more than 50km, cut through by irrigation and drainage canals, roads and dykes for flood defence (Brito et al. 2009). The total area of the scheme is 34,000ha, divided in three sections: Montante, Sul and Rio (Table 14). Theoretically 23,000ha of this is irrigable land. However, due to past floods (particularly in 1977, 2000 and 2013), salinisation problems and lack of rehabilitation, the actual irrigation area is currently estimated at around 7,000ha (HICEP 2011).

Table 14: Total area and cropped area in sections of the CIS (2012/13 season)

Hydraulic section	Total area (ha)	Crop area (ha) during dry season (2012/13)	Crop area (ha) during wet season (2012/13)	Productivity (per crop area, 2 seasons, total area in ha)
Montante	6,164	1,493	1,364	0.46
Sul	18,946	635	2,319	0.15
Rio	8,738	501	1,013	0.17

The management of the CIS falls within the mandate of the *Hidraulica do Chókwè, Empresa Pública* (HICEP). HICEP is responsible for the management of water, land and irrigation infrastructure in the CIS, and the organisation of users for its administration, operationalisation and maintenance, with a view to promote the sustainable economic development of the irrigation scheme (HICEP 2009). Importantly, HICEP administers the water licence from *Administração Regional de Águas – Sul* (ARA-Sul), the government water board responsible for the Southern region of Mozambique which manages the Massingir and Macarretene dams. HICEP is also responsible for collection of the water fees that should cover the annual payment for the licence (HICEP 2009). Water fees are currently based on cropped areas within the scheme. Permission to cultivate is not required and water users 'are entitled to receive water in a quantity proportional to the size of their plot' (Pellizzoli 2010: 215), which means that having a land use right within the scheme includes a right to irrigation water. In theory, water users can be denied access to irrigation water if they do not pay the water fee, but in practice this has not been enforced.

The heart of the CIS is Chókwè town, home to a major market that connects the two agricultural districts of Guja and Chókwè, and the upper semi-arid Limpopo Valley to the southern part of the province (Ducrot 2011). Agriculture is the main economic activity, employing almost 80 percent of the labour force. The majority of farmers are women, many of them elderly and with little education. Farmers mainly produce food that can be stored for long periods after the harvest, such as rice (during the rainy season), maize, sweet potatoes, manioc and beans (during the dry season). Most of this production is for household consumption, but some of the farmers also sell rice to the Palmeiras factory, situated 120km from Chókwè, and vegetables (especially tomatoes, a product for which this region is famous) to the markets of Chókwè, Lionde, Xai-Xai or Maputo. However, according to interviewees, horticultural crops are less preferred by farmers because markets are already overflowing with products from neighbouring South Africa, thus lowering the price of local vegetables.

The history of Chókwè Irrigation Scheme

The CIS was originally a Portuguese project envisaged in the 1920s. Its construction effectively began in 1952, causing a process of land expropriation that affected about 2,000 households (key informants). The colonial government established the *Brigada Tecnica de Fomento e Povoamento de Limpopo* (BTFPL) to manage the irrigation scheme, and also provided land, seeds and technical support to farmers (Muguambe et al. 2009). By 1975, over 1,200 families of *colonos* (Portuguese colonisers) lived in the scheme. Another 400 *asimilados* (Mozambican families) were irrigating on less favourable terms, whilst the black population served as workforce in conditions of semi-slavery. The Chókwè area underwent a period of rapid economic growth between 1958 and 1960, with the development of an important agro-industrial complex. Nevertheless, by the late 1950s over one-third of the Portuguese *colonos* had left due to the numerous social (e.g. hard work, misery, illnesses) and technical/managerial (e.g. low yield attributable to low supply of inputs and lack of water) problems haunting the scheme (Pellizzoli 2010, citing Hermele 1988).

After independence in 1975, when Portuguese settlers left Mozambique and the FRELIMO government adopted new socialist policies, the CIS was brought under government control as a state farm. The Limpopo Agro-Industrial Complex (CAIL) controlled the land and production process, whilst the management of the irrigation scheme was assigned to the state-based enterprise *Sistema de Regadio Eduardo Mondlane* (SIREMO) (Pellizzoli 2010). After 1983, the CAIL was divided into four main areas: 1) the smallholder sector, meaning individual households farming plots of 0.5-1ha (totalling 9,000ha); 2) state farms managing 11,000ha; 3) the private sector, meaning better off farmers owning agricultural inputs and managing farms of 4-200ha each (totalling 3,000 farms); and 4) farmer cooperatives which occupied 1,500ha (Ducrot 2011).

HICEP replaced SIREMO in 1997. According to one key informant, this institutional change involved, *inter alia*, the sale of old buildings, a drastic reduction in the number of staff and the limitation of the agency's responsibility for the main canal system. HICEP was given the mandate to distribute water within the irrigation scheme and provide for the maintenance of the primary infrastructure, while water management from the secondary canal downwards became the responsibility of farmers and their associations (GoM 2010). WUAs, formally established in 2004, were reorganised according to hydraulic units, mostly at the level of the secondary canals (Ibid).

In 2000 the CIS was severely hit by floods which swept away most of the irrigation infrastructure. With the help of a number of donors, rehabilitation of the intake and main canal was completed in 2006, together with some secondary and tertiary canals, for a total area of 7,000ha (interviews with HICEP). In 2003 the Massingir Dam and Smallholder Agricultural Rehabilitation project (MDSAR) was approved to undertake repair of the infrastructure and to reorganise agricultural production with a loan from the African Development Bank. An additional 7,000ha are in the process of being rehabilitated with funding from the Islamic Development Bank, the French Development Agency (ADF) and the Japanese International Cooperation Agency (JICA) (HICEP 2011). Nevertheless, another devastating flood in early 2013 frustrated these efforts.

Scheme performance

Under Portuguese rule, the CIS was considered the breadbasket of the nation: its complex network of irrigation infrastructure was effective in exploiting the favourable climate and hydrological conditions of the Gaza province to ensure high rice yields. Cultivated for commercial purposes since the 1960s, the biggest yields were obtained in the agricultural campaign of 1974-75, when 70,000t of rice was collected. In the campaign of 1979/80 this number dropped to 46,000t, and such results have not been achieved since (key informant). The decolonisation process, two decades of civil war, devastating floods and a series of poorly thought through policy and institutional reforms continued to hinder performance of the CIS. Today, it is estimated that if timely irrigation water and appropriate seed varieties were made available, the area could achieve rice yields of up to 10t/ha, as high as that on the banks of the Nile in Egypt. However, because of a lack of rehabilitation investments and proper management of the scheme, the average rice yield is very low at 2.1t/ha (Kajisa and Payongayong 2011). Poor management has also exacerbated salinisation, thus undermining productivity – 42-70 percent of plots are salinised to a certain degree (Brito et al. 2009).

The economic sustainability of the CIS is a key concern. At present farmers pay a water fee amounting to an average of 450 Meticais (US$14)[19] per hectare in the wet season, and 800 Meticais (US$25) per hectare in the dry season (prices vary depending on the number of hectares owned by farmers). However, only 35-40 percent of farmers paid in 2013 as a consequence of the losses experienced after the flood (the payment rate was slightly higher in previous years). This is clearly not enough for HICEP to cover maintenance costs, nor to provide farmers with the required means of production – fertilisers, pesticides and machinery – as per its mandate (HICEP 2009). Despite being a public enterprise, the government can provide little support to the HICEP, given its strained budget. For example, key informants said that while in 2013 HICEP required 300m Meticais (US$9.4m) to start the agricultural campaign, it received only 20m Meticais. This also hampers the capacity of HICEP to repay ARA-Sul for the water released to the irrigation scheme, which in the past has caused some tensions between the two agencies.

The historical trajectory of the CIS mirrors some of the challenges experienced by the wider irrigation sector in Mozambique, with important consequences.

First of all, frequent changes of direction – colonial capitalism, a centrally planned economy, rapid transition to a market economy and a civil war in between – have created uncertainty amongst investors, both domestic and foreign. Irrigation is perceived as a risky enterprise. Moreover, ownership of land and infrastructure within the CIS has undergone several changes throughout history, at times integrated within the state-run production apparatus, other times operating under free market laws. This has given rise to multiple potential claims to the land and rendered patterns of accumulation complex.

Some key informants felt that the current discourse regarding rice production at Chókwè echoes the FRELIMO's almost mythical project of transforming the Limpopo Valley into the 'breadbasket of the country'. In response to the guidelines coming from Maputo, HICEP expects farmers in the irrigation scheme to grow rice on their plots, rather than subsistence crops. In reality, however, the productivity of rice crops remains quite low and farmers have very limited options for selling the rice they produce and have to supplement rice production with cultivation of other cash crops in the cold season, casual labour and non-farm income sources (key informants). The majority of farmers sell to *Orízicola Inácio de Sousa,* a rice-processing factory located in Palmeira, in another district. An additional factor constraining productivity is the lack of access to inputs, including fertilisers and pesticides.

Despite its poor performance, the CIS continues to be a high priority for the government for political reasons (at least in words), representing a 'waste of public money' according to some experts. The scheme is situated in an important area for the FRELIMO party, which is perhaps why the government simply cannot let it go. Opinions regarding the future of the CIS differ. For some the scheme continues to be a 'sleeping giant' that needs to be awoken through serious rehabilitation interventions (in the name of food security and poverty reduction), best if funded by foreign and/or private investors. Others believe that this outdated illusion of transforming the CIS into the granary of the nation should be abandoned and replaced by more realistic expectations and a coherent development strategy to benefit smallholders. The newly established INIR will play a key role in determining the future of the CIS, whichever direction this will take.

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Women working in the fields in Chókwè, Mozambique. In the Chókwè irrigation scheme 70 percent of farmers are smallholders with plots of less than 4ha. Women, who are the majority of small farmers, tend to own smaller plots of less than 2ha and cultivate rice and vegetables (Pellizzoli 2008).

Table 15: Factors influencing performance of the Chókwè Irrigation Scheme

		Barriers	Enabling factors
External	**Trans-boundary water rights management**	Limited information/data-sharing on water availability at the transboundary level, resulting in increased flood risk for downstream Mozambique; floods have repeatedly destroyed irrigation infrastructure in the CIS	Pressure from international donors and agencies on Mozambique and neighbouring countries to increase joint flood prevention strategies (particularly after 2000 and 2013 floods, but also in relation to climate change adaptation); better early warning systems established in Gaza Province and Chókwè District
	Donors/ IFIs	Piecemeal approach focusing on 'quick wins'; lack of coherent and integrated approach to rehabilitation of the CIS, and hence to its management and maintenance by HICEP and other stakeholders; lack of training and capacity building components	Funds from international donors have allowed the rehabilitation of part of the CIS which would have otherwise been entirely lost, allowing agricultural production to resume; project based interventions introduce new technologies and some capacity building of farmer associations
	Foreign investors	Investments aimed at profitability for the company, not benefit-sharing with farmers; project-based interventions with little long-term impact; risk of displacement and exclusion of small farmers from land (and water)	Introduction of new technologies and transfer of skills to local farmers (i.e. some capacity building)
National level	**Institutional coordination and capacity**	Confused and uncoordinated roles and responsibilities; frequent restructuring and loss of skilled staff; declining investments to the sector	Establishment of INIR and promulgation of irrigation strategy – renewed focus on irrigated agriculture as a tool for economic growth and pro-poor development
	Historical legacy and politics	Competing ministries, power struggles and prevalence of personal (political) interests over technical ones; CIS as a political project with a failure to see and address real management problems; destruction of infrastructure during civil war	Investments in irrigation infrastructure during the colonial era, including development of the CIS (although there was a lack of skills to maintain it once the Portuguese left); CIS continues to be prioritised by the government for political reasons
	Decentralisation	Incomplete decentralisation process leaves sub-national authorities with few resources to fulfil functions (and decision-making is still highly centralised in practice)	Decentralisation process gives more decision-making power to farmers (at least in theory)
Local/ scheme level	**Flooding and rehabilitation**	Floods, lack of maintenance and failure to rehabilitate extensive parts of the CIS; low productivity of the scheme; piecemeal approach to rehabilitation	Floods have attracted the attention of international donors and investors to the CIS, including for rehabilitation
	Inputs and markets	Limited access to credit and inputs but rising costs, weak extension service, poor market access (especially for rice) and lack of subsidies (for rice production); low productivity makes it difficult for farmers to go beyond subsistence agriculture	Ad hoc initiatives are occurring through PPPs to open market and credit opportunities for farmers (e.g. Saval initiative, initiated by HICEP and Moçfer Industrias Alimentares but now failed)
	Finance and management capacity	Concentration of responsibilities for land and water management in HICEP's hands (but with limited capacity); low coverage of water fee; HICEP not financially autonomous – dependent on government, donors and investors; conflicts with ARA-Sul	More integrated management of the CIS under HICEP; HICEP plays an important role in negotiating with and representing the interests of WUAs/farmers' associations
	Other	Theoretical possibility for HICEP to dispossess farmers from their land in favour of foreign investors	The CIS does have a great potential for agricultural production: good soil and fertility conditions, and the irrigation infrastructure is already present (although needs to be rehabilitated)

5.6 Conclusions

Chókwè Irrigation Scheme has clearly undergone an incredible evolution, its history intertwined with that of Mozambique over the last 50 years and more. Although irrigation has tended to occupy a fairly marginal position on the national agenda for much of this time, hopes remain that the sector could contribute to improved food security and help transform the national economy, given the right investments. The CIS is an illustration of how irrigation policies have evolved and been implemented over time, and what has gone wrong.

In theory the CIS represents an opportunity to harness river water in a semi-arid area for high-yield farming, close to an urban market (Maputo). Yet the viability of this scheme is undermined by technical difficulties, limited engineering capacity, high operation costs set against the limited commercial value of crops, and the unpredictable yet significant costs of flood damage. On the other hand there have also been some positive forces for change, or 'enabling factors' (Table 15). Interestingly, this case study has drawn out two opposing views in the sector: those who see huge potential in large-scale irrigation provided the job is done properly (i.e. using state-of-the-art technology and assuming good management); versus those who claim that, until capacity is developed, intermediate techniques, technologies or management options are the best that can be achieved.

The analysis highlights several emerging policy issues in relation to the irrigation sector in Mozambique today. Firstly, irrigation is proposed as a strategy to achieve food security in a context of increasingly uncertain water supply resulting from more frequent and intense drought and flood events, although interestingly the climate change discourse is not particularly prevalent in the sector. Moreover, smallholder farmers constitute the majority of the Mozambican population and remain a critical category to target for poverty reduction efforts. However, given the high costs and technology requirements involved, irrigation in Mozambique is mostly used for commercial agriculture, including private-public partnerships. Thus there appears to be a contradiction here between policy and practice, and it is not clear how future investments in irrigation will effectively contribute to improving the livelihoods of rural households.

Secondly, irrigation policy and investments in Mozambique are highly political. The government has not had a clear vision for the sector since independence, but has used it for political campaigning purposes, and most investment comes from external sources. As the CIS case study illustrates, the interests or agendas of powerful actors, including donors and foreign investors, have frequently been prioritised over practical considerations, such as technical feasibility or institutional capacity. This meant that interventions have not always been well thought through and the scheme has continued to underperform. There is also the risk of further marginalising certain social groups at the advantage of other, more politically powerful, ones.

Finally, the development of Mozambique's irrigation sector is plagued by serious questions related to financial and technical sustainability. The required investments to rehabilitate, operate and maintain the existing irrigation infrastructure and develop new schemes should be embedded in a coherent sector strategy, with the support of international donors and in partnership with private investors. Such a strategy would need to carefully balance multiple objectives (including food security and commercial agriculture development) and should be underlined by a serious political commitment. While there is a need to guarantee national ownership, the participation of smallholder farmers in decision-making is equally important for a scheme such as Chókwè to succeed. This model is recognised in theory, but poorly implemented in practice.

6 Discussion

6.1 The evolution of irrigation policy

A historical perspective reveals changing discourses relating to the use of (and rights to) land and water resources; the expected contribution of agriculture to national development; and the respective role of the irrigation sector. Interestingly, whilst Ethiopia, Morocco and Mozambique have followed unique political and developmental trajectories over the last few decades, there are some striking similarities in relation to irrigation policy (Table 16), partly reflecting Africa-wide trends. Importantly, past legacies continue to shape the sector today.

Broadly speaking, the 1950-60s were characterised by a drive for infrastructure development and agricultural modernisation in all three countries. An initial focus on the development of large centralised irrigation schemes was then followed by a shift towards integrated rural development in the 1970s and a preference for smaller farmer-managed (and farmer-financed) schemes. A decade later, economic crisis led to structural adjustment programmes imposed by the World Bank and IMF. Morocco was the first of these three countries to agree to a structural adjustment programme, including the adoption of neoliberal economic policies, in 1983. This led to significant declines in state and donor funding for agriculture, and reduced capacities for delivering extension services. Meanwhile, trade liberalisation and removal of constraints on the private sector encouraged private sector participation in irrigation. Favourable policies and access to affordable technologies, among

Table 16: Key changes in policy and investment in irrigation since the 1950s

	Ethiopia	Morocco	Mozambique
Pre-1950s	Modern imperial rule; feudal system of land tenure; little state support to agriculture; *some traditional irrigation*	French and Spanish protectorates; after the 1930s the mobilisation of water resources and agricultural modernisation are key policies; *investments in dams and irrigation structures; attempts to modernise traditional schemes*	Portuguese colony until 1975; land allocated according to customary rules to Mozambican peasant farmers
1950s	First five-year plan for national economic development, emphasis on infrastructure; *first private irrigation developments in Awash including FDI*	French protectorate continues to invest in water mobilisation *and irrigation*; Morocco gains independence in 1956	Economic expansion during the 1950s and 1960s; Portuguese settlers; investments in agriculture focus on exporting crops and profits to Portugal; *development of large irrigation infrastructure*
1960s	Second and third national plans; drive for modernisation of agriculture; capacity building in water and agricultural sectors, including establishment of an Awash Valley Authority; river basin studies; *further irrigation development in Awash (mainly commercial)*	1967 Royal Decree sets *ambition to irrigate 1m ha*; programmes of dam constructions and *large-scale centralised irrigation*	Imposition of Portuguese civil law over customary law to determine land rights (after 1961), but only a few farmers complied
1970s	Severe droughts; collapse of Imperial regime – socialism follows with centralised planning; land reforms; policy focus on rural development; *private irrigation schemes become state farms, little emphasis on small-scale irrigation(SSI)*	*Increasing state involvement in irrigation following the 1969 Agricultural Investment Code, which specifies rules to modernise agriculture and irrigation*	Declaration of independence in 1975; Portuguese flee the country; socialist model adopted – *irrigation schemes managed as state farms or producer cooperatives*; civil war begins in 1977
1980s	Drought; failing economy; *first real efforts to support SSI, including upgrading of some traditional schemes; farmer-management approach under producer cooperative model, but highly top-down and poor results*	Persistent drought; macro-economic crisis; structural adjustment; *move towards greater participation of water users in irrigation management, although with uneven results*	Civil war continues – destruction of infrastructure, drop in food production; failure of central state planning; divestiture of state enterprises; economic rehabilitation programme and structural adjustments; market-led agricultural policies; *focus on SSI and extension services*
1990s	Collapse of socialist regime; structural adjustment, ADLI, neoliberal policies and decentralisation follow; *mixed fates for irrigation schemes – some attempts to transfer management to farmers; some investment in SSI in drought-prone areas*	Drought episodes continue; publication of water law in 1995 in principle decentralises water planning and management to the basin level with creation of RBAs	Civil war ends in 1992; push to decentralise including in water and agricultural sectors; PROAGRI I and II (1998-2011) promote integrated approaches to agricultural development
2000s-now	Shifting policy emphasis from food security to agricultural commercialisation; ambition for middle income status by 2025; Green Economy Strategy; growing interest in groundwater development; *drive to provide household-level irrigation for all; increasing participation of private sector (from local farmers to FDI); ambitious plans for new irrigation projects e.g. in the Awash and Nile Basins*	Green Morocco Strategy places emphasis on commercial agriculture for export; National Water Strategy published; increasing policy focus on water demand management and delivering subsidies and *support for drip irrigation*; emergence of public-private investments	PRSPs; emphasis on food security and poverty reduction; promotion of smallholder sector; Green Revolution Strategy (2007) promotes smallholder commercialisation; *increased focus on investments in irrigation infrastructure to improve agricultural productivity, including through PPPs*

other factors, has led to expansion of irrigation by smallholder farmers, local enterprises and (to an extent) international investors.

Mozambique and Ethiopia share a number of features. First, state farms and producers' cooperatives were the main management models for irrigation schemes during their historical socialist periods (do Rosario 2012; Rahmato 2008). Producers' cooperatives were subsequently disbanded, with WUAs becoming the favoured model for community management, and most state farms have been privatised, although some irrigation schemes are still run by para-statal organisations. Second, over the last decade or so, development policy has focused on poverty reduction strategies. These initially stressed boosting smallholder production for food security, in which small scale irrigation played a minor role, but were later oriented to agricultural commercialisation with renewed interest in irrigation expansion (Mosca 2011; GoM 2010; Teshome 2006). Finally, the emergence of climate change on the development agenda has led both countries to produce strategies for green economic development. These include promoting certain forms of irrigation to mitigate greenhouse gas emissions and increase resilience to climatic variability.

In Mozambique and Ethiopia progress in expanding irrigation coverage has been slow and investment in the sector remains low (Box 7). In Morocco, by contrast, irrigation has been a significant area of state investment and support since the 1960s, and before that under the French protectorate. Consequently Morocco's irrigation sector is more extensive, modernised, commercialised and geared towards export. Interestingly Morocco is also less reliant on the agricultural sector in terms of contribution to GDP. There are nonetheless concerns regarding the impact of water scarcity and climate change on production, evident in government policies.

Box 7: Comparing irrigation coverage in Ethiopia, Morocco and Mozambique

Morocco has the lowest irrigation potential of the three countries – around 1.7m ha (FAO 2014b), compared to more than 3m ha in Ethiopia (Awulachew 2010) and Mozambique (FAO 2014b). Yet Morocco has made the most progress in expanding and modernising its irrigation sector. Low average rainfall and periodic droughts perhaps heighten the need to mobilise available water resources for agricultural production and reduce reliance on rainfed cultivation. The relatively early growth of the sector experienced under the French and Spanish protectorates also gave the country a head start. By 1954 Morocco had an estimated 355,800ha of agricultural land under irrigation (Houston 1954), whereas in Ethiopia the very first modern schemes were only just being built and the total area was still only 100,000ha in the mid-1980s (GoE 1984; this figure may not account for traditional schemes). Morocco has since benefitted from stable government, continued strong commitment to the irrigation sector and relatively high human capacity. By 2011 the area equipped for irrigation had reached nearly 1.5m ha (FAO 2014b), more than double that of Ethiopia which was irrigating 640,000ha the previous year (Awulachew 2010). Meanwhile, Mozambique's irrigation sector grew under Portuguese rule, reaching 100,000ha of land for rice and sugarcane production in 1973 (Mosca 2011), but with little subsequent progress. By 2005 a mere 118,000ha was equipped whilst only 40,000ha was actually being irrigated (FAO 2014b).

6.2 *Drivers of policy change*

In Ethiopia, Morocco and Mozambique irrigation policy has historically served agricultural and/or water policy. These in turn serve a number of different social, economic and political goals, including food security, economic growth and rural poverty reduction. Whilst these fundamental goals remain relatively unchanged, approaches to achieving them have differed through time. Policies for irrigation are contingent on the dynamics of this broader policy environment and shaped by multiple objectives, not always towards coherent positions. Both national and sectoral policies have been driven by factors such as political and ideological change, macro-economic conditions, donor agendas, political projects and climate or environmental concerns.

Political and ideological change

Although Morocco has seen significant policy shifts since independence in 1956 it has been politically stable when compared to Ethiopia and Mozambique. In these two countries, changes in government and associated ideological shifts have had a strong, at times disrupting, influence on agricultural policy. Moreover, political change and social upheaval have had more direct implications for irrigation practice, for example leading to the abandonment of projects or transfer of ownership and management responsibilities. Frequent changes in direction and uncertainties regarding the enforcement of policies, rights and regulations for land and water resources also serve to weaken incentives for smallholder farmers and private companies to invest in irrigation development.

Macro-economic conditions

Structural adjustment measures in the 1980s and 1990s, which were implemented following fiscal crisis, had profound implications for key sectors of the economy and repercussions for irrigation policy and development. For example, in Morocco following structural adjustment, a freeze on public sector recruitment diminished the

state's capacity to deliver agricultural extension services. The process of transferring management and financial responsibilities for irrigation schemes to farmers was partly driven by the need to reduce the burden on the state. 'Rolling back the state' coupled with market liberalisation has also enabled participation of the private sector. In Mozambique, for instance, the government has actively encouraged foreign investors in biofuel production. In Morocco the reduction of trade barriers opened the door for international trade, in particular supplying early harvest products to European markets.

Donor agendas

Over the last 50 years donors and international finance institutions have shaped the irrigation sector throughout Africa in directing funds and providing expertise and technology transfer. Of the three case study countries, donors and IFIs appear to have played a particularly decisive role in Mozambique, although sources of finance have shifted. Although Western donors tend to dominate, the Soviet Bloc was particularly influential in Mozambique post-independence, whilst in recent years support has come from new sources such as China and Brazil. Donors and IFIs have at times been actively involved in implementing new policy. For example, in Morocco during the 1980's the World Bank played a significant role in the transfer of irrigation management from state agencies towards community-based approaches. Interestingly, in Ethiopia donor influence is thought to have caused less distortion to the economy than in many other African countries (Brown and Teshome 2007).

Political projects

Technical and economic considerations have at times been overridden by political agendas. Firstly, there is often a bias towards high-profile public investments. Mozambique's Chókwè Irrigation Scheme has symbolic value as 'the granary of the nation', but is costly to manage and widely considered to be a wasted investment, at least in its current form. The government continues to promote commercial rice production at Chókwè, whilst according to farmers this is unprofitable. Similarly in Ethiopia, there is a tendency to prioritise relatively large modern irrigation developments, which are politically visible, without adequate attention to feasibility. Secondly, policy capture means that investments often serve the interests of powerful groups. In Morocco's Souss Massa basin, potential benefits to elites appear to have played a significant role in determining some irrigation investments, reflecting internal political relationships and dynamics.

Climate and environmental concerns

Climate change, extreme events, environmental issues and water scarcity have recently come to the fore in international debates. However, Morocco and Ethiopia in particular have long suffered from periodic droughts that can leave lasting impacts on local livelihoods and the economy. Hence the desire to better manage variable water resources and address food insecurity has had a strong influence on national policy and planning, and more directly on irrigation policy and practice. In Ethiopia, for example, the first public investments in smallholder (communal) irrigation focussed exclusively on semi-arid drought prone areas. In fact, the imperial regime's inability to deal with drought and famine came to be associated with revolutionary change and hence tackling these issues remained a core component in the policies of successive governments.

6.3 From policy to practice

The case studies have shown that changes in irrigation policy are mirrored in the histories of particular schemes, such as Chókwè in Mozambique, and can result in the co-existence of multiple forms of irrigation, for example in the Awash Basin in Ethiopia or Souss Massa in Morocco. However, these cases also demonstrate that irrigation practice is determined by multiple factors and not government policy alone. Moreover, determining the causal relationship between irrigation policy and practice is extremely difficult due to feedback effects and confounding factors. Firstly, it is evident that drivers of policy change at national level, such as ideological shifts or donor agendas, have more directly shaped the development of irrigation schemes and their performance (see 6.2 above). Other trends such as growth in domestic markets (e.g. Awash Basin, Ethiopia), new opportunities afforded by global trade (e.g. Morocco) and increasing interest from the private sector (e.g. Mozambique) have also driven changes at both levels. Secondly, policies are informed by practice and performance outcomes, for example availability of new technologies or lessons learned regarding different forms of management.

Policy and practice have essentially co-evolved in response to contingent factors and events. For example, during the 1980s drought exacerbated Morocco's macro-economic problems that eventually led to structural adjustment. Around the same time cheap imported technologies became more accessible to local farmers, improved infrastructure provided better access to markets and new neoliberal policies facilitated global trade (Faysse et al. 2012; Doukkali 2005). It was the convergence of these factors and events that drove changes in the irrigation sector.

6.4 The performance of irrigation schemes

The relationships between policy, practice and performance are further complicated by the fact that irrigation schemes are often expected to contribute to multiple objectives. For instance, Wonji Sugar Estate in Ethiopia has ambitions to meet national sugar demand

and begin exporting high value products, whilst claiming to provide local social benefits in the form of income, housing and services. In such cases, there are likely to be trade-offs given resource constraints; objectives may not be coherent; and priorities tend to change over time. Another important consideration is that individual actors have different goals which determine both their actions (practices) and their understanding of performance. For example, farmers in Morocco may be more concerned by personal profit; scheme managers by agricultural production totals; and basin planners by limiting water withdrawals. Performance therefore depends on one's perspective.

In the case studies investigated, little evidence was found that irrigation performance was being evaluated objectively in terms of progress towards (or contribution to) a set of stated objectives. Instead the management of irrigation schemes was primarily driven by narrow operational concerns and with little opportunity for those engaged in management or policy to draw strategic, system-wide lessons. This obscures understanding of potential trade-offs between different objectives for irrigation, and how individual farmers attempt to maximise their returns and benefits.

Given that objectives varied between cases and were often poorly defined, the following discussion of scheme performance is structured around a broader set of goals identified in the irrigation literature: increasing agricultural output; using water productively; ensuring the long-term sustainability of investments; and, ultimately, contributing to poverty reduction and socio-economic development.

Increasing agricultural output

Since the green revolution irrigation has been viewed as a key component of agricultural modernisation and the production of higher yields, essential to increasing food security at household and national levels and to generating exports. Chókwè Irrigation Scheme in Mozambique, for example, is thought to have the potential to produce rice at yields approaching those of the Nile Delta, which raises the question of why it does not.

The case studies show that there are aspects of irrigation systems and their management that contribute to unmet potential in terms of agricultural productivity. In particular there are challenges around water use, cost recovery and reinvestment in maintenance (discussed below). Irrigation itself, however, is just one dimension to achieving and sustaining higher agricultural productivity. The research found numerous other factors affecting performance, including the availability of agricultural inputs, technical knowledge, appropriate and functioning institutions, land fragmentation, access to markets and environmental factors such as soil degradation and the impacts of droughts or floods. Many of these relate to broader issues of land and water governance, institutional capacities and incentives or deficiencies of the wider agricultural system, rather than irrigation *per se*.

To illustrate, Chókwè was developed to produce rice and initially the scheme was able to exploit favourable climate and hydrological conditions; yields were high. Yet productivity has declined significantly since the 1970s, with important factors including poor management and lack of infrastructural investment to ensure continued water delivery (Kajisa and Payongayong 2011). However, also to blame are external factors such as political upheaval and civil war; changing policies and reforms; political biases; and incomplete decentralisation processes. Smallholder farmers complain that limited access to means of production (seeds, fertilisers, pesticides and machinery) and problems accessing markets, including competition from cheap food imports, have affected production. As a result there are limited incentives for commercial agriculture and farmers predominantly grow crops for subsistence.

In Ethiopia, Morocco and Mozambique irrigation is also promoted as a means to stabilise production in the context of a variable and unpredictable climate, yet production may still be vulnerable to climatic extremes. In Chókwè, flooding has repeatedly damaged infrastructure, significantly reducing the irrigated area. Better data sharing between riparian states would help reduce this vulnerability, but systems to translate early warnings into effective responses and mitigation measures are also required. In Morocco, irrigation has been promoted as a means of building resilience to drought. However, agriculture remains vulnerable to multi-year droughts, when stored water is prioritised for urban drinking supply rather than irrigation, and water-intensive crop production has depleted groundwater reserves. Similarly, in Ethiopia rainfall variability is often not adequately factored into scheme design and management resulting in fluctuations in yields.

Using water productively

Surface irrigation systems remain the dominant design and technology in much of Africa. However, as they are prone to 'lose' water (through evaporation, seepage and runoff) these systems are often viewed by engineers as ineffective and undesirable, particularly in areas of water scarcity or where water is conveyed over long distances. A common prescription is to invest in modern pressurised systems such as sprinkler or drip irrigation to more carefully regulate water use. These investments are expected to result in increased water productivity (crop per drop) and 'free up' water for other, higher-value, uses. However, in reality things are more complex, as illustrated by the examples below (see also Perry 2011).

Of the three countries, Morocco has made the most progress in adopting new technologies. Old schemes are increasingly being converted to sprinkler or drip irrigation, and all new schemes use modern technologies. However, smallholders don't have enough land to recoup investments in equipment, and there are barriers to accessing subsidies offered by the state. Further, individual farmers accrue more benefits from increasing water productivity than reducing their total withdrawals. Therefore investments in modern irrigation have often been followed by adoption of (higher value) water intensive crops and expansion of the irrigated area. Poorly maintained equipment also negates the potential benefits of modern technologies in reducing water losses from the network. The combination of these factors means that it is not clear whether drip irrigation is leading to a net reduction in water use at scheme level.

In Ethiopia there are some signs of modernisation in technology. Most examples found in the Awash River Basin were private initiatives. Although Wonji Sugar Estate is introducing sprinkler systems in new outgrowing areas, other publically funded developments such as Fentale are surface systems. For smallholder farmers access to new technologies remains difficult, and the government does not appear to be promoting the use of pressurised irrigation systems. Moreover, evidence suggests that many farmers do not monitor their water use, nor are they charged by the authorities for withdrawals, despite increasing scarcity in some areas. Although alternative technologies can contribute to increased water productivity, other incentives should also be employed to improve water management practices, such as better monitoring and regulation.

Sustainable management

To continue providing water services over the longer term, irrigation schemes must be managed effectively. This requires sufficient resources (financial, material and human) and appropriate incentives to invest in operation and maintenance. In the cases examined this was identified as a key challenge to performance, particularly for state-run or farmer-managed schemes. In Chókwè, for example, the state agency HICEP is expected to generate revenue for operations and maintenance from water users, but in practice severe flooding and low productivity of the scheme has meant that fee collection has been low whilst costs are very high. Incomplete decentralisation processes have also left sub-national authorities such as HICEP with limited resources to fulfil their functions. This creates dependency on central government and donor funds and exposure to external pressures, which serve to undermine the authority of the agency.

In Morocco, the state-managed scheme (Issen Modern) experiences frequent interruptions in services due to the agency's limited ability to operate and maintain the system, while the farmer-managed scheme (Issen Traditional) requires significant support from the state to collect fees and engage in maintenance. The WUAs have not been highly successful, partly due to constraints on forms of organisation imposed by the government, but also due to reduced extension services following structural adjustment in the 1980s. In contrast, the public-private scheme (Guerdane) has extremely high operation and maintenance standards, high levels of cost recovery and negligible interruptions to supply. The private company has sufficient finances and trained staff, and is motivated by profit. When farmers experience a disruption in service the company has to pay compensation. These kinds of incentives are often absent in public schemes.

In the Ethiopian case studies the pattern was similar: private irrigation generally appeared to be better managed than public schemes. At Wonji Sugar Estate (a state enterprise) production is centrally managed. Shortages of skilled manpower, machinery and funds have been a problem in the past, particularly during the socialist era. Extensive rehabilitation of storage reservoirs and canals is urgently required, but suspending sugar production in large areas of the scheme would be economically and politically costly. However, there are also exceptions. The WUA at Melkayida (near Wonji), for example, appears to have benefitted from inherited infrastructure, machinery and technical know-how passed on from the socialist period.

For state-led developments, the difficulties in recovering costs can be attributed to broader issues in the sector – a preference for relatively high-cost approaches (high-profile modern developments) coupled with frequent underestimation of technical challenges, overestimation of management capacities and inattention to market conditions. The lack of consideration given to 'software' elements in project design can also result in poor alignment with local institutions and, indeed, farmers' needs. This was particularly evident in Ethiopia and Mozambique. On the one hand, objectives are set by high-level bureaucrats and practical considerations are often undermined by political projects (see 6.2 above). On the other hand, engineers continue to dominate the sector. Farmers have little opportunity to participate in decision-making processes. Moreover, there appears to be reluctance among government experts to acknowledge and learn from the successes of farmer initiatives, perhaps because smallholders are considered ignorant or their technologies rudimentary.

Environmental sustainability is another dimension that needs to be factored in when planning and managing irrigation projects. Declining yields due to waterlogging and salinisation were noted at Chókwè Irrigation Scheme in Mozambique, caused by infrastructural decay and poor water management. However, problems can also originate outside the scheme. At Wonji Sugar Estate,

Ethiopia, sedimentation of water storage reservoirs is a serious concern, attributable to catchment degradation, and major rehabilitation is now required. In the upper Awash Basin there are also concerns that agricultural, industrial and domestic pollutants found in the water being used to irrigate food crops, particularly vegetables, could have negative health implications. Yet to date there has been little effort to assess or mitigate such risks. Finally, irrigation can have negative externalities. For example, intensive production also requires the use of inputs such as fertiliser and pesticides that bring associated risks to water users downstream. Appropriate incentives are needed to mitigate such risks.

Poverty reduction and development

Many irrigation investments have been justified in terms of rural poverty reduction or contribution to the broader economy, for example through export revenue. However, results have been mixed and there are often trade-offs involved. For example, in Morocco investments in centralised control irrigation, such as drip or sprinkler systems, are promoted to increase water productivity but can also reduce labour requirements. This can benefit the farmer or owner but have negative impacts on the income of agricultural labourers.

In addition to the performance challenges discussed above, more research is needed to understand the distribution of the benefits arising from commercial irrigation (e.g. employment, subsidies, revenue through taxation). In Morocco, land supplied by the Guerdane irrigation scheme has increased in value tenfold since the scheme began in 2009, which is cited as an indicator of commercial success by the scheme operator. These figures are encouraging the state to consider further public-private investments in expensive desalination options to meet demand. However, critics have raised questions about the economic and social returns on public investment, and the social costs of increased demand for scarce water. Speculation in land values has also had negative impacts on local small farmers who are effectively priced out of the market.

In the Awash River Basin conversion of pastoral grazing areas into irrigated cotton or sugar plantations has been a longstanding source of conflict as local livelihoods have been negatively affected by the loss of access to precious land and water resources (Behnke and Kerven 2013; Tiruneh 2013). In fact unclear or poorly enforced land and water rights are a significant risk for smallholder farmers and private investors alike. Although land reforms in Ethiopia are intended to strengthen the rights of local communities, successive redistributions have exacerbated fragmentation and created uncertainty. There are also concerns over the negative social impacts of land acquisitions in all three countries associated with the push for private investment. For example, some investments in Morocco, such as the Guerdane scheme, have mobilised water supplies for new irrigation projects without accounting for traditional users' customary rights, which have a complex legal status.

On the other hand, there are also cases where commercial government or private irrigation developments aim to provide direct benefits to rural households, albeit with varying degrees of success. For example, Wonji Sugar Estate in Ethiopia seeks to provide farmers with a stable income and source of employment, and to a limited extent infrastructure and services, although farmers reported that these benefits are not uniform. Similarly Merti-Jeju, a private farm, claimed to provide employment and benefits in the form of skills transfer. Further research is needed to better understand the incentives and opportunities for private sector investors to contribute towards food security and poverty reduction in addition to maximising profits. Finally, the extent to which large commercial irrigation schemes contribute to the economy in terms revenue is unclear. In the case study countries governments have implemented policies to incentivise private investment in irrigation such as tax breaks, cheap land leases or subsidies for new technologies, which could potentially serve to negate the economic benefits of such developments.

6.5 Emerging issues for future policy

This paper has looked at the history or irrigation policy and practice in Ethiopia, Morocco and Mozambique to shed light on past performance. But what does the future hold? Three inter-connected policy debates emerge from the literature and case studies, namely: 1) modernising irrigation systems; 2) governing increasingly scarce water resources; and 3) the role of the state versus the private sector.

Modernising irrigation systems

In light of the significant financial and human resource constraints experienced by many African countries, effective allocation of public investments is important. When investing directly in irrigation systems there are generally three options: build more, rehabilitate existing infrastructure or undertake reforms (technological or managerial). The objective in each case should be to ensure that irrigation services are (more) resource-efficient, responsive to farmers' needs and equitable. In this sense Plusquellec et al. (1994) argue for new approaches to the design and engineering of irrigation projects.

In Ethiopia and Mozambique the current drive in irrigation is predominantly for new infrastructure investments and, to an extent, rehabilitation, given low coverage figures and potential to harness untapped water resources for productive uses. However, although these countries do suffer from chronic underinvestment

in this regard, there is clearly an even greater challenge in operating existing installed capacity beyond the small-scale. Tackling underlying causes of poor performance, including issues relating to design and construction, should be paramount, as they are equally likely to undermine new investments. In large-scale irrigation schemes such as Chókwè, more integrated approaches to combat drought, floods and salinity are perhaps needed, for example. In modernising small-scale irrigation, particularly traditional schemes, the challenge is often to improve performance (such as increasing yields or improving water productivity) without compromising sustainability (FAO 2011). This requires closer attention to local context and farmer needs.

Modernisation is best understood as a continuous process of adapting to changing agricultural and socio-economic contexts (Renault 1999). In Morocco, extensive exploitation of surface and groundwater resources have mobilised nearly all the available supply in this increasingly water scarce country. As demand continues to grow, debates have shifted to concerns about water scarcity and environmental constraints. Reform is high on the agenda with policies emphasising demand-side management, use of modern technologies and greater water productivity. In many ways Morocco is simply a step ahead of Ethiopia and Mozambique.

Governing scarce water resources

Water supplies have natural limits, and growing demand can exacerbate existing scarcities. As noted above, water scarcity is a key driver of irrigation policy in Morocco, and is likely to become an increasingly pertinent issue for Ethiopia and Mozambique in future. As demand for water increases for drinking water and other economic uses, agriculture can come under pressure to reduce water consumption and use water more productively. On the other hand, investments in irrigation are often promoted to mitigate the impacts of climate variability, particularly unpredictable rainfall and drought, on production (discussed in Box 8).

A common prescription for improving water productivity and reducing 'wastage' is to introduce new technologies, such as drip irrigation. As alluded to above in the Moroccan case, however, this does not necessarily result in reduced agricultural water demand. Moreover, in a closed system such as Souss Massa, the argument against surface irrigation can be overstated as it does not reflect return flows to groundwater that can be reused downstream (recoverable losses). At the Guerdane scheme every user is on drip irrigation and network losses are very low, but if every scheme followed this example the aquifer level would drop rapidly.

Evidently, interventions at scheme level have their limits in addressing water scarcity. There is a need to consider water allocation and use at multiple levels – farm level, scheme level and basin level. Ultimately there will be trade-offs between competing water users as demand continues to grow beyond the 'natural' limits of resource mobilisation. How trade-offs are managed and who benefits are tricky questions. Good governance and equitable allocation of natural resources are often undermined by political and institutional factors.

In Ethiopia and Mozambique, particularly, there appears to be little capacity or inclination to limit water abstractions or charge for water, and the linkages between land and water governance are largely absent. In the Awash River Basin (Ethiopia) it was clear that the lack of regulation, growing demand for water and uncoordinated interventions could undermine the sustainability of irrigation schemes in future, particularly those downstream. Expansion of urban areas and industry onto agricultural land also poses a threat to some farmers. Moreover, there is emerging evidence in Ethiopia that weak enforcement of land laws and power imbalances has left some local communities at risk of losing usufruct rights to land and water resources to private investors, including in the Awash River Basin. Bossio et al. (2012) argue that safeguards are needed to protect local communities and downstream water users, and local water scarcity should be a strong consideration in regulating land leases.

Morocco perhaps has the stronger institutions, including greater human capacity, and there have been attempts to integrate water, agriculture and energy policy and planning, and make decision-making more inclusive. However, like Ethiopia and Mozambique, coordination is poor and questions have be raised regarding objectivity and transparency in managing conflicting water uses. These issues are particularly a challenge for areas relying on groundwater either wholly or for conjunctive use, such as Guerdane and Issen in Morocco, due to the specific problems of monitoring and managing this hidden common pool resource. Similarly, there are questions around elite capture of water resources, such as for commercial agriculture. Although often justified as an economic necessity or in terms of modernisation, it is frequently smallholder interests that are sacrificed for the 'greater good'.

Mozambique is not currently considered water scarce, but imbalances of power can similarly dictate access to resources. For example, as in Ethiopia, there are concerns that foreign direct investments in irrigation could jeopardise the rights of local farmers to land and water. Moreover, competition for water is likely to increase in future, both at local and regional level. Mozambique is a downstream riparian state dependent on powerful upstream neighbours for the water it receives. The Limpopo River, on which the Chókwè Irrigation Scheme relies, is heavily utilised by Zimbabwe, Botswana and South Africa and upstream abstractions are projected to grow; thus, tensions could arise over transboundary water allocations and management. In fact localised

conflicts already occur in the lower Limpopo Basin (within Mozambique) during dry periods, with commercial farmers taking priority over smallholders.

State versus private sector

Given the poor performance of public investments, whether in state or farmer-managed systems, one might ask whether the job of developing and operating irrigation systems is best left to the private sector. Evidence cited above supports the view that private irrigation schemes tend to be better managed and maintained than state schemes. Certainly there is growing participation of the private sector, both formal and informal, in these three countries, associated with the introduction of neoliberal policies following structural adjustment and opportunities offered by domestic or global markets. Governments have made concerted efforts to attract foreign direct investment in agriculture. Meanwhile, the local private sector has expanded rapidly in Morocco and is also growing in parts of Ethiopia and Mozambique, including entrepreneurs in small-scale irrigation.

Box 8: Irrigated agriculture is not inherently climate resilient: lessons from Morocco

Irrigated agriculture is frequently touted as a means to better cope with climatic variability and change, considered more resilient that traditional modes of production which are highly dependent on (unpredictable) rainfall. However, the relationship between irrigation and climate resilience is complex and not necessarily a positive one. In Morocco, private uptake of groundwater irrigation has partly been driven by demand for supplementary irrigation during droughts. Surface water irrigation can also help mitigate short-term declines in rainfall. However, in many areas demand has expanded to meet supply. Groundwater, particularly, is a common property resource and often over-exploited as farmers irrigate more and more land, with more water intensive crops, year round. For some communities, aquifer depletion has equated to the loss of strategic reserves during periods of drought.

Another caveat is that while irrigation can help to mitigate seasonal dry periods or short-term droughts, farmers are still vulnerable to longer-term declines in rainfall or persistent droughts. In Morocco irrigation dams are usually multi-purpose and will continue providing water during the first year of drought, after which supply is prioritised for urban drinking water. The prolonged drought of 2001-2003 meant that, in Souss Massa, dams dried up. Yet many farmers had committed to planting more valuable water intensive crops (such as citrus) based on the assumption that irrigation water would be available. Perennial crops such as citrus are particularly prone to 'lock-in' as they take several years to mature. Not only are many irrigation schemes designed and used based on average rainfall, hence relying on stable water supplies, but farmers also have little incentive to limit their abstractions. In a good year, returns are high. But when rains repeatedly fail, losses can be considerable. This includes off-farm losses, for example establishing supply chains or investments in processing.

While few argue that state agencies can effectively manage irrigation schemes unilaterally, effective governance and state regulation remains important. Firstly, as discussed above, regulation of land and water use is essential to ensure sustainability and manage trade-offs between users. Decisions regarding trade-offs should be made explicit, particularly where livelihoods are at risk, but in reality are often opaque. Groundwater abstractions and the activities of the informal sector are particularly difficult to govern, requiring new approaches. Fundamental changes to the rules governing water resource management, including reforms to institutions, rights, incentives and accountability mechanisms, may have to be made.

A related, second, issue is that of elite capture. Appropriation of land and water resources by private investors is often justified by the need to develop commercial export agriculture for national economic growth, yet it is frequently at the expense of smallholder interests. Elite capture can also occur in state projects, as the case studies have shown. Principles of good governance need to be enshrined in national laws, policies and regulations. The state has an important role to play in safeguarding the rights of local communities, as well as ensuring that commercial agriculture contributes (directly or indirectly) to economic development, for example through employment generation or revenues from taxation.

Thirdly, investments in irrigation can be risky, and without an appropriate enabling environment to support efficient risk taking the private sector is unlikely to flourish. Government investment in large infrastructure such as roads, electricity and dams for water storage, for example, may be an essential prerequisite for irrigation expansion in many parts of Africa. There is also a need to address market failures, for example in the provision of agricultural inputs or financial services, which usually hit the poor hardest. Measures to do so will require a process of active learning and tailoring (Wiggins and Keats 2014).

Box 9: Public-private partnerships

One model for private sector participation, found in the Morocco and Mozambique case studies, is the PPP model. PPPs come in a variety of forms and include private sector provision of inputs and services. In Guerdane (Souss Massa, Morocco), for example, provision of water for irrigation is viewed as a service for which farmers pay, and if they don't pay they risk losing their water supply to other customers. In return, the private company is expected to keep network losses to a minimum and ensure that there are no interruptions in service. However, the private partner neither addresses effective water management at farm level nor supports farmers to maximise yields. Besides, this PPP model may not work for non-commercial (subsistence) agriculture where farmers lack the means to pay for services. Irrigation development to meet food security objectives may, in some cases, require state subsidisation.

7 Conclusions

Africa continues to lag behind other developing regions in expanding and intensifying agricultural production and, related to this, developing its irrigation sector. Past investments in irrigation have yielded mixed, frequently disappointing, results. Yet there are cases where schemes have performed well. Future policymaking and practice should be informed by these experiences, which requires concrete evidence of what works (or not), why and where.

This paper has provided insights into the evolving policies and practices that have shaped irrigation performance over the last 50 years in three African countries - Ethiopia, Morocco and Mozambique. A review of national (sector) level trends was complemented with short case studies of specific irrigation schemes. Evidence was drawn from the literature, supplemented by in-country key informant interviews and rapid site visits.

Historical legacies shape the irrigation sector today

Ethiopia, Morocco and Mozambique have followed unique political and developmental trajectories over the last few decades, yet there are some striking similarities in irrigation policy and hence practice. These partly reflect Africa-wide trends, namely: the initial emphasis on large-scale infrastructure development (1950s and 1960s), a move towards irrigation management transfer (1970s onwards) and structural adjustment/market liberalisation policies (1980s onwards). Ethiopia and Mozambique share other common features, such as a socialist past. These historical legacies continue to shape the irrigation sector today.

Morocco has made the most progress in exploiting its irrigation potential

The relatively early growth in irrigation experienced under the French and Spanish protectorates perhaps gave Morocco a head start, which has been followed by a strong, political stable, centralised state with a commitment to further developing the sector. Morocco is also water scarce, which heightens the need to mobilise water resources for agricultural production. Ethiopia and Mozambique have undergone several regime changes and social upheaval in recent history, whilst irrigation has played a relatively marginal role in agricultural policy. The lack of financial and human resources devoted to irrigation, and poor coordination between agencies responsible for managing land and water, have been ongoing challenges.

Irrigation policy is contingent on broader societal goals and change processes

As in many countries, irrigation policy in Ethiopia, Morocco and Mozambique has historically served agricultural or water policy, which in turn serve a number of different socio-economic development goals. Thus irrigation policy is contingent on dynamics of the broader policy environment and shaped by multiple, sometimes conflicting, objectives. Although fundamental development goals have changed little in the last 50 years, approaches to achieving them have evolved. In Ethiopia, Morocco and Mozambique changes in policy have been driven to differing extents by: political and ideological shifts; macro-economic conditions; donor agendas; political projects; and climate or environmental concerns. It is often the convergence of various longer-term drivers and shorter-term events that prompts change.

Irrigation policy and practice have co-evolved

The analysis has shown that changes in irrigation policy are mirrored in the histories of particular schemes, such as Chókwè in Mozambique. Past legacies can also result in the co-existence of multiple forms of irrigation. However, the relationship between policy and practice should not be oversimplified. Irrigation practice has been shaped by processes at multiple levels, which often overlap. In the cases presented, several of the factors driving policy change at national level, such as donor agendas or political projects, have more directly played a role in the development of particular schemes. In turn, policies have been affected by irrigation practice and performance outcomes. Policy and practice have essentially co-evolved.

Performance is often not evaluated objectively

In the case studies investigated little evidence was found that the performance of irrigation schemes was being evaluated objectively in terms of progress towards a stated objective. Instead the management of these schemes was primarily driven by narrow operational

concerns and with little opportunity for those engaged in management or policy to draw strategic, system-wide lessons. This obscures understanding of potential trade-offs between different objectives for irrigation, and of how individual farmers attempt to maximise their returns and benefits.

Enduring challenges remain

In the absence of clear objectives, it is useful to assess and compare the performance of schemes against broader policy goals for the irrigation sector:

- **Increasing agricultural output:** While there are aspects of irrigation systems and their management that contribute to unmet potential, irrigation itself is just one dimension to achieving and sustaining higher agricultural productivity. The case studies have revealed numerous other factors affecting performance, including the availability of agricultural inputs, technical knowledge, appropriate and functioning institutions, land fragmentation, access to markets and environmental factors such as soil degradation and the impacts of droughts or floods. Many of these relate to broader issues of land and water governance, institutional capacities and incentives or deficiencies of the wider agricultural system, rather than irrigation *per se*.

- **Using water more productively:** Surface irrigation systems predominate in Africa yet are often viewed as wasteful and undesirable. Morocco has made the most progress in adopting modern technologies, namely sprinkler and drip irrigation systems. However, many smallholders don't have enough land to recoup investments in equipment, and there are barriers to accessing subsidies offered by the state. Further, investments in drip irrigation have often been followed by adoption of water intensive crops and expansion of irrigated area, whilst poorly maintained equipment negates potential benefits. Hence policies to promote specific technologies are clearly not sufficient to manage agricultural water demand.

- **Ensuring the long-term sustainability of investments:** A lack of finance and human capacity for operation and maintenance was a key factor contributing to poor performance in the case studies examined, particularly in public or communal schemes. The difficulties in recuperating capital and running costs can partly be attributed to broader sector issues: the pursuance of relatively high-cost approaches, frequent underestimation of technical challenges, overestimation of management capacities and/or lack of attention to market conditions. Moreover, irrigation users have little voice in the planning process. Greater attention is needed to local institutions, farmer priorities and successful low-cost innovations.

- **Contributing to poverty reduction and socio-economic development**: The outcomes of public investments in irrigation have been mixed and the contribution of the private sector to societal goals requires greater scrutiny. Commercial enterprises can offer direct benefits to local communities, such as employment or training, but profit remains the primary objective. Private irrigation developments can also undermine local livelihoods where regulation is weak. Meanwhile governments have implemented policies to incentivise private investment in irrigation such as tax breaks, cheap land leases or subsidies for new technologies, which could potentially serve to negate the indirect economic benefits of such developments if not carefully managed.

Policymakers have some difficult decisions to make

Three interconnected policy debates have emerged from the literature and case study analysis:

- **Modernising irrigation systems:** Many African countries face significant financial and human resource constraints, so effective allocation of public investments is important. The objective of system-level investments should be to ensure that irrigation services are (more) resource-efficient, responsive to farmers' needs and equitable. In Ethiopia and Mozambique the current drive is predominantly for infrastructural expansion, yet tackling poor performance in the sector should be paramount. Underlying governance issues are equally likely to undermine new investments. Morocco is a step ahead – reform is high on the agenda and significant progress has been made in modernising the sector, although challenges remain in managing agricultural water demand and coordinating across sectors. Modernisation is best understood as a continuous process of adapting to changing agricultural and socio-economic contexts.

- **Governing scarce water resources:** Water scarcity is a key driver of irrigation policy in Morocco, and likely to become an increasingly pertinent issue for Ethiopia and Mozambique in future. As the Morocco case illustrates, technological interventions have their limits. There is a need to account for water

at multiple levels – farm level, scheme level and basin level. Ultimately there will be trade-offs between competing users. How these are managed and who benefits are political questions and decision-making processes are often opaque. Legal safeguards are needed to protect local communities and downstream water users. Increased capacity to monitor abstractions, better coordination and integrated sector planning could also help ensure that decision-making is equitable.

- **State versus private sector:** Given the poor performance of public investments, one might conclude that irrigation development and management should be left to the private sector. However, it is argued that the state still has an important role to play in governing the irrigation sector: 1) to ensure the sustainable and equitable development of land and water resources; 2) to ensure that commercial agriculture contributes (directly or indirectly) to economic development; and 3) to provide an enabling environment for investments and address market failures.

Future research

The rapid decline in donor funding for irrigation from the 1970s onwards was not restricted to technical interventions, but also had implications for scientific study, monitoring and measurement. The lack of reliable data with which to make objective assessments, or test new concepts, continues to hinder advances in both irrigation theory and practice. Funding for longitudinal multi-disciplinary studies of irrigation performance would generate more robust evidence regarding 'what works, why and where'. Further research is also needed to understand causal linkages between indicators at different scales of analysis or decision-making, and explore the potential trade-offs involved.

The review has touched on a number of additional topics that would merit further research. The authors have challenged the assumption that irrigation is inherently climate resilient, citing evidence from Morocco. When does irrigation contribute to resilience, for whom, over what time-scales and under what conditions? They also noted the emergence of the private sector and PPPs in African irrigation. What incentives are there for the commercial irrigators to provide social benefits? Are local entrepreneurs more likely to support their communities than external investors? Are there common features of successful PPPs? Can PPPs work for subsistence agriculture, and in what form? These would be interesting questions to explore further.

End Notes

1 EAU4Food seeks to address the need for new approaches to increase food production in irrigated areas in Africa, while ensuring healthy and resilient environments. To this end, transdisciplinary research is being conducted in five irrigation sites in Ethiopia, Mozambique, South Africa, Tunisia and Mali. The project is led by *Stichting Dienst Landbouwkundig Onderzoek* (Alterra, Wageningen University) and funded by the European Commission. For further details and a full list of project partners please visit the website. *http://www.eau4food.info/*

2 http://www.fao.org/nr/water/aquastat/data/glossary/search.html

3 The AVA later became the Awash Basin Authority, responsible for Integrated Water Resources Management in the basin. The River Basin Councils and Authorities Proclamation (Proclamation 534/2007) was approved by the Ethiopian Council of Ministers in 2007 to authorise the establishment of River Basin High Councils (RBHCs) and River Basin Authorities (RBAs) for each of Ethiopia's major river basins.

4 Initially called the Coordinating Committee of the Armed Forces, Police, and Territorial Army.

5 State control over the populace has arguably increased under the EPRDF (see Rahmato 2008 and Berhanu 2012 for further discussion).

6 ADLI can be broadly defined as 'a development strategy which aims to achieve initial industrialization through robust agricultural growth and close linkages between domestic agriculture and domestic industry' (GDF 2011).

7 The Development Assistance Group (DAG), established in 2001, comprises 27 bilateral and multilateral development agencies providing assistance to Ethiopia. The DAG serves as a forum for donors to exchange information for better coordination of activities and to provide advisory support to the government in the development and monitoring of national and sectoral strategies and plans. See www.dagethiopia.org

8 More recently, anecdotal evidence suggests that non-traditional donors or sources of private finance are playing a role in enabling government to implement large infrastructure projects, with less political interference than Western donors; further research is needed to understand the implications for irrigation specifically.

9 A previous paper by Awulachew et al. (2007) provides a much lower figure of 44 percent. Note that traditional irrigation is more difficult for the government to monitor as compared to publically-funded schemes; hence coverage of the former tends to be underestimated.

10 The Awash catchment can be sub-divided based on physical and socio-economic characteristics: the upper (above 1,500masl), middle (1,500 to 1,000masl) and lower (below 1000masl) basins form

part of the Great Rift Valley System, and the eastern catchment joins the Awash River near its end (Tiruneh 2013).

11 Lankford (2012) argues that it is too simplistic to say that one type of irrigation technology is more effective that another – one needs to look at the problems faced by specific systems at different times of year.

12 The authors do not provide a definition for irrigation efficiency. However, this is often defined as the ratio between water used by growing crops and water diverted from a source for irrigation (e.g. Lankford 2012).

13 Exchange rates from OANDA (23/01/15). 1 ETB = 0.05 USD; 1 USD = 20 ETB.

14 Exchange rates from OANDA (23/01/15). 1 MAD = 0.11 USD; 1 USD = 9.4 MAD.

15 In Morocco, the distinction between large, medium and small schemes is primarily based on institutional structure. Large scale irrigation is administered by the state through the Offices Régionaux de la Mise en Valeur Agricole (ORMVA), schemes ranging from 30,000ha to 250,000ha. There is less distinction made between small and medium scale irrigation, which are managed by communal or private institutions, and state actors other than ORMVA. These range from a few hectares to 4,000ha (Laamari et al. 2011; Ben Abderrazik and Doukkali 2002). Small scale irrigation generally refers to schemes of less than 500ha (Oudra 2011).

16 Network efficiency relates to water losses in the conveyance of water from the source to the farm, and is used by ORMVA as an indicator of operation and maintenance performance. Low efficiency implies that a large fraction of the water goes to non-beneficial consumption (e.g. evaporation from canals) and/or non-consumption (e.g. seepage).

17 It is not clear why the total of these lands exceeds the 4,440ha commonly accepted as the extent of the Issen Traditional irrigation scheme.

18 The ten-year Plano Prospectivo Indicativo (Indicative Perspective Plan), launched in December 1981, constituted the long-term development plan of Mozambique at this time, and envisaged: the creation and development of heavy industry; the development of the state agricultural sector; cooperative transformation of the countryside; and massive human resource development (Tarp et al. 2002).

19 The authors do not provide a definition for irrigation efficiency. However, this is often defined as the ratio between water used by growing crops and water diverted from a source for irrigation (e.g. Lankford 2012).

20 Exchange rates from OANDA (23/01/15). 1 MZN = 0.03 USD; 1 USD = 32 MZN.

21 Cover photo: Farmers discuss the local news as they irrigate their maize fields at Gumsalasa, a smallholder irrigation scheme in the semi-arid Tigray region, northern Ethiopia. Photo by Eva Ludi, ODI.

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