Shaping Sustainable Socio-Ecological Landscapes in Africa: The Role of Transformative Research, Knowledge, and Partnerships

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ISABELLE PROVIDOLI, GETE ZELEKE, BONIFACE KITEME, AMARE BANTIDER, JOHN MWANGI

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Photos on front cover: (top) Lower Ewaso Ng'iro Basin, Kenya (Hanspeter Liniger).
(bottom) Abagerima learning watershed, Ethiopia (Isabelle Providoli).

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Foreword

Water and water-related environmental services constitute one of the most pressing global development issues of the 21st century. Closely related to water availability and quality are land use change and environmental degradation. By 2030, over 40% of the world's population will be living in severely water-stressed river basins. Hence, water scarcity has become a systemic global risk with complex effects on people's health and well-being, the economy, environment and society at large. In many countries, water scarcity can pose a significant threat to national security and spur conflict in already unstable and fragile regions.

Switzerland is committed to promoting the successful implementation of the "water agenda 2030" throughout the world. In this way Switzerland helps to promote a water-secure world, in which people have the capacity to safeguard sustainable access to adequate quantities and quality of water for their livelihoods, their well-being and their socio-economic development. Simultaneously, this ensures protection against waterborne pollution and water-related disasters, and conserves ecosystems in a climate of peace and political stability. The Dispatch on Switzerland's International Cooperation 2017–2020 highlights the importance of sustainable management of, and access to, natural resources including water, as a means to reduce inequalities, improve living conditions and create better prospects for people in developing countries.

The Swiss Agency for Development and Cooperation (SDC)'s Global Programme Water (GPW) is dedicated to attaining a water-secure world, and to promoting policy changes and the implementation of innovative solutions. The GPW is a bridge-builder, positioning water on the international agenda, and harnessing Swiss expertise to ensure that sustainable access to water becomes universal.

To meet the Sustainable Development Goals (SDGs), strategies are needed to tackle persistent inequalities in the poorest economies, where development needs and dependency on natural resources are greatest. The requirement to address the SDGs simultaneously calls for integrated approaches aimed at achieving coherence in policies and actions across scales, from local to global, and across multiple sectors. In this process, science is tasked to provide knowledge for negotiations and shaping transformations towards sustainable development.

SDC and the Centre for Development and Environment (CDE) look back to more than 30 years of cooperation in East Africa and the Horn of Africa. Over the years, CDE and its long standing regional partner networks have become leading experts and knowledge brokers in sustainable land management and sustainable regional development. Based on these unique assets, the collaboration between SDC and CDE continued under the "Water Diplomacy and Governance in Key Transboundary Hot Spots" programme in the frame of the Global Water Programme. Within the Water and Land Resource Centre (WLRC) project, solutions for improved sustainable water and land resource management and governance, as contributions to conflict prevention and mitigation in national and transnational river basins, were tested and put into practice.

This publication highlights the results of this collaboration and provides snapshots of jointly elaborated sustainable development pathways in the Blue Nile, Ewaso N'giro and Pangani river basins. Furthermore, it shows the importance of transformative research as an indispensable component in addressing sustainability challenges and shaping policies in the water sector and beyond.

We wish you interesting reading.

Johan Gély
Head Global Programme Water Division
Swiss Agency for Development and Cooperation (SDC)

Thomas Breu
Director
Centre for Development and Environment (CDE)
University of Bern

Acknowledgements

The foundations of the Water and Land Resource Centre (WLRC) project were built upon the Centre for Development and Environment's (CDE) collaboration in East Africa and the Horn of Africa, which began in the 1980s. Firm and lasting partnerships have evolved through various projects and phases. WLRC's work has been focussed around two regional centres: the Water and Land Resource Centre (WLRC) in Addis Ababa, Ethiopia and the Centre for Training and Integrated Research in ASAL Development (CETRAD) in Nanyuki, Kenya. Over this period, countless participants in Switzerland, East Africa and the Horn of Africa have made crucial contributions. A special mention must be made of two key initiators from CDE: Professors Hans Hurni and Urs Wiesmann. Without their steadfast dedication and commitment the partnerships could not have continued, and thrived, through all these years.

Many other colleagues were involved. There are too many to name here: thanks to them all, nevertheless. However we would like to specifically acknowledge the following institutions and their key personnel:

- The Water and Land Resource Centre (WLRC) of Addis Ababa University (AAU) in Addis Ababa, Ethiopia under Dr. Gete Zeleke.
- The Centre for Training and Integrated Research in ASAL Development (CETRAD) in Nanyuki, Kenya under Dr. Boniface Kiteme.
- The Centre for Development and Environment (CDE), under Prof. Thomas Breu, and the WLRC coordinator, Dr. Isabelle Providoli.

The Swiss Agency for Development and Cooperation (SDC) has been part of this endeavour from the very beginning – some forty years ago - and has actively supported WLRC's transformative research efforts. Through this long-term commitment it has been possible for CDE to build up significant expertise in sustainable land management and regional development, while establishing a unique information base, and creating a strong and reliable institutional network.

The WLRC project started in 2011 under the SDC Water Programme leadership of François Münger, followed by Johan Gély in 2015. They placed their trust in the WLRC project team. We would like to thank them for their support, and their critical and constructive inputs, which helped to strengthen and shape the project.

The following SDC programme officers were responsible for the WLRC project: Johan Gély, Manfred Kaufmann, Nadia Benani and Dina Meli. We would like to thank them for their committed and unwavering support.

The WLRC project had two external evaluations, carried out by Olivier Cogels (freelance consultant) and Christophe Bösch (SDC) in 2012, and Sabine Blumstein Schulze (adelphi) in 2015. Their critical and constructive reflections helped to shape the WLRC project further.

Furthermore, we would like to thank all the authors who contributed to this publication. The wealth of knowledge collected in these pages reflects their broad expertise and in-depth experience in East Africa and the Horn of Africa.

Lastly, we would like to thank the technical and language editor, William Critchley (SLM Associates Ltd, UK), and our layout specialist, Simone Kummer (CDE) for their careful and diligent work.

The editors: Isabelle Providoli, Gete Zeleke, Boniface Kiteme, Amare Bantider, John Mwangi

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Acronyms and Abbreviations

AAU	Addis Ababa University (Ethiopia)
AEZ	Agro-Ecological Zone
ASAL	Arid and Semi-Arid Lands
ASP	Actions Strategies and Perceptions in NRM Project
CBO	Community-Based Organisation
CBPWD	Community-Based Participatory Watershed Development
CDE	Center for Development and Environment (Switzerland)
CETRAD	Centre for Training and Integrated Research in ASAL Development (Kenya)
CSO	Civil Society Organisation
ESAPP	Eastern and Southern Africa Partnership Programme
GIS	Geographic Information System
FREG	Farmer-Research-Extension Groups (Ethiopia)
INGO	International NGO
ILUP&P	National Integrated Land Use Plan and Policy (Ethiopia)
IWM	Integrated Watershed Management
LRP	Laikipia Research Project (Kenya)
LU/LC	Land Use Land Cover
LW	Learning Watershed (Ethiopia)
MoEFCC	Ministry of Environment, Forest and Climate Change (Ethiopia)
MoANR	Ministry of Agriculture and Natural Resources (Ethiopia)
NCCR	North-South Swiss National Centre of Competence in Research North-South
NGO	Non-Governmental Organisation
NRM	Natural Resource Management
PIWM	Participatory Integrated Watershed Management
SCRP	Soil Conservation Research Project (Ethiopia)
SDC	Swiss Agency for Development and Cooperation
SDGs	Sustainable Development Goals
SLM	Sustainable Land Management
SWC	Soil and Water Conservation
WDC	WRUA Development Cycle (Kenya)
WLRC	Water and Land Resource Centre
WRA	Water Resources Authority (Kenya)
WRUA	Water Resources Users Association (Kenya)
WUA	Water Users Association (Tanzania)

Glossary

Conservation Agriculture: Farming that simultaneously embraces the three practices of minimum tillage, maintenance of soil cover and crop rotation.

Co-production of knowledge: The generation of "new knowledge involving both academics and non-academics in a strongly interactive way, so that the research process requires forms of knowledge and expertise that cannot be supplied by the researchers alone" (Robinson and Tansey 2006).

Integrated Watershed Management (IWM): A coordinated approach to implementing sustainable management of land and water resources within a watershed to ensure the sustainability of vital ecosystems.

Interdisciplinary Research: Research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialised knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice (NAS/NAE/IOM, 2005).

Multidisciplinary Research: Drawing on knowledge from different disciplines but researchers remain within their disciplinary boundaries.

Outscaling: Expansion of activities on-the-ground (geographically).

Participatory Approach: Involving stakeholders in watershed management, particularly the local population living in the affected area in which the project is taking place.

Participatory Integrated Watershed Management (PIWM): as IWM – but where local government and other stakeholders work closely together.

Soil and Water Conservation (SWC): Technical activities at the local level, which maintain or enhance the productive capacity of the land in areas affected by or prone to degradation. SWC includes prevention or reduction of soil erosion, compaction and salinity; conservation or drainage of soil water; maintenance or improvement of soil fertility (WOCAT, www.wocat.net).

Sustainable Land Management (SLM): The use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions (WOCAT, www.wocat.net).

Syndrome Context Analyses: A 'syndrome context' is a region in which one or more syndromes of global change occur or may potentially emerge. These can be broad societal, economic, political and ecological contexts – urban and peri-urban regions, semi-arid regions in transition, and highland-lowland interactive regions (Hurni et al. 2004).

Systems Knowledge: A form of knowledge that provides the basis that explains past and current challenges and opportunities, and thus enables understanding of processes and dynamics at the interface of environment and society. It provides knowledge of the current status (ProClim / CASS 1997).

Target Knowledge: The knowledge derived from evaluation of current situations, prognoses and scenarios, providing critical levels, guiding ideas, ethical boundary conditions and visions. It deals with values and goals to be achieved (ProClim / CASS 1997).

Transformation Knowledge: Knowledge about how to shape and implement the transition from the existing to the desired target situation. It addresses the means to achieve these goals (ProClim / CASS 1997).

Transdisciplinary Research: Research that integrates the social and natural sciences in a common approach, and includes non-scientific knowledge systems in a participatory and interactive process to improve societal practices (Hurni et al. 2004).

Upscaling: Adoption of approaches/practices institutionally.

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NB: where no reference is given these definitions are provided by the authors to cover the terms as used in the context of this book

Setting the Stage

ISABELLE PROVIDOLI, BONIFACE KITEME AND GETE ZELEKE

Global and Regional Challenges

River basins face multiple and complex environmental, social, and economic challenges, which have a considerable impact on hydro-political relations both within and beyond single countries. Transboundary water issues are growing in importance: many rivers and aquifers cross international boundaries. Thus, activities undertaken within a watershed not only have consequences downstream in the same country – but can impact on resources and people in a neighbouring nation. In most of the region, rapidly evolving socio-economic dynamics are driving water demand upstream, which is in turn threatening downstream supplies. At the same time, growing populations are depleting natural resources and land degradation usually follows. Again, this has local and off-site consequences. Thus, there are local, national and transboundary issues that need to be faced simultaneously. To support hydro-political negotiations and decision-making, it is therefore crucial to have evidence-based information and knowledge – as well as powerful products for policy and practice – about water and land management and governance in the various basins.

Natural resources in river basins are finite and are increasingly under pressure in a world of fast-changing social and economic conditions. There are competing claims on diminishing resources from a growing number of different actors. Sustainability is under severe threat. Many of the claims are for water and land, especially in the domain of agriculture and food sufficiency – from small-scale subsistence farmers to massive international agri-businesses. Over the last two or three decades there has been a rapid escalation in these struggles. Pressure has come from within (for example population pressure) and simultaneously from outside (for example new actors/investors). Thus, not only has the pace and size of claims accelerated, but the number and variety of stakeholders has proliferated too.

In East Africa and the Horn of Africa such developments have led to an exacerbation of already existing problems – both within and between local farming systems. Subsistence farming and pastoralism are clear examples. In the Ethiopian Highlands, where subsistence food production has been practiced for millennia, land degradation continues to be serious and is threatening the security of subsistence farmers. Due to population pressure and new claims to use of the land – whether cut-flower farming, hydropower, or industries - these problems are becoming increasingly severe, more complex, and further intertwined. Soil erosion by water, which is the main cause of land degradation in Ethiopia, is no longer merely a local problem, threatening food production on a specific farm.

(top) Blue Nile Fall, Ethiopia (Isabelle Providoli).
(bottom) Lower Ewaso Ng'iro Basin, Kenya (Hanspeter Liniger).

The issue is rapidly spreading with connections and links: farmers are no more able to move to another plot as most arable land has already been exploited. Soil erosion not only threatens food production, but is impacting on water quantity and quality downstream. This causes siltation of dams and lakes and endangers water supplies. To compound the problem, rural-urban migration is leading to an aging rural population - and unemployed farmers congregating in urban regions.

In the Mount Kenya region problems are similar in terms of complexity and interconnectedness, but land degradation is less of an issue than water itself. Water demand, availability, variability of supply in space and time, and the "water balance" between upstream and downstream are all major challenges. Since the colonial period smallholders, large-scale farmers, and pastoralists have been increasingly expanding into the zone along the Ewaso Ng'iro river. Rapid population growth and fast land use change, largely explained by expanded agricultural activities, have led to increased river water abstraction upstream and confinement of pastoral communities downstream. Bitter conflicts arise in years of drought when pastoralists start to move towards the highlands in search of water and pastures - which are no longer available to them. In recent years these problems have grown with increased climate variability in the region (for example the start, duration and amount of the rains becoming more erratic), and also due to more and more demands on the land for multiple uses. A further sinister threat is from investment in water-thirsty 'mega-projects' which have led to land speculation and further increased uncertainty, posing yet another challenge to sustainability of livelihoods, and land and water use in the region.

Simply stated, there is increasing pressure on traditional land use systems and lifestyles in East Africa and the Horn of Africa. People urgently need innovation to locally deal with these issues and to seek out sustainable solutions – above all for food production and efficient and equitable use of water. However, the multitude of claims and actors, the interconnectedness of issues, and their relationships across time and space suggests that sectoral and local problem-solving initiatives are insufficient. More holistic and integrated approaches are required. The changes that are happening are within social, economic, political, and ecological dimensions; they span various scales, may be unidirectional (e.g. rural-urban migration), and involve both powerful new players, as well as the original, and now often marginalised, inhabitants. It is evident that there is a need for carefully tailored approaches and analytical tools to identify problems and to negotiate trade-offs to open up opportunities for natural resource use in these river basins that can continue to sustain livelihoods.

The 2030 Agenda for Sustainable Development provides such a normative compass and ambition, urging all countries and stakeholders, including governments and non-governmental actors from civil society, science and business, to embark on fundamental societal transformations in a rapid timeframe. In this process, science is tasked to provide knowledge capable of guiding negotiations and shaping transformations towards sustainable development.

The Role of Transformative Research

In its current five-year strategic plan (2016–2021), the Centre for Development and Environment (CDE) has defined transformation towards sustainable development as processes that go beyond incremental adaptation of existing systemic conditions or mitigation of growing threats. CDE views transformation towards sustainability as creative, innovative processes that simultaneously change the socio-ecological system and its underlying values, structures, and behavioural patterns. To realise this vision, engaged and transformative research is needed. CDE firmly believes that scientific knowledge is crucial to achieve transformation towards sustainable development. However, "wicked" sustainability problems are seldom captured within the boundaries and approaches of established scientific disciplines. This very often limits the usefulness and effectiveness of conventional scientific research.

Thus, CDE has grasped the challenge of advancing and complementing research approaches that focus on three specific forms of knowledge: systems knowledge, target knowledge and transformation knowledge. Systems knowledge provides the basis that explains past and current challenges and opportunities, and thus enables understanding of processes and dynamics at the interface of environment and society. This systems knowledge then needs to be complemented with target knowledge, which deals with values and goals to be achieved, and then transformation knowledge, which addresses the means to achieve these goals (ProClim/CASS 1997). Scholars furthermore stress that the generation of knowledge for sustainable development - in particular target and transformation knowledge - requires transdisciplinary approaches, stakeholder collaboration and intense social learning and deliberation processes.

It is for this reason, therefore, that CDE and its partners are engaged in social learning and co-production of knowledge in multiple global regions, investing in long-term partnerships, and connecting local realities to theoretical global debates. CDE links science to transformation by advancing inter- and transdisciplinary approaches that establish dialogue between scientists and policymakers, foster evidence-informed decision and policymaking, and set joint learning processes in motion to shape alternative development pathways. CDE brings together knowledge about transformation in different contexts, from local to regional, and up to global levels, and develops concepts and methods for cross-scale comparison and generalisation of findings.

CDE's Engagement in East Africa and the Horn of Africa

The Centre for Development and Environment maintains a worldwide network of long-term research partnerships. These partnerships across the global North and South make it possible to develop and empower "knowledge societies", and to share values on transformative research for sustainable development. In Africa, CDE has long-standing partnerships with actors from science, policy and civil society in East Africa and the Horn of Africa. The partnership has evolved through various projects and is currently, founded in two centres, the Water and Land Resource Centre (WLRC) in Addis Ababa, Ethiopia and the Centre for Training and Integrated Research in ASAL Development (CETRAD) in Nanyuki, Kenya. The two centres serve as platforms for exchange of data and information - and as national knowledge hubs. They provide highly contextualised knowledge to inform dialogue on the implementation of Agenda 2030, and aim to reach as many stakeholders as possible (community members, policymakers and professionals) from the sub-national to the national, up to regional/transboundary, and international levels.

The most recent project in the region is the Water and Land Resource Centre (WLRC) project (2011–2019), supported and co-funded by the Swiss Agency for Development and Cooperation. The project was built on the legacy, and the previous engagement, of CDE and its partners in the region. The aim is to improve sustainable water and land resource management and governance, secure environmental services, and deal more effectively with inherent conflict in national and transnational river basins in Ethiopia/Eastern Nile and East Africa. This was to be achieved by generating knowledge for devolved processes of negotiation, planning, implementation, and conflict-resolution, with a view to balancing benefit-sharing and long-term preservation of water-related environmental services. The project has played a critical role in generating knowledge, and informing decisions regarding innovative interventions, both at the policy level and in practice.

Why this Publication?

In this publication, we synthesise results of the long-term co-operation between CDE and its partners: the WLRC in the Horn of Africa and the CETRAD in East Africa on sustainable development, specifically demonstrated through the WLRC project. We illustrate the generation of different kinds of knowledge needed for sustainable development through transdisciplinary approaches, stakeholder collaboration and intensive social learning and deliberation processes.

The first chapter: 'Several decades of learning, innovation and action in land and water management and governance' illustrates how different knowledge types were generated through inter- and transdisciplinary approaches that established dialogue between scientists and non-scientific actors setting in motion the joint learning processes that can shape alternative development pathways.

The second chapter: 'Transformative knowledge - triggering changes in policy and society' then showcases two examples of how the different knowledge types provide a basis for designing and shaping national-level policies.

The third chapter: 'Web platforms as enablers for guiding negotiations and shaping landscape transformation' demonstrates how fragmented knowledge can be shared through web-platforms among a range of key actors.

Target Group of the Publication

The publication is intended for a broad range of actors working on similar issues in East Africa and the Horn of Africa - and beyond, at different levels. The target group thus ranges from governmental and non-governmental actors from civil society (INGOs, NGOs, CBOs), international development partners, international agencies, science/research centres and the private sector.

We hope that the highlights presented here successfully illustrate the role that transformative research can play in addressing sustainability challenges and in establishing innovative solutions. It is our hope and aspiration that the examples will inspire, inform and help trigger similar programmes on transformative research in the future.

CHAPTER 1

Several Decades of Learning, Innovation and Action in Land and Water Management and Governance

1

The way in which knowledge is produced from research has evolved steadily - and has changed considerably - over the last decades. In the 1980s, land management research was focused on the biophysical aspects of ecosystems, while people living within those areas were largely ignored. The aim was to measure and monitor biophysical characteristics in order to develop technically appropriate soil and water conservation measures. There was a defined link to capacity building of development agents who could then translate this knowledge into practice. This is classified as "systems knowledge", which provides information about past and current challenges and opportunities, and enables understanding of processes and dynamics at the interface of environment and society.

However, over the years, it became apparent that the technical measures were much more likely to be taken up by local people, and better sustained, if the people themselves were directly involved in technology development, and if they understood and appreciated the benefits. Thus in the 1990s "participatory approaches" were embraced and the thematic research focus opened up beyond biophysical measures to include aspects of land governance. Systems knowledge was then complemented by "target knowledge", addressing values and goals, and "transformation knowledge", covering the means to achieve those goals.

This development led to inter- and transdisciplinary research approaches, in which the active participation of local stakeholders was key. Currently, there are complex and intertwined sustainability challenges that have to be addressed under the 2030 Agenda for Sustainable Development. These call for new research approaches. CDE and its partners are engaged in social learning and co-production of knowledge. CDE views transformation towards sustainability as being part of a creative, innovative process that simultaneously changes the socio-ecological system and its underlying values, structures, and behavioural patterns.

Chapter 1 illustrates two different examples – from Ethiopia and Kenya - where CDE and its regional partners have had several decades of learning, innovation

Learning watershed, Ethiopia (Gete Zeleke).

and action in land and water management and governance. Two specialised centres have been established which promote inter- and transdisciplinary approaches that establish dialogue between a wide range of actors, and set into motion joint learning processes for shaping alternative development pathways.

The first example deals with land degradation and land management issues in Ethiopia. The Water and Land Resources Centre (WLRC) working in the Ethiopian Highlands has gone through different research stages from the 1980s to the present. Lessons learnt and experiences are summarised, and a snapshot captures the knowledge development approaches. This culminated in a new approach, termed "learning watersheds". These are innovative learning platforms, bringing together a wide range of stakeholders, which lead to co-production of innovative solutions and consequent improvement of livelihoods: something quite new for Ethiopia.

The second example illustrates decades of learning related to water governance and society-rooted institutions in Kenya. Increasingly, limited water resources are leading to multiple conflicts between upland and lowland water users. The Centre for Training and Integrated Research in ASAL Development (CETRAD) working in the Mount Kenya region went through different research stages, from the late 1970s until now, searching for solutions to address the particular combination of technical, social and institutional water issues. CETRAD developed the society-rooted approach of Water Resource Users Associations (WRUAs) in the 1990s and evolved the approach further by employing transdisciplinary approaches for knowledge production, awareness-raising and capacity building. The WRUAs have contributed considerably to stability and sustainability of water use in the basin.

From Land Degradation Monitoring to Landscape Transformation: Four Decades of Learning, Innovation and Action in Ethiopia

AMARE BANTIDER, GETE ZELEKE, GIZAW DESTA, TENA ALAMIREW, ZEWDU ALEBACHEW, ISABELLE PROVIDOLI AND HANS HURNI

Learning watershed Abagerima, Ethiopia (Gete Zeleke).

Challenges and Issues

In response to the widespread droughts and famine of the 1970s, soil and water conservation (SWC) programmes were initiated in Ethiopia to address the root cause, which was believed to be land degradation. However, the campaigns were led without true understanding of the nature, severity, processes, causes and consequences of the situation, and without clear criteria for selection of land rehabilitation technologies or approaches to match different contexts. This was "planning in the dark"[1]. Two underlying problems were initially identified. First, the nature of land degradation was not known; it was a "black box". The second was that the recommended technologies and approaches were not derived from applied research tailored to the particular biophysical and socio-cultural contexts. It became clear that "one-size-fits-all" simply did not work. As an example, level soil bunds with one metre vertical intervals were applied everywhere - irrespective of rainfall and slope. In high rainfall areas this caused the formation of huge gullies, and on steep slopes the land was actually damaged further by the structures. These problems above triggered the establishment, in 1981, of the Soil Conservation Research Project (SCRP) by the University of Bern, Switzerland in collaboration with Ethiopia's Ministry of Agriculture, and with financial support from the Swiss Agency for Development and Cooperation (SDC). The goal of the project was: "to support soil and water conservation efforts in Ethiopia by monitoring soil erosion and relevant factors of influence, by developing appropriate soil and water conservation measures for different contexts, and by building local and international capacity in the field of research" (Hurni 1984). These efforts were continued in the next decades. The two challenges – the black box of land degradation and the need to tailor conservation measures to specific situations were the driving forces behind the research. As will be seen, a third challenge emerged later: how to bring local stakeholders more clearly into the picture in order to ensure sustainability. This chapter provides a snapshot of how knowledge production in research has evolved over the years in Ethiopia from the 1980s onwards, through the long-term partnership of the Centre for Development and Environment (CDE) with its local partners. It further shows how current sustainability challenges can be addressed through the development of new and innovative research approaches.

The Role of Research and Learning Watersheds in Developing Solutions

The initial concern of the SCRP project was to understand the nature and impacts of land degradation. Hence, a major focus was on generating systems knowledge – that is the understanding of processes, causes and consequences. That was followed by devising appropriate technologies to combat degradation, and especially soil erosion by water. Furthermore, the early 1980s witnessed pioneering work in analysing the processes of land degradation through the establishment of hydro-sedimentology monitoring in eight experimental

[1] It is impossible to plan in the dark (Woldemariam, 1986)

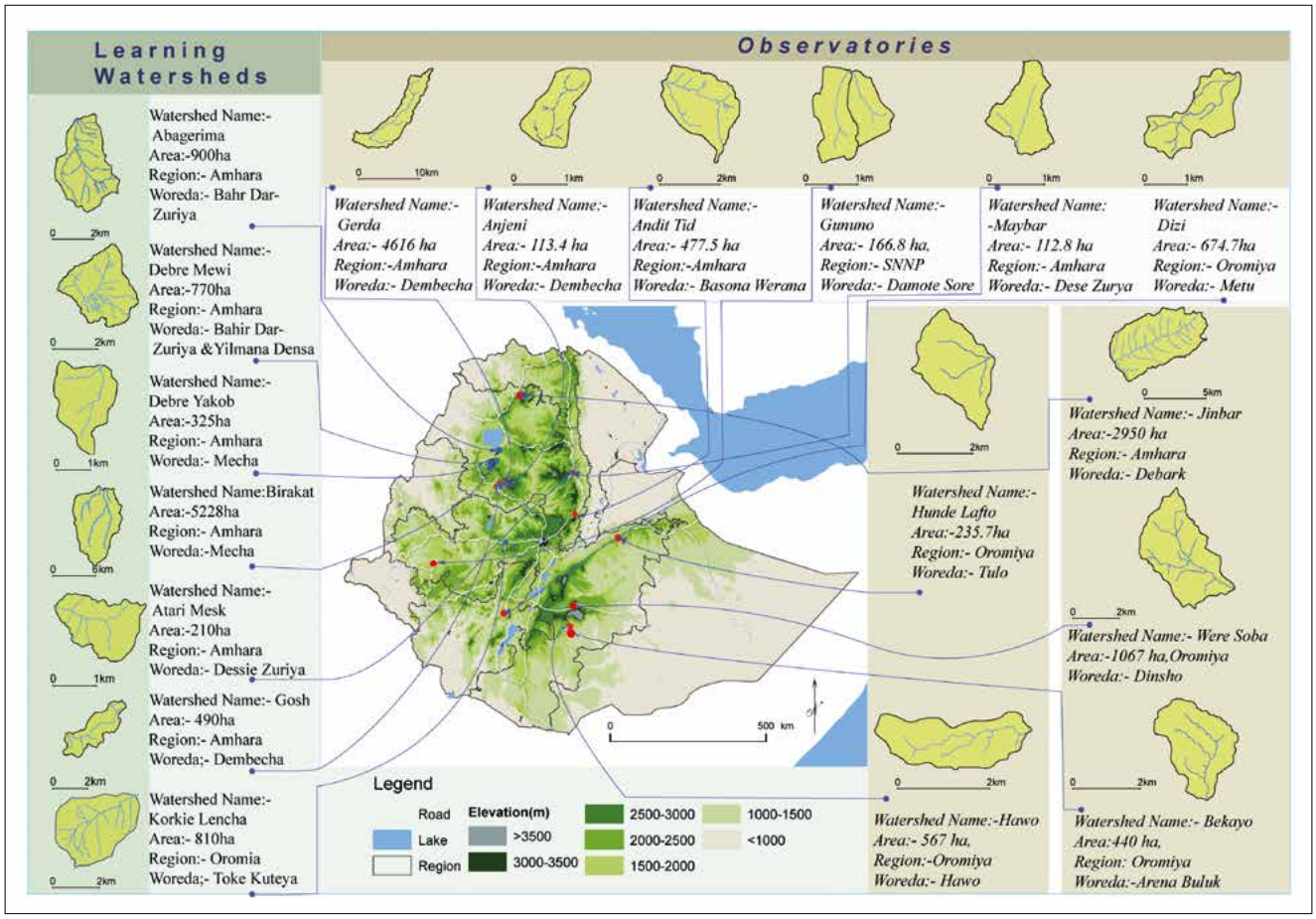


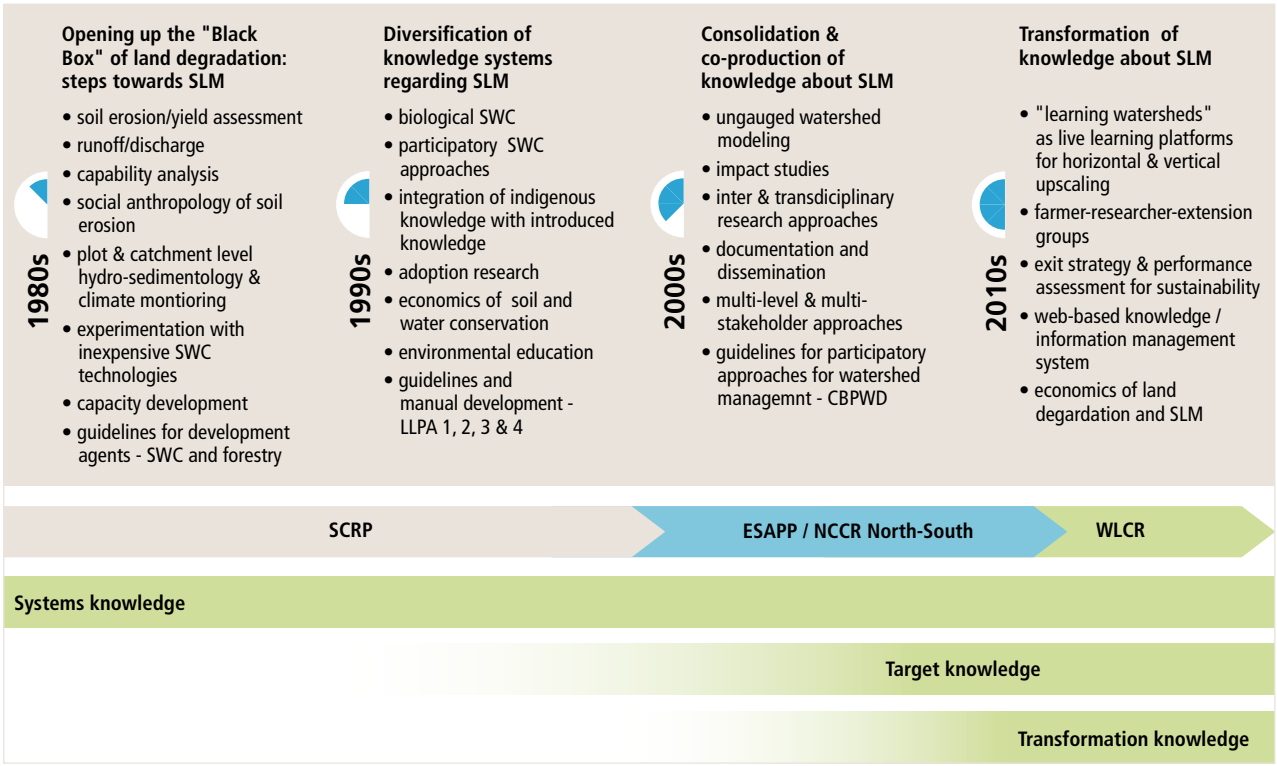
Figure 1.1: Location of observatories and learning watersheds (Source: WLCR).

watersheds. SCRP certainly laid the foundation and shaped the SWC approaches and technologies, as well as assessing the severity and extent of land degradation in the country (Gete 2001, 2006). In 1986, the first Guidelines for Development Agents on SWC and afforestation was developed and published by SCRP (Hurni 1986).

After the project ended in 1998, the hydro-sedimentology and climatic observatories were handed over to the regional Bureaus of Agriculture, and monitoring continued in four out of eight. By this time, much experience had been gathered in soil and water conservation implementation under a wide variety of projects and programmes – a process that is continuing to this day in the form of integrated watershed management. New research programmes such as the ESAPP (1999-2015) and the NCCR North-South (2001-2013) followed. In these programmes knowledge production evolved from "systems knowledge" to "target knowledge" - which deals with negotiated values and goals for a shared vision for a sustainable future, and on to "transformation knowledge", which addresses the means to achieve these goals. This development led to inter- and transdisciplinary research approaches, in which active participation and consultation of local stakeholders was key (see glossary for definition of terms).

The Eastern and Southern Africa Partnership Programme (ESAPP) was a research implementation programme that sought to advance sustainable development through joint action and co-production of knowledge in the context of local and regional initiatives. It promoted sustainable land management and equity-oriented sustainable regional development in Eastern and Southern Africa. ESAPP supported the regional research institutes in Ethiopia to continue data collection and instrumentation, and demonstrated practical technologies for land management, while also contributing to knowledge transfer/dissemination and documentation. Running more or less simultaneously, the Swiss National Centre of Competence in Research North-South (NCCR North-South) was a 12-year research programme, which established an integrative research approach in order to generate knowledge for sustainable development in developing and transitional countries. In Ethiopia, it brought the land degradation discussion into the wider context of sustainable development through "syndrome context analysis" by analysing clusters of core problems of development (Hurni and Wiesmann 2004).

However, a third problem emerged during the conservation efforts of the late 20th century: that was the lack of true involvement of local communities and, as a result, slow uptake. During this period, the development of the national Community Based Participatory Watershed Development (CBPWD) guidelines in 2005 was an attempt to reverse top-down implementation towards a bottom-up participatory approach (Lakew et al. 2005). It was intended to shape the direction from an emphasis on the technical application of SWC towards integrated watershed management (IWM) with more local involvement.



SCRP: Soil Conservation Research Programme (1981-1998).
ESAPP: Eastern and Southern Africa Partnership Programme (1999-2015).
NCCR North-South: Swiss National Centre of Competence in Research North-South (2001-2013).
WLRC: Water and Land Resource Centre (2011-2019).

Figure 1.2: Evolution of land management research, learning and co-production of knowledge from 1980 (Source: WLCR).

IWM needed to be made more participatory: thus it gradually evolved over the next decade into a Participatory Integrated Watershed Management (PIWM) approach.

The Water and Land Resource Centre (WLRC) project, established in 2011, was an initiative that picked up on the foundations laid by the SCRP, NCCR North-South, ESAPP and other programmes. It represented renewed commitment from SDC. The WLRC was founded on the legacy of these previous programmes and evolved the research approaches further, with a strong emphasis on target and transformation knowledge. The term 'transformative research' can be used to describe its overall methodology. While WLRC established additional observatories/monitoring sites to cover important ecosystems and eco-regions of the country, most importantly it recognised the importance of building more active participation amongst stakeholders by pushing the frontier of action-research from monitoring and understanding of land degradation processes, through to the highly innovative concept of "learning watersheds" (LW) (see Figure 1.1 for the location of observatories and learning watersheds). This approach was designed to promote integrated watershed development under a live learning platform, following an improved version of the CBPWD approach, while simultaneously monitoring changes through scientific observation. The learning watersheds were developed to actively involve multiple stakeholders (farmers, agricultural development agents and specialists, planners and decision-makers) to help trigger rapid upscaling

BOX 1
Terminology: definitions and an explanation

As approaches to the problem have evolved, so too has the terminology. The key terms are defined below: the original term "soil conservation" (SC) evolved quickly into soil and water conservation (SWC) when the importance of conserving water as well as soil was recognised. SWC (with its technological emphasis) was then gradually absorbed and replaced by the broader concept of SLM (where ecosystems and people are included) during the 1990s. IWM became PIWM around the same time, highlighting the participatory element.

SWC (Soil and Water Conservation): technical activities at the local level, which maintain or enhance the productive capacity of the land in areas affected by or prone to degradation. SWC includes prevention or reduction of soil erosion, compaction and salinity; conservation or drainage of soil water; maintenance or improvement of soil fertility (WOCAT, www.wocat.net).

SLM (Sustainable Land Management): the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions (WOCAT, www.wocat.net).

IWM (Integrated Watershed Management): a coordinated approach to implementing sustainable management of land and water resources within a watershed to ensure the sustainability of vital ecosystems.

PIWM (Participatory Integrated Watershed Management): as IWM – but where local governments and stakeholders work closely together.

Figure 1.3: Meteorological and hydro-sedimentological monitoring at different observatory watersheds (Source: Tatenda Lemann).

of watershed development activities. The following paragraphs discuss the evolution and focus areas of research, approaches and methodologies that were followed - and their link to sustainable land management and sustainable development (see Figure 1.2). Through these engagements, dialogue between scientists and non-scientific actors are fostered setting joint learning processes in motion to shape alternative development pathways.

Opening up the "black box" of land degradation

Research in the 1980s was primarily focused on systems knowledge generation regarding the nature, processes, scale, severity, causes and consequences of land degradation on the one hand, and technology development and experimentation for soil conservation on the other. It gave attention to the assessment of soils and land degradation in general, and soil erosion by water in particular, at multiple spatial scales through plot to catchment level experiments and monitoring (see Figure 1.3). The following sources explain specific aspects in detail: plot level measurements and experiments (Hurni 1982, 1984, 1988b; Werner 1986; Mulugeta 1988; Tolcha 1991; Belay 1992); catchment scale measurements and experiments (Hurni 1984, 1988a; Weigel 1986); assessment based on agro-ecological belts and land use types (Mesfin 1991; Hurni 1985); at national level (Hurni 1983; Krauer 1988).

With respect to technology generation, the focus was on testing physical measures (such as soil and stone bunds, waterways and cut-off drains) and, later, vegetative measures (reforestation, area closure, and grass strips). The knowledge generated was compiled as guidelines for development agents in 1986, and extensive training was given in use of the guidelines.

In a nutshell, these studies enabled:

- building of a long-term hydro-sedimentology and related database, over a period of up to 40 years, with a high temporal resolution;
- establishment of a cause and effect relationship between erosion and productivity decline;
- understanding of the vicious cycle of land degradation and poverty;
- development of recommendations for technologies and actions to break the vicious cycle;
- capacity building in national expertise; and
- confidence and competence in implementation of conservation technologies in degraded landscapes.

Among the major findings, the severity of soil erosion by water was demonstrated across various land use types and agro-ecological zones: erosion rates ranged from 4 t/ha/year in forested landscapes to over 300 t/ha/year in cultivated, humid areas. The relationship between soil loss, and reduced fertility and productivity was clearly established. In addition, different SWC measures and their design specifications for different agro-ecological zones were recommended. This was one of the most important outcomes of SCRP as it terminated the "one-size-fits-all" approach of the government on SWC.

Diversification of knowledge systems

The 1990s saw a phase of expanding the thematic focus of the research beyond systems knowledge, that is the monitoring of biophysical and agronomic parameters, and going further than simply developing SWC technologies and guidelines for development agents. The new focus included production of field manuals, and investigating rates and determinants of SWC adoption. In this decade, shifts took place in the transition from pure systems knowledge to target knowledge – which deals with negotiated values and goals to be achieved. This was accomplished through: (a) integration of indigenous and outside knowledge; (b) promotion of participatory approaches; (c) technical and economic assessment of technologies; and (d) promoting and supporting environmental education.

Consolidation: inter- and trans-disciplinary research

The 2000s witnessed a consolidation of overall knowledge by adopting a logical flow through systems to target knowledge. Modelling of land degradation in ungauged watersheds was undertaken, using the long-term data from observatories, which formed the basis for calibration and validation of these models (Yihun et al. 2018). Inter- and trans-disciplinary research approaches were advocated, and systems thinking, in terms of upstream-downstream linkages, and syndrome context analyses of highlands and lowlands, were aimed at informing policies (Hurni and Wiesmann 2004).

BOX 2

Learning watersheds: an innovation in participation and upscaling

The "learning watershed" (LW) is a key WLRC initiative that supports and strengthens technical, institutional, and knowledge management of integrated watershed development efforts. LWs are learning sites for implementing integrated watershed management practices and improved agricultural technologies, as well as for documentation of lessons for scaling-up. The approach involves active participation and collaboration of multiple stakeholders: land users, local community organisations, extensionists, researchers and policy makers - at all stages of watershed development. Inherent to the approach is the integration of agricultural practices for improved productivity, sustainable natural resource management and climate change adaptation, combined with income generating activities linked to homestead development packages. The approach demonstrates how to streamline scaling-up of integrated watershed approaches. It ultimately ensures sustainable natural resources management, and improved, more resilient environment and livelihoods. (WLRC 2015) (see Figure 1.4 for the LW conceptual framework).

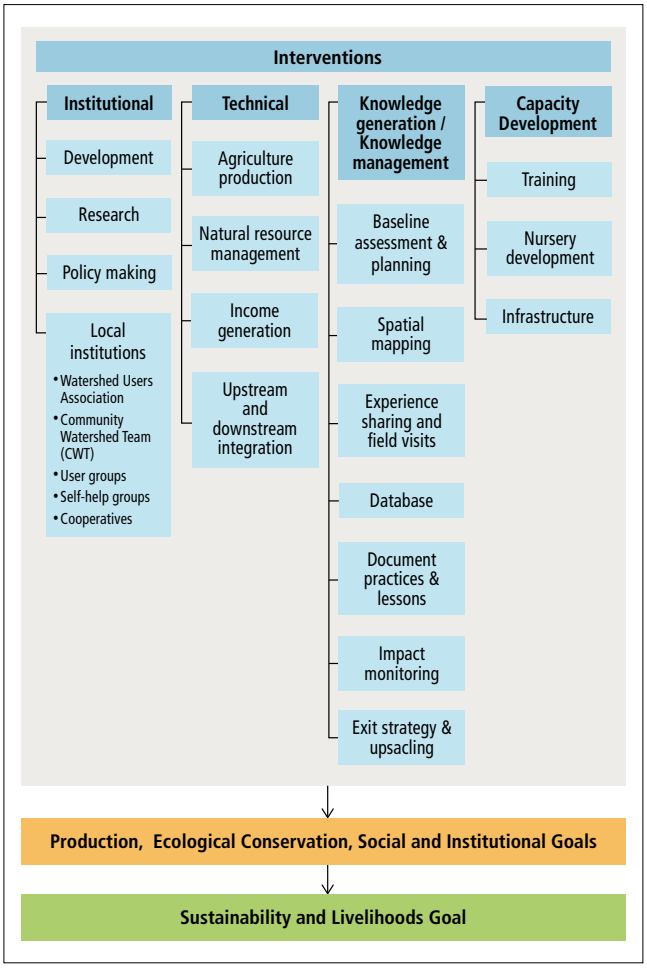


Figure 1.4: Learning watersheds: the conceptual framework (Source WLRC).

During this period, a large number of studies were conducted regarding implementation of SWC and watershed management. Off-site benefits were found to be rapid - in terms of shallow groundwater replenishment. However, the economics of SWC yielded mixed results. Several of them revealed that soil and water conservation alone in smallholder farming systems did not bring rapid economic benefits. Such results alerted policy makers first to the fact that compensation mechanisms were important - depending on the food security status of the communities, and second (and most importantly) the need for integrating technologies as the key to successful PIWM.

Transformation: "learning watersheds" facilitating participation and upscaling

The period from 2011 onwards can be considered a phase of transformation from systems and target knowledge building, to fully-fledged implementation of PIWM for enhanced ecosystem services and improvement of livelihoods – in other words transformation knowledge. Transformation knowledge describes the path to follow in order to achieve a sustainable future. Such change was enabled and enhanced through the establishment of innovative "learning watersheds". These have facilitated the establishment of live learning platforms which accelerated upscaling activities of PIWM both vertically (institutionally) and horizontally (spread on the ground), (WLRC 2015) (see Box 2). In the process, "Guidelines for Sustainability" were developed under WLRC in 2015 (revised in 2017), which identified key lessons and recommendations on the economic, social, ecological and institutional aspects of watershed development through community mobilisation approach.

One important component of WRLC's learning watersheds is the use of Farmer-Research-Extension Groups (FREG). This comprises a platform of the main agents in agriculture and

Poster showing gully rehabilitation

International exchange visit to a learning watershed

Demonstration of the use of a water pump

Figure 1.5: Learning watersheds used for capacity development and training activities of different kinds (Source: Amare Bantider, Isabelle Providoli).

Large gully in Debre Yakob learning watershed (Jan 2012)

Rehabilitated gully with water harvesting structures combined with vegetative measures (Feb 2015)

Degraded hillside in Debre Yakob learning watershed (Jan 2012)

Area closure combined with in-situ water harvesting structures in Debre Yakob learning watershed (Feb 2015)

Figure 1.6: Rehabilitation of degraded lands through gully treatment and area closure (Source: Gete Zeleke).

natural resource management. The philosophy of FREG is to co-generate and co-learn technologies and approaches for effective adoption, transfer and dissemination to achieve sustainable land management and sustainable development. Experience-sharing visits of farmers within, and between, these learning watersheds are key. Since 2012, several hundred people each year have visited the LWs – including scientists and researchers from different parts of the world (Figure 1.5).

Impacts of SCRP and WLRC's Long-Term Engagement in Ethiopia

Reversing land degradation and harnessing benefits from sustainable land management practices necessitates committed efforts from a group of stakeholders - researchers, planners, decision-makers, donors and, most important of all, the community. It is only through this coordinated collaboration that true impact can be achieved. Impact can be assessed at different levels and in various ways.

Awareness creation and capacity development

The foremost impact of the SCRP and WLRC projects has been creating awareness and building capacity. Research conducted under these frameworks has revealed and demonstrated:

- the severity of land degradation in general and soil erosion in particular (noted above) made vivid by a calculation that one year's soil loss would take natural processes 10 years to replace (Hurni 1983, 1988a; Tolcha 1991; Belay 1992; Herweg and Stillhardt 1999; SCRP 2000, WLRC 2015);
- the immediate onsite consequence of soil erosion: namely a reduction in agricultural production (Sutcliffe 1993; Gete 2000): for example yield loss due to soil erosion was estimated to have caused a decrease of between 0.4% and 1.0% in the agricultural GDP of 1990;
- that findings such as these cause alarm and can trigger stakeholders, including the government, to take immediate action. Thus, awareness creation is the first entry point for SLM;
- that inexpensive conservation technologies can reduce soil erosion (Werner 1986; Mulugeta 1988; Berhanu 1991; Herweg and Ludi 1999) (Figure 1.6);
- the offsite consequences of soil erosion include reducing the lifetime of dams; and
- that properly implemented watershed management can make communities water-secure and diversify their income generating activities. As a consequence, WLRC is working to make water security one defined outcome of the national SLM programme.

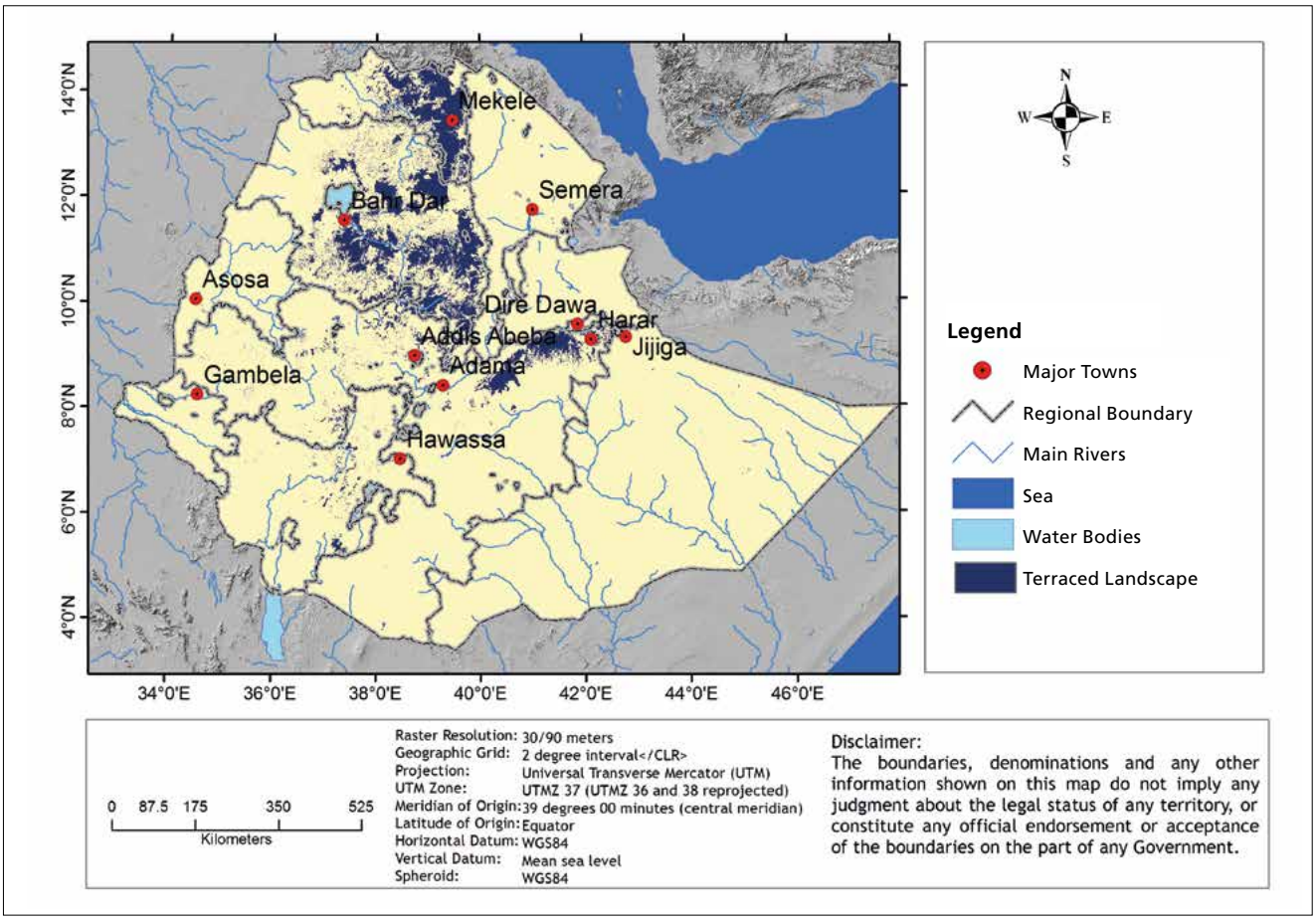


Figure 1.7: SWC coverage in Ethiopia by 2016 (Source: WLRC, 2018).

Likewise, research has led to, and directly supported:

- a widespread programme of capacity building and the establishment of courses at colleges and universities, as well as adult education for farmers, and on-the-job training for field practitioners;

- the development of influential and comprehensive SWC guidelines (Hurni 1986; Hurni et al. 2016) for agricultural development agents, as well as manuals on (a) assessment of erosion damage (Herweg 1996) (b) photo monitoring (Bosshart 1997), (c) participatory knowledge development (Michael and Herweg 2000); (d) SWC (Daniel et al. 2001); (e) community based participatory watershed development (Lakew et al. 2005); and (f) exit strategy and performance assessment (Gete 2015, 2017);

- the development of a very substantial knowledge system over the last four decades including geo-spatial database and maps through the ETHO-GIS set-up. This has raised awareness at national and international levels and led to a series of large investments in NRM/SWC and watershed management in particular (e.g. by WFP, GIZ and the World Bank); and

- on-the-ground activity: about 7.7 million ha (23% of the area requiring treatment with SWC structures) in the Ethiopian Highlands has been already covered (WLRC 2018a) (Figure 1.7).

SWC/SLM research impact in ensuring improvement of ecosystem services and livelihoods

Improvement of ecological services

Soil and water conservation (see Box 1) has proved effective in reducing soil loss from steeply sloping cultivated lands, while also reducing sediment yield from the catchment. This is substantiated by multiple experimental and empirical research results that testify that SWC structures considerably reduce soil erosion compared to untreated land (Hurni 1985; Mulugeta 1988; Tolcha 1991; Herweg and Ludi 1999; Lemann et al. 2016). Soil fertility improvements due to SWC practiced over several decades has also been demonstrated (Tadele et al. 2013). Furthermore, biodiversity and vegetation cover has improved in conserved areas and in rehabilitated gullies. Reduced peak discharge and improvement in the base flow of rivers in the drier months within rehabilitated watersheds, as well as shallow ground water recharge, are experimentally proven.

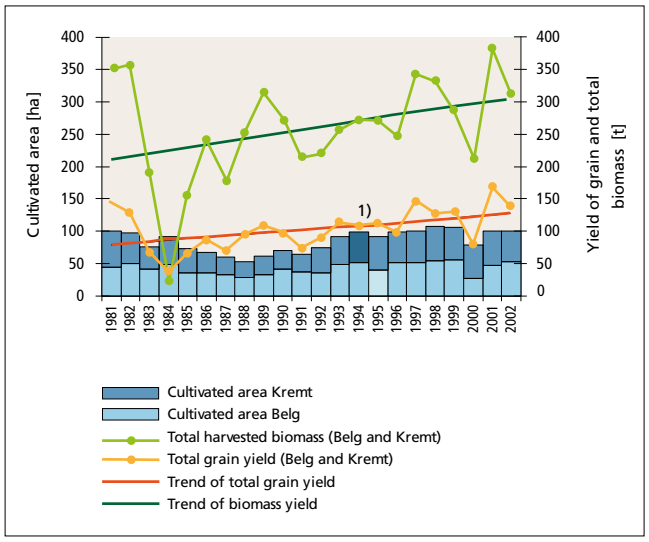


Figure 1.8: Yield changes in a 110 ha catchment conserved in 1983. Note 1) Kremt area estimated in 1994 ("Kremt" is the main rainy season from July to September and "Belg" is the secondary rainy period from March to May). Analysis: Lötscher, 2004.

Improvement of the economic situation of residents - and beyond

The economic significance of integrated watershed management has been observed in many ways. In combination with integrated soil fertility management, land productivity is improved considerably. Improvements in agronomic practices lead to agricultural intensification. Increased upstream recharge has also improved the availability of water for irrigation downstream: this is one example of where best practice in learning watersheds is being effectively upscaled. The longevity of downstream water storage structures is also a very important off-site impact of upland watershed management. A study conducted in Maybar to check whether SWC alone was able to increase productivity, other practices being the same, concluded: "Despite low fertilizer inputs, grain production throughout the catchment did not decline but actually rose during the 22-year period" (Lötscher 2004) (Figure 1.8).

Livelihoods improvement

PIWM targets the twin objectives of achieving sustainable livelihoods for the watershed's residents through diversified livelihood options while ensuring healthy ecosystem function. In the learning watersheds, homestead development was one of the components that helped families to have better access to water for vegetables and fruit production, honey production and small-scale animal production. This is very important in terms of improving diet and income at household level – while simultaneously empowering women.

Contribution towards effective institutionalization and policy of SLM

Continued research has confirmed the connection between erosion and poverty, as well as the impact of SLM (see Box 1) in improving livelihoods and ecosystem functions: consequently it is little surprise that decision-makers have been convinced of the importance of emphasising SLM. Thus SCRP, ESAPP, NCCR North-South and WLRC have directly, and indirectly, contributed to policy making. Through the various ministries involved at national level, these policies are being acted upon at the lowest administrative tier. Confidence in the impacts of SLM (through a participatory integrated watershed management approach) has attracted investment from numerous international development partners – multinational and bilateral agencies as well as NGOs. Similarly, contributions have been made towards designing and refining an integrated land use plan; for policy formulation; towards a Decision Support System for assessing sustainability and exit strategies; and in setting up the national SLM Knowledge Management System (Gete 2017; Gizaw et al. 2017; WLRC 2018b).

Contribution to SLM science and research

The observatories have received international recognition in tropical highland hydro-sedimentology research, and have provided one of the most comprehensive, long-term, databases in sub-Saharan Africa (Hurni and Herweg 2006). The knowledge accumulated not only helped trigger the establishment of academic departments in universities, but it directly provides data for modelling and model calibration – and has formed the basis for a very large number of scientific articles.

Facilitation of science-based discussion on offsite benefits of SLM

The findings of the multi-year studies and measurements of the impacts of SWC/SLM in the highlands of Ethiopia on the downstream countries reveals very positive impact. One study (El-Swaify and Hurni 1996) reached the following conclusion: "Several countries within the Nile basin stand to gain from enhanced conservation of soil and water resources. We suggest that a solid basis exists for constructive forums of dialogue on substantive cooperation among these countries' peoples and their leaders towards improved basin-wide conservation and water resources utilization".

Contributions towards the development of national policies

The Federal Government of Ethiopia and its Regional States have enacted a very wide range of natural resource management policies and laws. Above all, the government enacted the Climate Resilient Green Economic Strategy in 2011 - which is internationally renowned. These policies have been informed by the vast knowledge base accumulated over the years - including that from SCRP, ESAPP, NCCR North-South and WLRC. Although the process was not a straightforward trajectory - from research findings to policy development - the landscape transformation study along the major development axis of Ethiopia conducted in 2009/10 by NCCR North-South/WLRC was a key influential scientific output (see Chapter 2 – Ethiopia) . Indeed it convinced the government to decide to develop the National Integrated Land Use Plan and Policy. Prior to the decisions by the government, the study results were presented at various forums. These included a high-level workshop led by the-then Prime Minister HE Hailemariam Desalegne, where the evidence was put forward to support a recommendation to set a National Integrated Land Use Policy and Plan. This was clear evidence of research having direct impact on policy making.

Promise for the Future

In present-day Ethiopia, sustainable land management, specifically through the integrated watershed management approach, is firmly established in rural development endeavours. Impact can now be witnessed by the amount of physical soil and water conservation coverage seen in the country (Figure 1.7). The question now is not about the need for watershed management, but rather how to expand the area covered - and make sure it is sustainably managed. Widespread application and use of the Guidelines for Sustainability will help to address this sustainability challenge.

One of the lessons learned over the last four decades regarding SWC/SLM activities in the country is that they never come to an end: new issues are constantly emerging and increasingly complex and intertwined sustainability challenges have to be addressed, all of which call for new research approaches. To understand these emerging issues and then to address them accordingly, different knowledge types are needed and continuous monitoring of the multiple aspects of natural resource management activities is vital. This includes responses of ecosystems and livelihoods; changes in the behaviour of land users; adaptation mechanisms to global changes; effectiveness of institutions, and so forth. This process can be readily guided by the decision support system for sustainability developed by WLRC and other initiatives.

Moreover, transformative research for enhanced technologies and innovative management approaches needs to be continued in order to facilitate responses to emerging dynamics, and thereby optimally manage natural resources. In this regard, because they have proved indispensable sources of data and knowledge, WLRC's hydro-sedimentology monitoring stations and learning watersheds should continue to function as they have done to-date. In addition, attempts should be made to add extra monitoring stations to cover areas and agro-ecologies that are so far unrepresented, using a "hybrid" version combining monitoring stations and learning watersheds. Replicating new versions of LWs, which include monitoring, is strongly recommended to improve accessibility of knowledge to land users – towards the greater goal of widespread upscaling of SLM.

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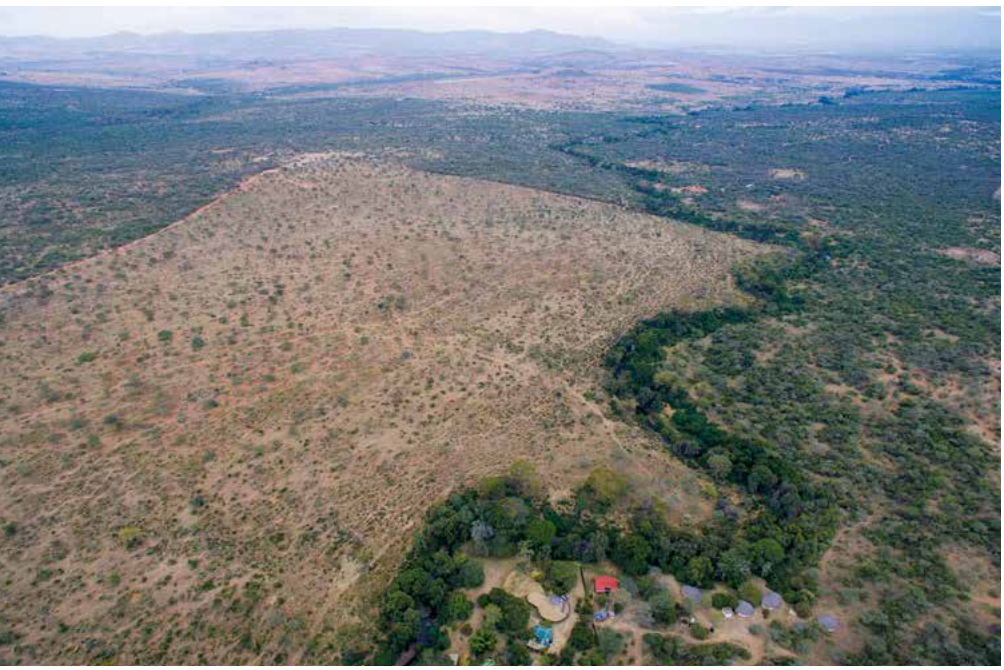
Promoting Equity, Peace and Sustainability through Society-Rooted Institutions: Four Decades of Learning, Innovation and Action in Kenya

BONIFACE KITEME, JOHN MWANGI, EMMA ODERA, HANSPETER LINIGER, ISABELLE PROVIDOLI AND URS WIESMANN



Lower Ewaso Ng'iro Basin, Kenya (Hanspeter Liniger).

The Challenge

Water scarcity has become an increasingly serious issue over much of East Africa, posing economic, social and political threats. Kenya has serious concerns over water scarcity - and one of its most affected river basins is the Ewaso Ng'iro, which drains the largest water tower in the country: Mount Kenya.

The Ewaso Ng'iro River Basin lies on the north-western side of Mt. Kenya (Figure 1.9), and covers just over 210,000 km^2 (in Kenya: it extends further into Somalia). The basin has an altitudinal variation that ranges from the mountain peak at 5200 masl, through the Laikipia plateau at an average of 1500 masl, down to just below 1000 masl in the dry lowlands of the north: Isiolo, Samburu, Marsabit, Wajir and Garissa (Figure 1.10). The rainfall regime in the area follows this altitudinal profile. From the mountain and highlands upstream rainfall drops from over 1200 mm/year to about 800 mm at the 2000 masl belt, to between 300 and 500 mm on the Laikipia plateau, and below 300 mm in the lowlands. This represents one of the steepest ecological gradients in East Africa. Conversely, temperatures increase northwards reaching the highest of over 30 degrees C in the lowlands, causing very high evapotranspiration rates there. As a result, only a very small fraction of the basin - on the slopes and footslopes of Mt. Kenya - registers a positive annual water balance; the rest of the basin experiences a water deficit that reaches over 3000 mm in the lowlands (see Figure 1.10). The basin supports a high human population (approx 3.6 million; Kenya census, 2009) which is densest in the upland areas. This population is swollen by spill-over immigration from neighbouring, densely populated, areas.

The primary limiting factor to agricultural production is water. Historically, water flowed abundantly down the mountainside with plenty for the small-scale farmers of the uplands, then onto the lowlands, providing water for livestock and wildlife, while replenishing aquifers. However, over the last six decades the situation has changed dramatically, especially during the dry season. A combination of factors have played their part in decreasing water availability.

During this period, this basin has experienced persistent, and sometimes dramatic, changes in land ownership, land use and land cover. In the better areas, the pastoralists were displaced by white colonists at the beginning of the 20th century; and then upon independence in the early 1960s, the "White Highlands" were rapidly settled by African smallholders. This meant rapid increases in population density. Farming systems changed too: with an expansion of rainfed farming systems – which were often ill-adapted, having been imported from afar together with the immigrant population. There was also the emergence of intensive small-scale irrigation: a development that was to have serious consequences with respect to water use in the basin (see also Eckert et al. 2017). As a result of these changes, the indigenous pastoralists were confined to ever-decreasing grazing areas. This limited their capacity to maintain the herds of cattle and

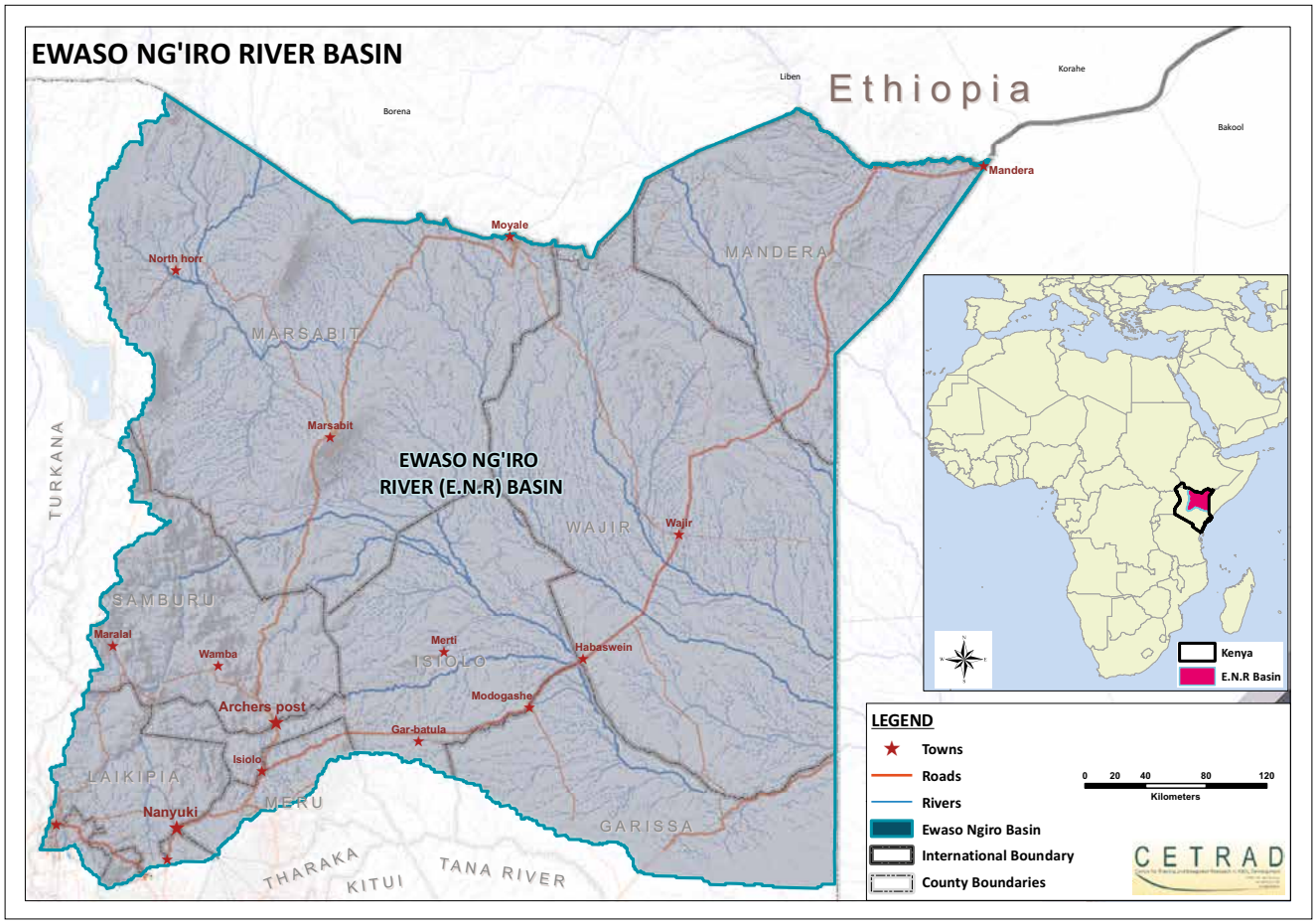


Figure 1.9: Map of Ewaso Ng'iro river basin in Kenya (Source: CETRAD).

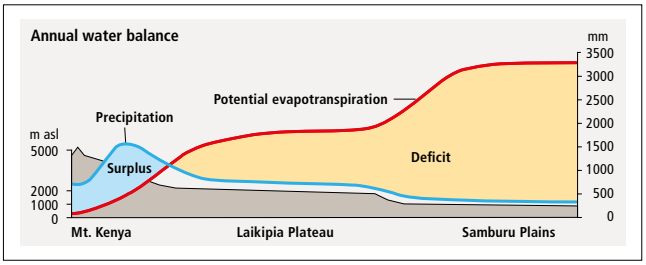


Figure 1.10: Annual water balance in the Ewaso Ng'iro River Basin (Source: Wiesmann et al. 2000).

smallstock that they depended upon, and it especially diminished their ability to maintain traditional seasonal movements that tracked the rains and vegetation (Kohler 1987; Kiteme et al. 1998a, 1998b; Wiesmann and Kiteme 1998). Significant recent developments have taken place in the horticultural industry, with the few remaining large-scale farms taken over, and application of state-of-the-art irrigation technology for export-oriented horticultural enterprises (Schuler 2004; Ulrich et al. 2012; Ulrich 2014; Lanari 2014; Zaehringer et al. 2018).

The impacts of these changes have manifested themselves most clearly in terms of the water resources. The ever-growing population and changing land use systems against the backdrop of poorly matched agro-ecological conditions has hugely increased the demand for water - for domestic use, livestock and irrigation - and on river water in particular. This is the preferred source due to its reliability, accessibility, ease of capture and conveyance. It requires the least technical knowledge and material input during both construction and operation. Simultaneously, alternative sources of water are either non-existent or too expensive. This enormous hike in demand for river water raised the amount of abstraction by, for example, over 278% between 1997-2002; thereby reducing the dry season flow from 9m³/s in the 1960s to less than 1m³/s the mid-2000s at the lowlands monitoring station on the Ewaso Ng'iro river at Archer's Post (Figure 1.11a, 1.11b). The net result of these developments are dwindling water resources, leading to a water crisis of unprecedented scale as manifested in the seasonal drying-up of the river system in the middle and lower segments. This has led to increased competition and conflict among and between the different user groups that include large-scale commercial farms, smallholder farmers, pastoralists, large-scale ranchers – as well as wildlife both in and outside protected areas (Liniger 1998; Wiesmann and Kiteme 1998; Wiesmann et al. 2000; Liniger et al. 2005).

Pressure on water resources overall, both surface and groundwater, will continue to build further as a result of major developments ongoing and planned within the different segments of the basin. These include the water reservoir at Crocodile Jaws (mid-basin) and the Habaswein-Wajir Water Supply Project (lower basin) (Luedeling et al. 2015). But the one project expected to cause truly major socio-ecological impacts in the basin is the massive LAPSSET (Lamu Port

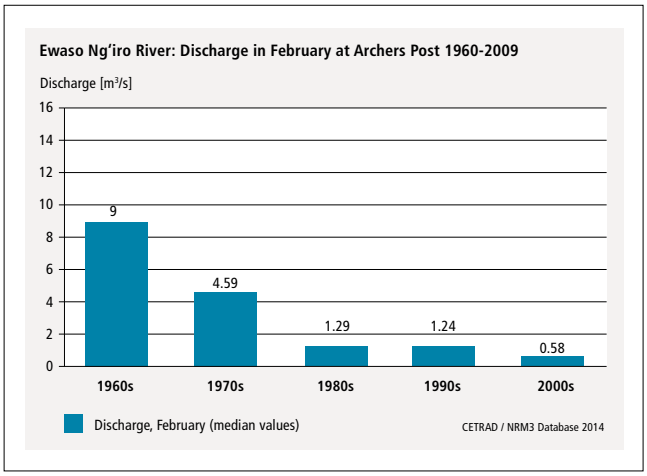


Figure 1.11a: Average discharge in February (dry season) Ewaso Ng'iro River at Archer's Post: m³/s (Source: CDE/CETRAD Long-term trends analysis, Compilation: H.P. Liniger 2018).

Southern Sudan-Ethiopia Transport Corridor) initiative with its ambitiously designed components – resort cities, international airport, pipelines, and super highways. Coupled with these developments are associated land degradation, and increasingly clear effects of climate change (especially rainfall variability) on the natural resource base. From the human perspective there are expectations created by the new institutional and governance structures, as well as the ongoing related policy reforms resulting from the new constitutional order.

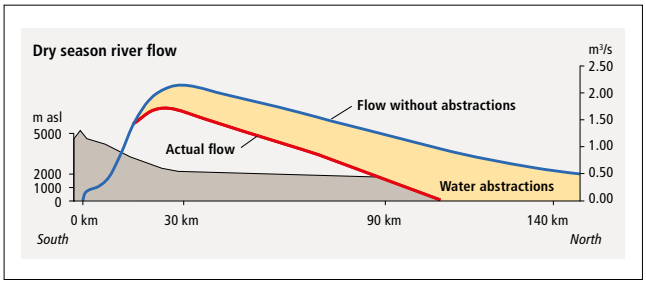


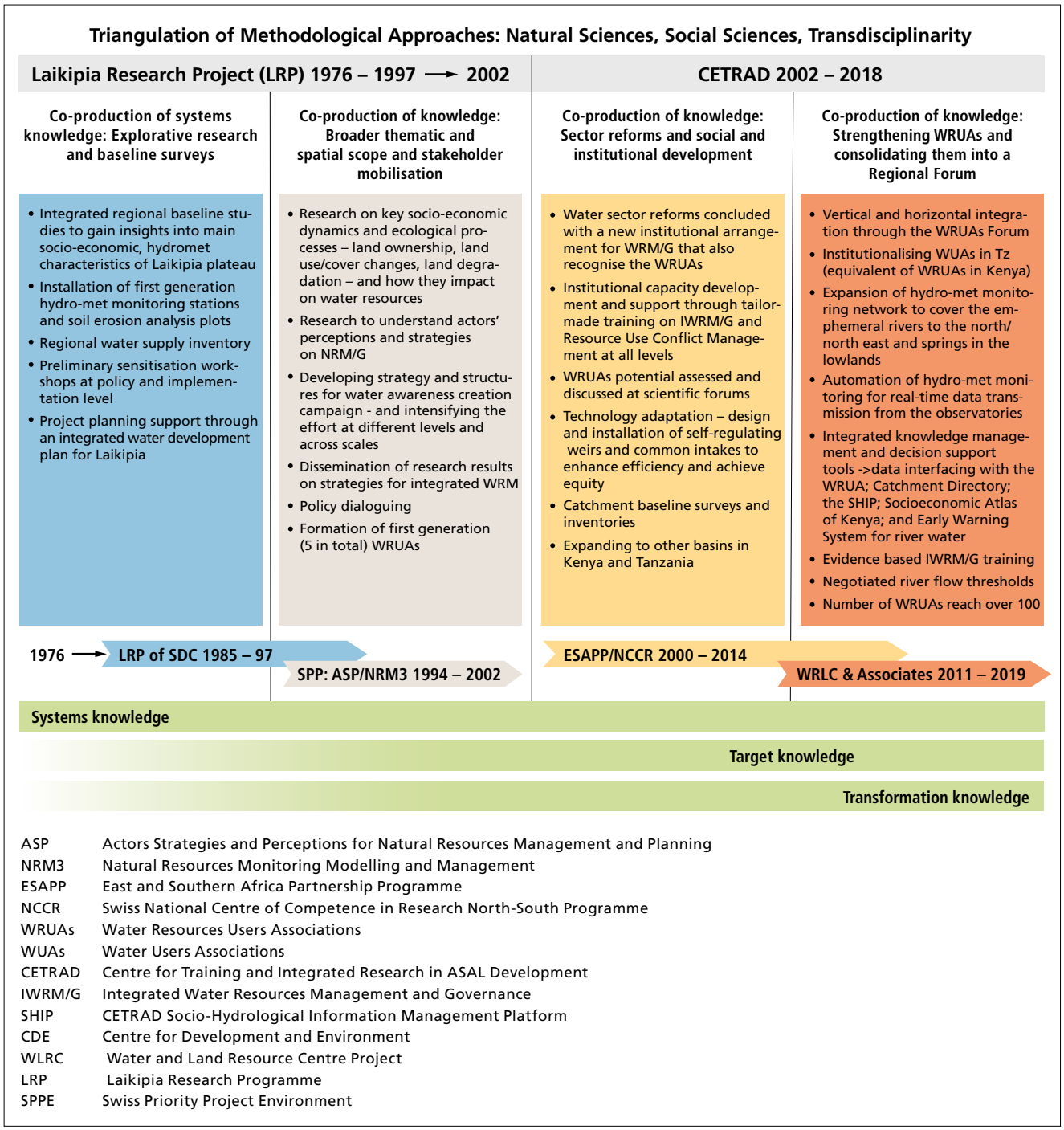
Figure 1.11b: Ewaso Ng'iro River: dry season river flow (Source: Wiesmann et al. 2000).

Thus, the problems that need to be addressed are complex: a combination of technical, social and institutional issues. Clearly a top-down approach to addressing the water crisis cannot work efficiently due to the complexity and sensitivities of the situation, but most importantly because it does not foster robust stakeholder participation, cooperation and collaboration. An approach that recognises and accommodates the role of top-down structures but strongly emphasises stakeholder involvement is needed to ensure sustainable management and governance of water resources in the basin. Of necessity, such an approach should be built on legitimate society-rooted structures that guarantee local ownership, acceptance and therefore perpetuation. Such society-rooted structure are found in what are known as Water Resources Users Associations (WRUAs). Their task is to manage and allocate water in the river they are associated with, resolve conflicts, and monitor water availability and use. Research can play an important part in contributing to better understanding of the associated dynamics and processes, and in generating knowledge and informing decisions regarding innovative interventions both in practice and at the policy level.

The Role of Research

Increased water use conflicts, sometimes culminating in loss of lives and property, was a wake-up call to practitioners and researchers in the water sector of the Ewaso Ng'iro basin. It was not simply conflict resolution that was required, but a whole set of initiatives that would help to reduce water loss, improve efficiency of use, and make land users more responsible for decisions regarding equitable water allocation. Simultaneously, there needed to be more knowledge about technical aspects regarding rainfall, river flow, land use and water abstraction, as well as social and institutional aspects in order to understand the associated dynamics and processes. Hence, it was an ideal case for transdisciplinary methodological approaches for knowledge production between non-academic and academic actors (Ott and Kiteme 2016; Kiteme and Wiesmann 2008; Pohl et al. 2010). Furthermore, there was a need to harness this work to make it, ultimately, "transformative research" that would help open up more sustainable development pathways.

Part of the overall research process embraced setting-up WRUAs. The concerted efforts of the Centre for Training and Integrated Research in ASAL Development (CETRAD) with its partners was key in the sequence of innovative and strategic interventions culminating in, among other outcomes, the current strong WRUAs movement in the country, in general, and the Ewaso Ng'iro River Basin in particular. CETRAD's long-term engagement spans over four decades - in collaboration with the Centre for Development and Environment (CDE) (Figure 1.12). The initial phase (1976-1996) focused on co-production of mainly "systems knowledge" and design of strategy and frameworks for awareness creation; the mid-phase (1997-2011) then invested in spearheading water sector reforms and institutional development, stakeholder mobilisation and formation of first generation WRUAs ("target" and "transformation knowledge"); then the current phase (2011-2019) has served to consolidate and strengthen the WRUAs through continuous capacity building in technical and legal aspects ("systems", "target" and "transformation" knowledge: refer to glossary). This has been a combined effort of CETRAD (building on the structures of her predecessor, the Laikipia Research Programme, LRP) in concert with associated projects including the Actors Strategies and Perceptions in Natural Resources Management project (ASP), the Natural Resources Monitoring, Modelling and Management project (NRM) of the Swiss Priority Project Environment (SPPE), the Eastern and Southern Africa Partnership Programme (ESAPP) and the Swiss National Centre of Competence in Research North-South (NCCR N-S) Programme, and now the Water and Land Resource Centre (WLRC) project; (see also Kiteme and Wiesmann 2008).



ASP	Actors Strategies and Perceptions for Natural Resources Management and Planning
NRM3	Natural Resources Monitoring Modelling and Management
ESAPP	East and Southern Africa Partnership Programme
NCCR	Swiss National Centre of Competence in Research North-South Programme
WRUAs	Water Resources Users Associations
WUAs	Water Users Associations
CETRAD	Centre for Training and Integrated Research in ASAL Development
IWRM/G	Integrated Water Resources Management and Governance
SHIP	CETRAD Socio-Hydrological Information Management Platform
CDE	Centre for Development and Environment
WLRC	Water and Land Resource Centre Project
LRP	Laikipia Research Programme
SPPE	Swiss Priority Project Environment

Figure 1.12: Four decades of research underpinning WRUAs (Source: CETRAD).

Based on the needs of all stakeholders, it was strongly emphasised that to achieve equitable distribution of water, social negotiation for water sharing arrangements was essential, especially during the dry season when every water user – upstream and downstream - depended largely on river water. This mechanism for conflict resolution had to be knowledge-based in order for it to avoid bias, gain acceptance, and eventually be sustainable. Consequently, socio-economic and ecological monitoring systems were established to understand the system better ("systems knowledge"). Socio-economic surveys were carried out to understand the drivers and dynamics of water users, while ecological monitoring was intended to enhance the understanding of natural resource potential, as well as key ecological processes and their impacts on the natural resource base in the basin. Thereafter, more research-driven technology development followed in a transdisciplinary context, leading to better information for decision-making, and more equitable distribution and efficient use of river water ("target knowledge"). In all of this, social learning and negotiation processes were key in developing new solutions based on "target knowledge" and "transformation knowledge". Research accompanied the overall transformational process, and helped catalyse the effectiveness and impacts of awareness-raising and capacity building, as well as influencing policy.

Results and Impact

Water Resource Users Associations (WRUAs) were first established in the late 1990s, evolving from CETRAD's efforts, founded in its 3-year water awareness campaign during that decade. WRUAs are society-rooted organisations formed at the sub-catchment level to promote participatory governance of water resources at that scale. WRUAs provide a platform where all those holding a stake along the different segments of river catchment come together. These organisations help to prevent conflict, but additionally they are designed to deal with situations where conflict has already arisen. WRUAs have proved so effective as instruments of governance that Kenya's Water Act of 2002 officially embraced and legitimised them. Within the Ewaso Ng'iro river basin, the number of WRUAs grew from 13 in 2003, to 32 in 2007, and rose to over 80 in 2015. The number has currently reached over 100, with the movement reaching almost every corner of the basin – though complete coverage would require just over 160 WRUAs.

For the time being, the WRUA formation process is stipulated in the guidelines popularly known as the WDC (WRUA Development Cycle) designed by the Water Resources Authority (WRA) in consultation with relevant stakeholders in the water sector. Formally, the local office of WRA facilitates stakeholder mobilisation and nomination of an interim management committee that spearheads the negotiations and drafting of by-laws and a constitution, before registration of the WRUA with the Office of the Attorney General. The WRUAs are then able to carry out the various and many activities required regarding management and governance of water resources. WRUA membership is accessed through existing community or corporate water projects in each respective sub-catchment. Administratively, no WRUA should manage more than 100 km^2: sub-catchments that are larger than this are divided between two or more WRUAs.

Although the WRUAs were found to function well initially, they lacked a platform for negotiation of water use across different river catchments. This gap called for the formation of a basin-wide "WRUA Forum" – which was registered in early 2012. The WRUA Forum has provided the much needed, independent, platform for negotiations at both horizontal (between WRUAs) and vertical (at a higher level of administrative authority) levels regarding water sharing arrangements, and in particular conflict resolution between upstream and downstream users. All the WRUAs in the basin are affiliated to the forum. Meanwhile the FORUM approach has been adopted by other sub-basins and subsequently mainstreamed into water policy by the government.

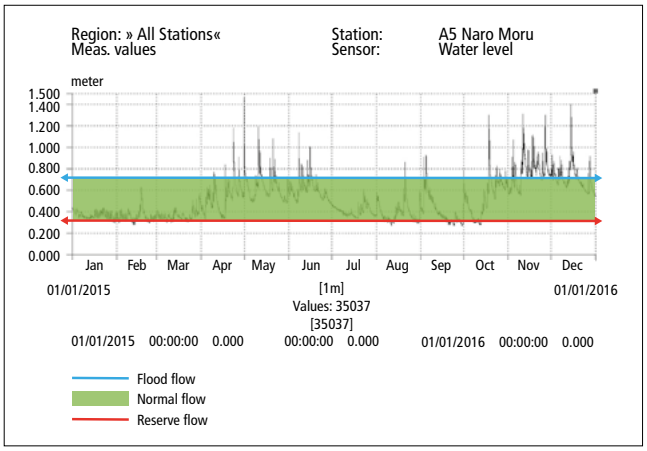


Figure 1.13: River flow threshold values – Naro Moru A5 (Source: CETRAD).

Negotiated river flow thresholds

CETRAD's continued research involvement from those days until now has helped to further advance the WRUA consolidation effort and negotiation abilities to a more scientific level by assessing their potential in terms of technical, social and institutional aspects in a transdisciplinary manner. There have been more achievements in transformative research. For example, recently, a strong focus has been placed on the analysis of hydrological data and computation of trends, with a view of re-examining the long-standing and administratively enforced "Q-values" in determining availability of flow before approving water abstraction applications. These values were technically established and embedded in water rules for enforcement - without participation of the affected water users. Because of their lack of understanding of values, or indeed ignorance of the theory, the users simply complied. It was therefore deemed necessary to design an approach that allowed involvement of water users in determining critical levels regarding water abstraction. This gave birth to the concept of negotiated context-specific river flow thresholds, which retained the commonly understood labels of flood flow, normal flow and low flow. Through these "negotiated river flow thresholds" WRUAs can determine type and quantity of water use to be permitted at different times of the season in order to ensure continuous availability of water, within all river segments, at all times (Figure 1.13). When the river is at its maximum flow during the rains, the threshold level is termed "flood flow". At this level little or no abstraction takes place - because no irrigation is required. When the rains cease and flooding subsides, the next level, termed "normal flow" is reached. It is at this stage that most smallholder farmers along the riparian zone turn to river water to supplement moisture for their crops, which include maize, beans, potatoes and various types of vegetables. While there is increased dependence on river water at this level, there is enough water for all. If it doesn't continue to rain, river flow begins to decrease to a level where river flow fails to reach the last user in the downstream zone. This level is the most critical as it indicates water shortage.

Figure 1.14: Spring at Gotu, Kenya (Source: Hanspeter Liniger).

At this stage small-scale upstream farmers need, ideally for them, to irrigate on a daily basis, while at the same time most of the communities downstream depend mainly on river water for domestic use and for their livestock – notwithstanding the important contribution from the springs in the lowlands (Figure 1.14). To address the potentially conflicting demands during the critical flow period, the WRUAs introduced water sharing schedules to allow every user access to water. For this to be effective, the distribution schedules must be adhered to, and the WRUAs in conjunction with the government's Water Resources Authority (WRA: formerly WRMA), ensure compliance. This process brings together very different users in the water sector – including large and small-scale farmers, and pastoralists all of whom have started working together.

Live data transmission system

To allow robust data and information sharing/exchange at different levels and scales, and in order also to make the negotiated river flow thresholds technology functional, CETRAD embarked on installing all river gauging stations with a live data transmission system. These were then interfaced with those WRUAs stations considered most critical and strategic, thereby sending functionally useful data to WRUA offices. Water use decisions, underpinned by evidence-based data, were therefore facilitated and informed decisions could be made almost instantaneously. The final step was to pilot an early warning system, which would enable the various water users to receive text messages, through their mobile phones, concerning the river flow status and informing them of the related actions that were needed.

Empowerment through training

Empowerment through training of water users remained a key strategy throughout. The training programme, designed and delivered in conjunction with partner institutions, notably the WRA and Laikipia Wildlife Forum, helped to enhance sound understanding of water scarcity situations, and imparted knowledge about the best ways of dealing with associated challenges - such as water user conflicts. The training programme also covered other important topics including basic legislative and policy frameworks, group dynamics, good governance practices and advocacy; resource mobilisation and management, project management; and participatory resource mapping and management. In response to inherent differences among the WRUAs based on training needs that vary with age of the association (which determines each WRUA's level of membership, resource endowment, experience and competence, etc) the WRUAs were grouped into three distinct categories: namely infancy, youthful and mature. This helped to enhance training relevance as the individual WRUAs graduated from one stage to the other. This training substantially improved general awareness and understanding of key issues affecting the water sector in the basin, and most importantly it enhanced ownership of the WRUAs, giving them the confidence to carry out various activities on their own, backstopped by CETRAD and others.

Multiple user (community) common intakes

Single user intake (large-scale horticulture farm)

Drip irrigation at household level

Farm-based water harvesting structures

Figure 1.15: Innovative methods for water monitoring and efficient water use (Source: Boniface Kiteme, John Mwangi).

Technological advances and broadening the scope beyond conflict resolution

Although the WRUAs' primary mandate is to enhance participation and resolve water use conflicts, they have embraced technological advances, stemming from CETRAD's research, to also address water use efficiency and reduce pressure on river water. Innovative and cheap high-technology methods of water monitoring have enhanced the process of participatory water monitoring, and thus further empowered the WRUAs. Prominent technologies include common (i.e. shared) intakes fitted with tamper proof self-regulating weirs, which automatically ensure river water abstraction up to a specific amount (Figure 1.15). In addition, catchment protection through community afforestation programmes, promotion of water use efficient methods of irrigation such as drip irrigation kits, promotion of dryland farming techniques including "conservation agriculture", and construction of farm-based water harvesting structures, as well as diversification of livelihoods into non-farm income generating activities, has reduced degradation and wastage of water, and diverted pressure from river water. Technology has also helped facilitate equitable water distribution within the river catchment, and between upstream and downstream water users. These techniques have helped in diversification of livelihoods into other water-dependent on-farm income generating activities: especially kitchen gardens growing high value, nutritious, horticultural crops like tomatoes, kale and cabbages. This has been underpinned by the greater security of irrigation supplies, and thus improved and more reliable planning. Consequently, these efforts have contributed to maintaining peace by ensuring river flows to the dry lowlands and thereby preventing disputes before they arise.

Conflict resolution at different scales

Conflict resolution is one of the key mandates of the WRUAs, though it is a complex challenge. This is where training has proved crucial as it enhances the capacity of the local community - as well as other water users – in dealing with conflict at different scales of magnitude. To achieve this, each WRUA negotiates water distribution schedules, especially during the dry season, and defines the specific activities to be carried out. For example, water use is allowed for domestic, livestock, and controlled irrigation in order of priority. During extreme low flows, water is permitted for domestic use only, and one abstractor is allowed water once per week for irrigation (see also Kiteme and Wiesmann 2015). This frequency is adjusted on the basis of the prevailing river flow.

At a higher level in overall watershed terms, the WRUA Forum negotiates distribution of water between upstream and downstream water users. To this effect, specific WRUAs are required to forbid all upstream abstraction on specific days, so as to allow flow downstream. Defaulters are dealt with in accordance with agreed by-laws. Where conflicts persist, both the WRUAs and the umbrella WRUA Forum directly intervene, depending on the scale of the issues. For

Ewaso Ng'iro river near Isiolo, Kenya (Isabelle Providoli).

instance, if the conflict is between two or three WRUAs and they cannot solve this themselves, the matter is referred to the forum for further probing and arbitration. A reduction of court cases has been noted: this is evidence that WRUAs have demonstrated their ability to resolve water use disputes, some of which could not even be handled by litigation in the past. Between 1997 and 2003, a total of 52 water use related conflicts were recorded: 48 of them were amicably solved at WRUA level, with only four being referred to the courts due to their complexity.

Conclusion and Prospects for the Future

The development of the WRUAs has been supported through transdisciplinary and transformative research since the 1990s. Through that, these society-rooted institutions have been strengthened in various technical, social and institutional aspects. WRUAs are increasing in number, as the Water Act of 2016 (replacing the Water Act of 2012) requires every river catchment to have a WRUA. Indeed about 55% of all river catchments in the country are now covered by a WRUA. It can be concluded that transdisciplinary research has effectively facilitated policy formulation and implementation.

The WRUAs have contributed considerably to sustainability in the basin in different ways. With respect to the environment, water flow has been maintained through equitable water sharing between various users, and a reserve flow has been maintained to cater for environmental needs throughout its course. On the socio-economic side, diversification of livelihoods has been achieved through various income generating activities, by greater security of irrigation supplies and through more reliable planning. On the social side, WRUAs have helped in securing peace and unity in a multicultural, multi-ethnic setting; and in a society where hitherto resource sharing was strongly based on the "power first" principle. The Ewaso Ng'iro Basin is home to more than ten ethnic communities who depend on river water. Through WRUAs, conflicts have been significantly reduced within the catchment and stabilised in the highland – lowland system (see also Kiteme et al. 2018). The firm ethnical boundaries and the associated deeply-seated tensions that have persisted for generations have been, to a great extent, moderated by the institutionalisation of the WRUA Forum and its basin-wide mandate. Furthermore, negotiated water sharing and distribution schedules have signaled clear progress towards embracing equity considerations.

The empowerment of local people was key throughout the whole process. By raising awareness about the water issue and the different hydrological and societal links throughout the catchment, behaviour can indeed be changed, leading to long-term improvement of the management of the scarce water source.

The question remaining regards WRUAs' potential and their resilience against sustained political manipulation and legislative erosion, evident in the recent past, all which could impact negatively on them and affect their long-term sustainability. There are risks involved in the formation and management/running of the WRUAs. While the need for and demands on the WRUAs are high, the opportunities for impact are bigger still. Despite being effective, they require sustained support with recurrent costs to maintain strong governance and management of water resources, catchment protection and conservation. In this process, transformative research has to be continued to respond to emerging issues in the water sector, and elaborating new and innovative response pathways, also in view of Agenda 2030. In all this transdisciplinary approaches, stakeholder collaboration and intensive social learning and deliberation processes are crucial.

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PHOTO

CHAPTER 2

Transformative Research - Triggering Changes in Policy and Society

2

Development agencies, policy makers and other members of society concerned with the problems of sustainable land management, and livelihoods in river basins need innovative solutions. These solutions must help foster benefits and navigate trade-offs between competing claims on land and water, while adhering to the goals of the United Nations 2030 Agenda for Sustainable Development.

The 2030 Agenda provides a normative compass and ambition, urging all countries and stakeholders, including governments and non-governmental actors from civil society, from science and business, to embark on fundamental societal transformations within a rapid timeframe. Knowledge is seen as a key component of governance in these processes. In this context, science is tasked to provide knowledge that is useful in guiding negotiations - and shaping transformations towards sustainable development.

Thus, CDE and its partners have grasped the challenge of advancing and complementing research approaches that focuses on three specific forms of knowledge: systems knowledge, target knowledge and transformation knowledge. Systems knowledge provides the basis that explains past and current challenges and opportunities, and thus enables understanding of processes and dynamics at the interface of environment and society. Systems knowledge then needs to be complemented with target knowledge, which deals with values and goals to be achieved, and on towards transformation knowledge, which addresses the means to achieve these goals. Scholars furthermore stress that the generation of knowledge for sustainable development - in particular target and transformation knowledge - requires transdisciplinary approaches, stakeholder collaboration and intensive social learning and deliberation processes.

This chapter illustrates different examples – from Ethiopia and Kenya – where CDE and its regional partners demonstrate how knowledge production can trigger changes in policy and society. Two specialised centres have been established which promote inter- and transdisciplinary approaches: approaches that establish dialogue between a wide range of actors, and set into motion joint learning processes for shaping alternative development pathways.

City development in Debre Tabor, Ethiopia (Isabelle Providoli).

The first example deals with land use planning in Ethiopia. It illustrates how research data compiled by the Water and Land Resources Centre (WLRC) on land use change has been employed to inform policy about competing claims on land - and their consequent ecological impacts. The rapid expansion of urban and industrial areas into natural ecosystems poses a major threat, aggravating land degradation and seriously compromising key ecosystem functions including food production, fresh water provision and support to biodiversity. Two case studies are illustrated in more detail: a land use change analysis over the last four decades along the five major development axes from Addis Ababa, and landscape transformation in the Central Rift Valley lakes region and the Chefa wetland. This research is required not just to present the scale and dynamic of these developments and changes, but also to help evaluate their ecological impacts. Without this information it is simply not possible for decision-makers to make, with confidence, evidence-based land use planning decisions for the future. This research has triggered the drafting of a pioneering, first, national land use policy in Ethiopia.

The second example illustrates how transformative research can support and guide the sustainable management of river basins in Kenya and Tanzania, respectively. For this, transdisciplinary research processes, involving a full range of actors touching different spatiotemporal scales, were initiated. Joint learning processes were begun, aiming to share, and reconcile, visions to tackle the water challenge through local innovative solutions linking the multiple scales. A particular focus was given to three aspects: (i) social and institutional development, (ii) improvement of the available information base, and (iii) influencing policy development processes. This was facilitated by deepening the understanding of local socio-ecological systems, as well as designing innovative tools and participatory approaches. Simultaneously current policies and related policy processes were investigated, while exploring alternative pathways.

City development in Debre Tabor, Ethiopia (Isabelle Providoli).

National Land Use Policy Triggered by Transformative Research

GETE ZELEKE, TIBEBEU KASSAWMAR, AMARE BANTIDER, ANDREAS HEINIMANN, ZEWDU ALEBACHEW, ISABELLE PROVIDOLI AND HANS HURNI

View over Addis Ababa, Ethiopia (Isabelle Providoli).

The Challenge

Land use change in a developing economy is inevitable, and necessary for growth. However, if ungoverned, the consequences can be devastating to the environment. When land use planning and policy are weak or absent there can be severely damaging impacts on ecosystems. This is a major challenge in Ethiopia. It is common to see urban centres and industrial areas expanding rapidly into wetlands, grasslands and fertile farmland. Similarly, conversion of remnant natural forests, savannah woodlands, grasslands and important wetland ecosystems to both large and small-scale farms is another frequent and widespread form of change. Furthermore, marginal lands and hillsides reaching up to slopes of 70% are now being brought under cultivation or afforestation with exotic tree species (mainly eucalyptus) without appropriate land management practices. In these cases, ecosystem function is impaired, and as a consequence vital ecosystem services are seriously affected: these include provision of clean water, maintenance of biodiversity, food production and flood control. In some areas the consequences are particularly grave – especially where the encroached areas are hotspots in terms of ecosystem value and vulnerability.

Thus, in Ethiopia, changes in land use and associated human-environment interactions over the last centuries reflect modifications in the human-agriculture interface, and have left their marks on the landscape. Some studies focusing on the Northern and Central Ethiopian highlands show that almost all land use/land cover changes have been unidirectional – from natural landscapes (forest and grasslands) to human-managed farmlands, plantations of exotic tree species and settlements (Kebrom and Hedlund 2000; Gete 2000; Gete and Hurni 2001; Woldeamlak 2002; Muluneh 2003; Amare 2007; Tibebu et al. 2011). These studies demonstrate that, in the rural context, the very dependence of nearly 83% of the total population on subsistence agriculture, coupled with increasing population pressure and the subsequent need for additional farmland, are common factors propelling land use conversion.

While this has been the general historical trend, within the last two decades other forms of land use/land cover (LU/LC) changes have emerged, especially along the major development axes of the country. Urban centres have been expanding, and both secondary and tertiary sectors (light and heavy industries, and services including hotels and lodges) and agricultural investment in intensive commercial enterprises, have emerged from the once totally agrarian landscape. Similarly, in the hinterlands, a massive resettlement programme has been implemented and has resulted in considerable land use change, particularly in the western part of the country (Worku and Mengistie 2011). According to the Ministry of Agriculture and Rural Development (MoARD), in 2003 alone about 440,000 households, or approximately 2.2 million people, were resettled in new areas from all four major regions of the country (i.e. Amhara, Oromia, SNNP and Tigray). In addition, further resettlement and expansion of commercial farms are under implementation and/or planned to be undertaken in the country (see first and second Growth and Transformation Plans of the country for the periods 2010/11-2014/15 and 2015/16-2019/20, respectively).

While the change towards urbanisation and industrialisation may be unstoppable - and in many ways desirable - land use change is clearly not following any well thought-through land use master plan. The rapid expansion of urban areas brings a particular set of problems, as does the continuous march of agriculture into natural ecosystems. Land use change associated with economic development must not be detrimental to overall ecosystem function. Studies are required both to

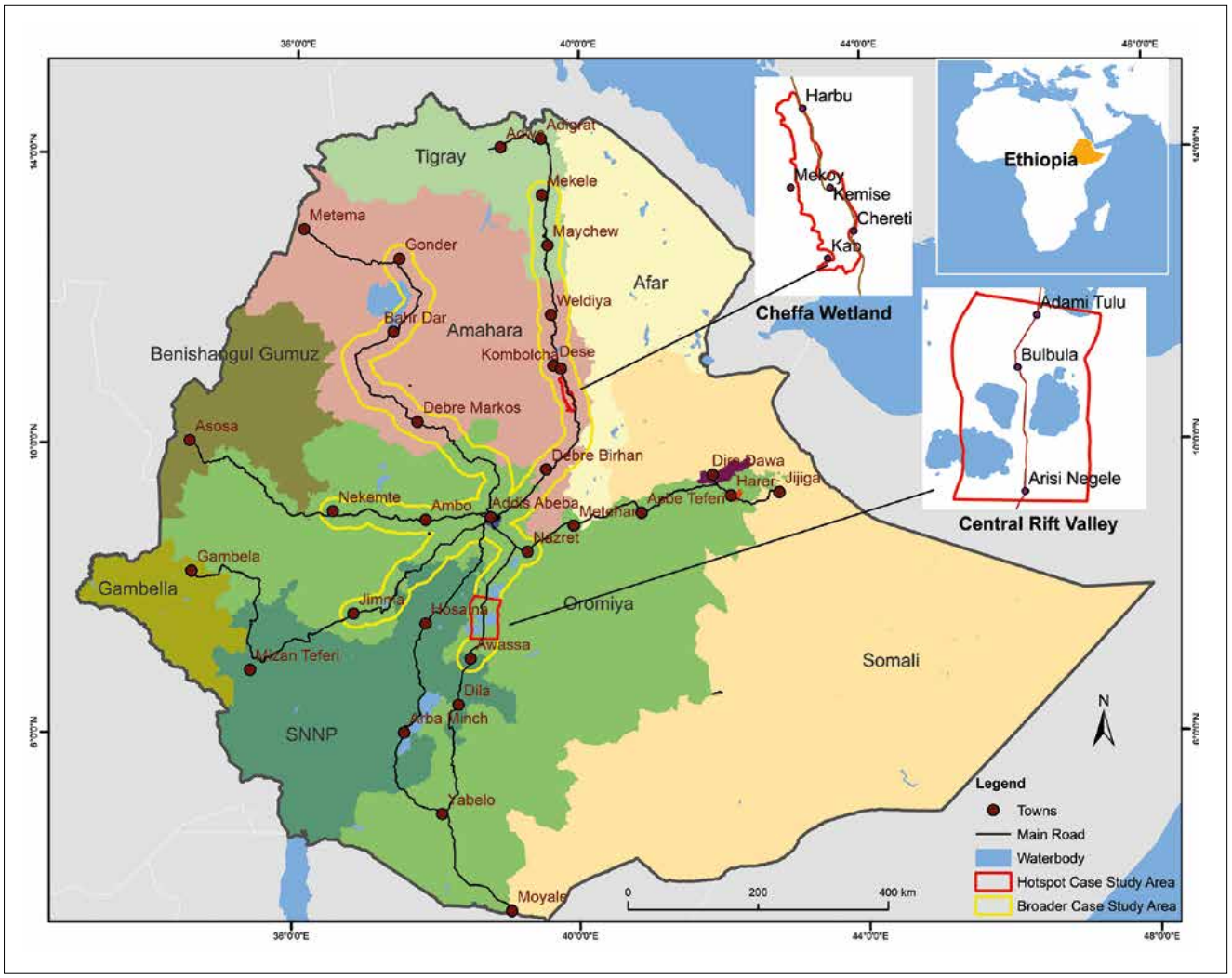

Figure 2.1: The study area (Source: Meso-Scale Landscape Transformation (RP12) Project in NCCR North-South HOA).

assess the historical, current, and predicted rates of land use change, and the associated impacts on people and the environment. Research data and analysis can then help to inform and guide policy-makers. They will then be in a position to reconcile the often-competing demands of development and the environment.

The Role of Research

Research is required not just to substantiate the scale of these developments and changes by providing the basis about past and current challenges (i.e. systems knowledge) but also to help evaluate their ecological impacts, and to elaborate goals and shared visions to be achieved for a sustainable future (i.e. target knowledge). Without this information, it is not possible for decision-makers to make evidence-based land use planning decisions in the future. The country is in a state of transformation: the process needs to be better guided, and thus research can help to steer this process and identify solutions jointly. This can be achieved by advancing inter- and transdisciplinary approaches that establish dialogue between scientists and policy makers, foster evidence-informed decision, and set in motion joint learning processes for shaping alternative development pathways. This chapter focuses on the contributions of research into land use change – and its implications for land use planning. The studies were conducted by an interdisciplinary team of researchers from the disciplines of land change science, socio-economics, natural resource management, and land use planning.

To empirically demonstrate the transformation described in the forgoing, LU/LC change analyses covering the last four decades were undertaken along narrow strips (20 km wide on each side of the road along the main highways) of five development axes and two selected biodiversity hotspot areas. The study area along the five development axes covers approx. 81,830 km^2 and radiates in all directions from Addis Ababa (AA): they are: AA-Gonder, AA-Mekele, AA-Adama-Hawassa, AA-Jima and AA-Nekemte. The two hotspots are the Chefa wetland and the Central Rift Valley Lakes Region, which in total cover about 3000 km^2. The analysis was performed to examine change dynamics in light of their wider land use planning and policy implications (Figure 2.1).

The 20 km radius (on each side of the road - 40 km wide) study strip was selected based on three considerations: first, much of the recent transformation in terms of infrastructure,

heavy and light industries, large-scale agro-enterprises, and urban expansion, has taken place within 20 km of each side of the road; second the maximum distance a person can easily walk to an urban centre to access services is around 20 km, and third, it is clearly within this range that a concentration of settlements and dynamic socio-economic activities are evident. Thus, this buffer has its own, unique characteristics and role in the observed landscape transformation. The research was also informed by concerns raised from practitioners and experts during key informant interviews.

The Findings

Landscape transformation in the broader study area

The time series analysis (from 1986-2010) in the study area shows that some land cover classes such as urban areas, built-up areas (i.e. industries, agro-industries, lodges, etc), bare land and cultivated land are increasing consistently over time. During this period, urban areas expanded by 193%, other built-up areas by 384%, and bare land by 405% - significantly surpassing the rate of transformation of cultivated land at 25%. The results also show that cultivated land remained the dominant land cover type in all periods: it covered 63% of the study area in 1986, reaching 78% by 2010. The remaining land cover classes show a reducing trend over time: namely forest (-14%), bush (-44%), shrub lands (-66%), and grassland including wetlands (-48%)[1]. This vividly demonstrates that land use/land cover changes aligned with expansion of human managed land are achieved at the expense of natural landscape. Furthermore, there was no evidence of guidance or restrictions of the overall landscape transformation by any land use plan or land use policy.

The change detection analysis shows that the expansion of urban centres, industries and agro-industries is mainly into formerly cultivated lands, grasslands, wetlands and naturally vegetated areas. While Addis Ababa, Bishoftu and Dukem, are the best examples of the expansion of urban centres and industries into fertile cultivated lands (Figure 2.2), Sululta is the clearest case of indiscriminate expansion of urbanisation and industry into grasslands and wetlands. Under a land use masterplan, such expansion could have been best carried out into bare land, and agriculturally unsuitable areas such as hills, and it should have strictly avoided eating into ecologically sensitive areas such as grasslands, wetlands and forest areas.

A simple spatial analysis carried out on the expansion of Addis Ababa and four regional towns (Adama, Bahir Dar, Hawassa and Mekele) provides clear-cut evidence of how urban centres have been expanding at an accelerating rate over the last two decades (Figure 2.3). For instance, Addis Ababa was expanding at 5.2 km^2/year between 1986 and 2000 - and this grew to 14.5 km^2/year between 2000 and 2010 (see Table 2.1). The next fastest growing city, Adama, has been expanding at 1.6 km^2/year between 2000 and 2010, followed by Mekele and Bahir Dar both growing at 1.2 km^2/year. Surprisingly, Hawassa shows a deceleration of expansion over the last decade (2000-2010) compared to 1986-2000: down to 0.3 km^2/ year from 0.43 km^2/year.

Figure 2.2: Expansion of Addis Ababa into prime cultivated lands (Source: Gete Zeleke).

Figure 2.3: Expansion of Addis Ababa (Source: Isabelle Providoli).

The overall rate of expansion between the overall period of 1986 and 2010 shows that the five urban centres were expanding at a cumulative 12.3 km^2/year. Addis Ababa was the highest at 9.1 km^2/year followed by Adama at 1.1 km^2/year, and then followed by Mekele, Bahir Dar and Hawassa at 0.9, 0.8 and 0.4 km^2/year, respectively (see Table 2.1). From the analysis we know that the expansion was largely at the expense of cultivated lands and grasslands, and to some extent bush and shrub lands (Figure 2.4 as an example of Hawassa expansion). It is clear therefore that food and livestock production, and water and wetland biodiversity, which are the key services of such ecosystems are very significantly affected in the vicinity of these urban centres. The expansion recorded here does not respect the land potential-based development principle, nor does it reflect any carefully-designed land use master plan. These impacts of urbanisation on peri-urban livelihoods demand careful study in the immediate future, and this should be used to inform policy decisions. This because the expansion is associated with huge displacement of rural communities with very little compensation, and simultaneous interference with the environment and key ecosystem function and services.

[1]The land use and land cover analyses were made during the dry period where seasonal flooding areas (seasonal wetlands) cannot be differentiated from satellite imagery.

Table 2.1: Spatial expansion of selected major urban centres between 1986 and 2010. (Source: Meso-Scale Landscape Transformation (RP12) Project in NCCR North-South HOA).

Towns	1986	2000	2010	1986-2000	2000-2010	Total change	1986-2010	Expansion trend
	Area (km^2)	Area (km^2)	Area (km^2)	Rate of change per year (km^2)	Rate of change per year (km^2)	1986-2010 (km^2)	Average rate of change (km^2)	
Addis Ababa	132	205	350	5.2	14.5	218	9.1	Exponential
Adama	10	20	36	0.7	1.6	26	1.1	Linear
Hawassa	6	12	15	0.4	0.3	9	0.4	Logarithmic
Bahir Dar	5	13	25	0.6	1.2	20	0.8	Exponential
Mekele	5	15	27	0.7	1.2	22	0.9	Linear
Total	158	255	453			295	12.3	

Landscape transformation in Central Rift Valley Lakes Region and Chefa wetland

The two hotspot areas, namely the Rift Valley Lakes Region and the Chefa wetland are among the most important, and most fragile ecosystems of the country which have already been degraded - and therefore demand careful and judicious management.

The detailed satellite image analysis of a small strip of land (2,570 km^2) in the Rift Valley Lakes Region stretching between Adami-Tulu and Arsi-Negele towns (Figure 2.5) shows that natural vegetation cover (mainly acacia forest/woodland) was reduced in extent by 77% between 1973 and 2010, while rain-fed and irrigated cultivated land (including farm homesteads) increased by 91%. Bare land increased by 162% and built-up areas including smaller urban centres, agro-industries and tourist lodges increased by 436%. The environmental impact of such LU/LC change are obvious. These visual impacts include siltation and pollution of the lakes, reduction in the size of the waterbodies (especially Lake Abijata) and reduction in biodiversity (particularly of aquatic species and birdlife) (Figure 2.5).

Chefa wetland is an important and strategic natural resource located on the eastern extension of the Rift Valley. It is the major source of dry season forage and water for the lowland pastoralist and agro-pastoralist communities of Afar and Oromia Zone of Amhara National Regional State. Every year, during the dry season, between 120,000 and 150,000 head of cattle (as well as camels and other livestock) graze this wetland for three to four months. Although this is the tradition developed and practiced by communities for centuries, the wetland has, during the last few decades, suffered from severe encroachment through cultivation (both small-scale and large-scale farming), drainage, over-abstraction of water, deforestation of its upper catchment, siltation and infestation by invasive species. Analysis shows that cultivated land within the wetland boundary increased from 46% to 65% between 1973 and 2013, and settlements (including small towns) increased from 3% to 8% between 1973 and 2013. The wetland itself decreased dramatically in size from 43% to 15% of the overall area between 1973 and 2013 (Figure 2.6).

Policy implications

The findings of this study were packaged into a summary paper in 2015 outlining the problem, the consequences, and making clear recommendations. This was presented at various forums between 2015 and 2018. It was the basis for establishing dialogue between scientists, practitioners and policy-makers. The ultimate goal of the presentations and exchanges was to provide all concerned actors with evidence of the trend of land transformation in Ethiopia, and to set in motion a joint learning process for shaping alternative development pathways. For this, various consultations were held with groups across different sectors and levels. The message delivered was powerful: if we allow uninhibited expansion into critical land, nature's protective and productive ecosystems will be ruined. While the precise impact is still an unknown, enough is understood to state unequivocally that the calculated rates of uncontrolled penetration into sensitive areas is hugely damaging. The findings were presented to various forums that can be grouped into four stages: i) pre-decision by Cabinet Ministers, ii) for broader awareness of key actors after the Cabinet of Ministers agreed on the general principle, iii) for consolidation of preliminary agreements by Cabinet Ministers and iv) post-decision to the broader funding agencies to get better support for the formulation of the land use policy and plan.

The first presentation was made in 2015 to the Minister of Agriculture and Natural Resources (MoANR) in the presence of the State Ministers and Directors of the Ministry. The Ministry of Agriculture and Natural Resources reviewed this study and brought the issue to the attention of the Prime Minister's Office. The Cabinet of Ministers agreed on the need to develop a national land use policy and plan, and established a secretariat under the Prime Minister's Office. To create better awareness and get broader support, the MoANR organised a national workshop in 2015 and the findings of the study was presented. After some momentum was created, considering the seriousness of the problem, the Prime Minister took prompt action and called for a symposium in 2016 where the findings were presented for the third time. This symposium brought together cabinet members, regional officials and heads of different institutions to discuss the imperative of formulating a national land use policy and preparing a

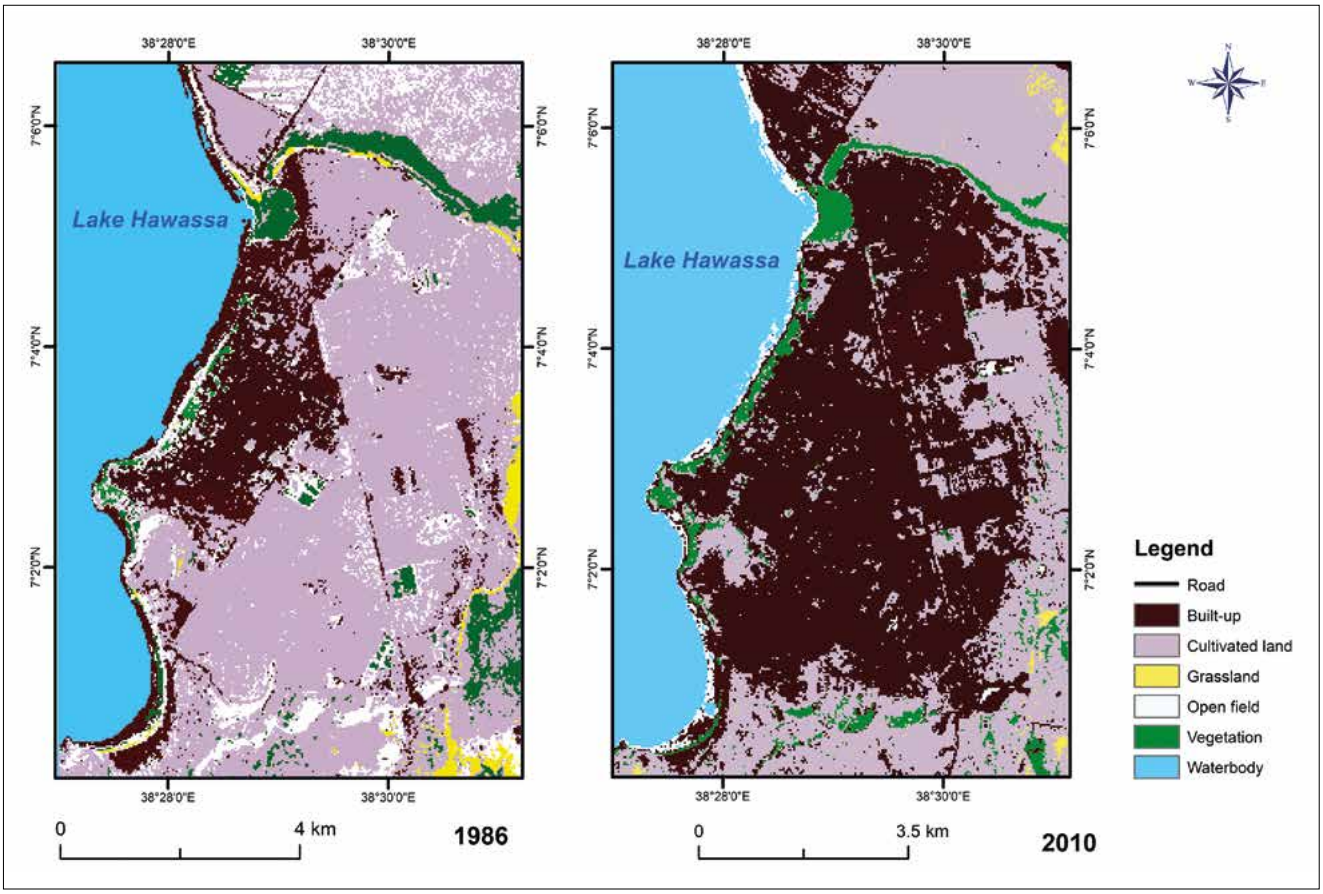

Figure 2.4: Temporal and spatial dynamics of land use and land cover in Hawassa City, Southern Nations, Nationalities and Peoples' Region (SNNPR) (Source: Meso-Scale Landscape Transformation (RP12) Project in NCCR North-South HOA).

national integrated land use plan. After the symposium, the-then Prime Minister gave a directive to move to the next step: the formulation of a national land use policy, and a road map, to prepare a national integrated land use plan for implementation in the third Growth and Transformation Plan. It was declared a top priority on the nation's development agenda. The secretariat under the PM's office started moving at full speed to draft "a national integrated land use policy and land use plan" (ILUP&P). In 2017, various preparatory works were undertaken by the secretariat such as the road map was prepared, and presented to another national workshop where WLRC participated. The land use policy will eventually align national, sectoral and regional demand for land and thereby protect biodiversity and environmental hotspots (Zemen et al. 2017).

The Government of Ethiopia would like the land use plan to be ready for implementation in its third Growth and Transformation Plan for the period 2020-2024. This will require the mobilisation of enormous resources, and therefore the alignment and support of major development partners in the country. That is why the government requested WLRC to present the findings to the Rural Economic Development and Food Security (REDFS) forum in 2017. REDFS is a high-level joint government–donor platform co-chaired by two Ministers (MoANR and MoLF) and two heads of Agencies (EU and WB). After this presentation the EU delegate in the country requested the same presentation to be made, in the same year, to its country technical staff and heads of agencies of EU members states in Ethiopia. A similar request was made by SIDA and a presentation was made in June 2017. The EU is now supporting the secretariat financially as per recommendations during the presentation. Recently, following the new political environment in the country, the-then Ministry of Environment, Forest and Climate Change (now Commission) was designated the focal point for coordination of the development of the national land use policy and integrated land use plan. The secretariat is positioned under the Commission.

The journey from research to policy has not been smooth or linear, as most of the transformations were politically driven, or pushed by groups that made use of the weak capacity of the public sector. Despite this, the outcome of this transformative research exercise was very encouraging. It had the effect of raising concerns at the very top level of policy makers and development partners in the country.

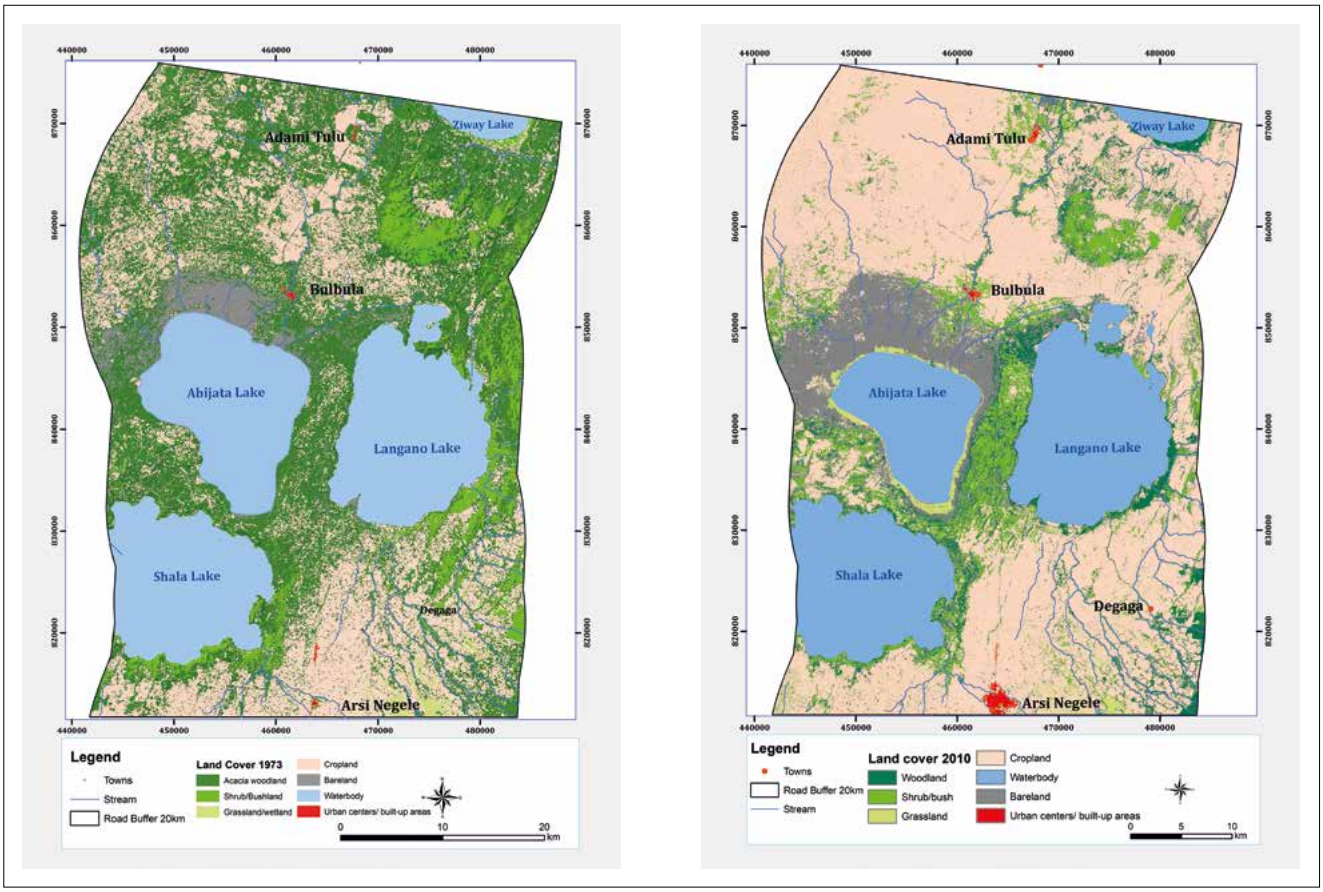

Figure 2.5: Land use and Land cover changes in the Central Rift Valley Lakes Region between 1973 and 2010 (Source: Meso-Scale Landscape Transformation (RP12) Project in NCCR North-South HOA).

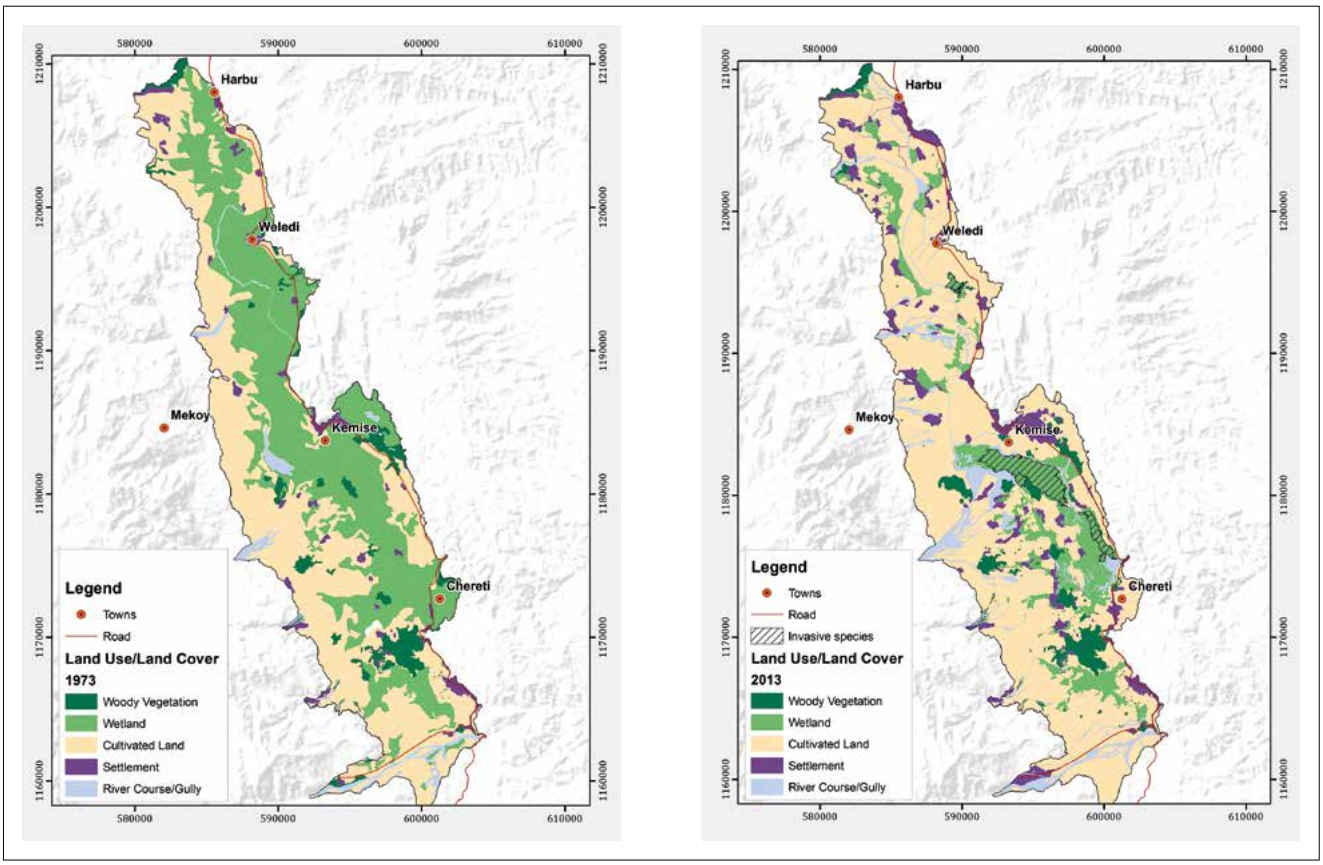

Figure 2.6: Land use land cover change between 1973 and 2013 showing an alarming conversion of the wetland area to cultivated land and settlement areas (Source: Meso Scale Landscape Transformation (RP12) Project in NCCR North-South HOA).

Exchange visit in learning watershed Debre Mewi, Ethiopia (Gete Zeleke).

The response to this potential man-made disaster is to regulate the changes through the elaboration of a national land use policy and a national integrated land use plan. The process is underway. Formulation and institutionalisation of robust and appropriate policy, laws and regulatory mechanisms are unanimously agreed as a requisite for sustainable land use management. The secretariat is in place and the procedures and steps laid out in the road map will help planning experts to follow uniform and standard approaches in the collection, analysis and mapping of data to produce sound land use plans. The land use planning process is not expected to go smoothly and without challenges. Lack of skilled manpower, resource limitation and cultural and social factors will continue to affect the process. The time allocated to the elaboration of the land use policy seems to be very ambitious: but the urgency of the situation demands ambition.

Promise for the Future

The research carried out revealed strong evidence that the major part of the current land use and land cover changes do not respect the land's potential; it is aggravating land degradation and seriously compromising key ecosystem function and services including food production (both crop and livestock based), water and biodiversity. Furthermore, assuming a business-as-usual scenario, the rate of land transformation in the decades to come is predicted to be even faster than ever, with the rapid socio-economic-political-institutional changes in the country, greater linkages to the global market and unprecedented climate change.

In the process of the development of the national land use policy there is clearly additional work to be addressed by the WLRC in supporting this initiative. This includes: i) developing an approach and guidelines for avoidable land use actions until the ILUP is finalised and approved, and ii) updating and monitoring changes using the latest remote sensing images and GIS software, as well as modelling. This is important in order to help make amendments and improvements to the policy and guide its implementation on the ground. The ILUP & P is also expected to suggest the formation of a robust implementing agency that will be active at all levels of the administration. Side-by-side will be the establishment of strong collaboration between actors at all levels, and it is clear that skilled human resources are essential and thus capacity building needs to be undertaken simultaneously.

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Innovative Knowledge Management Approaches for Policy and Practice Across Scale

BONIFACE KITEME, JOHN MWANGI, MILTON MUTUMA, HANSPETER LINIGER, ISABELLE PROVIDOLI AND URS WIESMANN

Exchange visit between Kenyan WRUAs and Tanzanian WUAs in Tanzania (Boniface Kiteme).

The Challenge

Transboundary water issues are growing in importance in East Africa: rivers and aquifers know no administrative frontiers. What happens in one country impacts on resources in another. In most of the region, rapidly evolving socio-economic dynamics are driving demand upstream, which is in turn threatening downstream supplies. Already serious when confined to a single country, the impacts and potential remedies are even more complex when water resources are shared internationally. The implication is that while people living in these areas simply have to find sustainable sub-basin management solutions for themselves, the decisions they make will have an impact on others far away. A major complexity these basins are facing is that water management and governance processes are taking place at different - and intertwined - spatiotemporal scales and societal levels. This involves a multitude of actors. What makes the situation even more difficult is that, commonly, there is a lack of connection between (i) social and institutional development, (ii) the available information base, and (iii) policy development processes. Ideally, these three aspects should be smoothly linked, supporting each other and leading to informed decision-making and effective action.

Transformative research can support and guide the sustainable management of such basins by helping to steer appropriate, tailored, development pathways. This can be effected by providing the knowledge required and developing context-specific approaches through stakeholder collaboration, intensive social learning and deliberation processes. Such transdisciplinary processes can be key in informing policy and helping to trigger change - and societal transformation.

Here, two transboundary river basins are examined: the Ewaso Ng'iro Basin, shared between Kenya and Somalia, and the Pangani Basin which stretches across Kenya and Tanzania (Figure 2.7). Both basins are facing serious challenges in managing water sustainably, and innovative solutions followed by action are urgently needed.

The Ewaso Ng'iro Basin typifies socio-economic problems that are exerting ever-increasing pressure on water resources both upstream and downstream into the lowlands - where pastoral land use systems are being further marginalized. Rapidly growing populations; quickly expanding irrigation and a multitude of other emerging demands on water have led to a crisis of unprecedented scale. The middle and lower segments of the river system have started to dry up, further increasing competition and conflicts between different user groups: large-scale commercial farms, smallholders, pastoralists, large-scale ranchers, and wildlife. The crisis is compounded by proposed major infrastructural development projects with local and international dimensions. Examples are the Lamu Port and Lamu–Southern Sudan–Ethiopia Transport flagship Kenya government initiative, and the Crocodile Jaws dam - a series of seven new irrigation and water supply dams on the foot slopes of Mt. Kenya. At the same time, the effects of climate variability on the natural resource base are increasingly being felt. Moreover, the institutional and governance structures resulting from the new constitutional order and ongoing related policy reforms, since 2010, have given rise to fresh expectations in Kenya, but to new challenges also. Overall, these developments set the stage for serious water conflicts, making the region a major hotspot that demands rapid and concerted policy and development interventions (see Chapter 1 – Kenya).

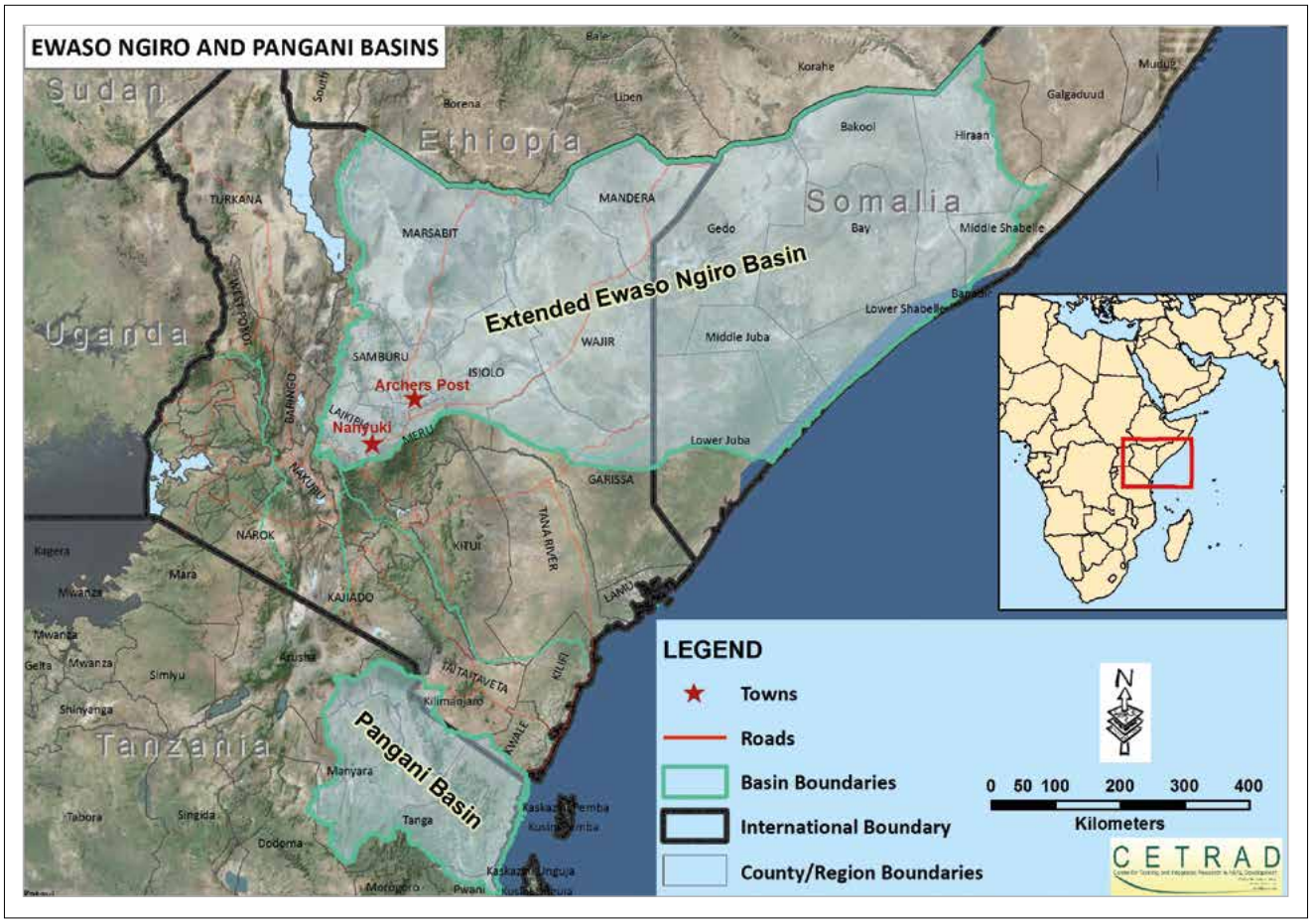


Figure 2.7: Ewaso Ng'iro and Pangani Basins (note: the Ewaso Ng'iro North River Basin covers the part of the basin that falls within Kenya).

The Pangani Basin also faces serious water challenges. Once again cross-border water management is essential, as mishandling of this scarce resource could readily trigger hard-to-resolve cross-border conflicts made doubly difficult because of the contrasting rules and regulations in the two countries.

Efforts to tackle the water crisis in the Ewaso Ng'iro and Pangani Basins face two major challenges. Firstly how to deal with "multiple scale" problems and secondly how to identify effective "combined approaches". The challenge of multiple scale arises from the different spatiotemporal dimensions within and across the basins. Crises may occur at different places and different times. The impacts can manifest themselves at local, regional, national or international level. Despite this, most decisions on measures to mitigate the problems are taken at the regional/basin level - and then they cascade down to the local level without consultation or the mechanisms in place for feedback. Related to this is the second challenge of identifying "combined approaches". These are needed because of the complex interlinkages and interdependencies of systems in and across the different scales and socio-ecological themes that must be integrated. This chapter discusses the role of transformative research and its imperatives in finding solutions to the water challenge in the two basins. The Centre for Training and Integrated Research in ASAL Development (CETRAD) has organised itself to address these two challenges: namely through the support of the Water and Land Resource Centre (WLRC) project and other related initiatives.

The Role of Research in Finding Appropriate Solutions

CETRAD took up the water challenge in the two river basins by exploring new options to promote sustainable development. For this, transdisciplinary research processes, involving a full range of actors touching different spatiotemporal scales, were initiated. Joint learning processes were started, aiming to share, and reconcile, visions to tackle the water challenge through local innovative solutions linking the multiple scales. A particular focus was given to three aspects: (i) social and institutional development, (ii) improvement of the available information base, and (iii) influencing policy development processes. This was facilitated by deepening the understanding of local socio-ecological systems and designing innovative tools and participatory approaches, while investigating current policies and related policy processes, and exploring alternative pathways and their implications (Pohl et al. 2007; Ott and Kiteme 2016).

The research process needed to be aware that decisions are made at multi-scales - requiring vertical integration of local, regional and national/international elements. The most crucial and far-reaching decisions regarding water resource management and development tend to be those made at the basin level. The problem becomes more complex with a devolved governance system, where counties demand full control of

BOX 1

The three interlinked research fields in river basin development

Social and institutional development	Improvement of available information management tools	Contribution to policy development processes
• Continuous capacity building of WRUAs through training, provision of legal and technical support, and resource mobilization among others • Transfer of WRUA approach of Kenya to Tanzania • Set-up of WRUA Forum in Kenya	• Sub-Catchment Directory (Kenya) • Socio-Economic Atlas (Kenya) • Hydro-met monitoring network • Social and Hydrological Information Platform (SHIP)	• Hotspots of water scarcity and conflict

water resources and management within their respective internal administrative areas, even when these contradict existing laws and regulations.

In any decision-making process, reliable information is needed in order to support decisions at different levels – for policy formulation and implementation. There is, therefore, need for a comprehensive and up-to-date information database to enhance evidence-based decision-making (Providoli et al. 2017). It follows that there is a requirement for well-established and strong institutions to act as the key generators of information. These same institutions are simultaneously consumers of the information, as well as being the implementers of policies. For this process to be complete, there must be formulation of functionally useful, guiding policies for water resource management and governance.

Thus, effective policies that lead to transformation must be well-informed, and this requires the generation of robust data and information that is timely, reliable and presented in a way that makes a clear and strong impression. Policy-makers can then act on the basis of evidence and knowledge, rather than impressions or ignorance. It is, furthermore, stressed that none of these three aspects – social and institutional development, improvement of the available information base, and contribution to policy development processes - can operate alone. They must be coordinated. This continues to pose complex challenges for the management and governance of resources. It calls for continuous socio-economic and ecological monitoring and assessment in order to facilitate the formulation of knowledge-based interventions to restore ecological sustainability in the affected areas.

Results and Impact

Here examples are illustrated of how CETRAD was able to influence and strengthen the three interlinked aspects noted above: (i) social and institutional development, (ii) improvement of the available information base, and (iii) contribution to policy development processes (Box 1).

I) Innovative social and institutional development

Continuous capacity building of Water Resource Users Associations (WRUAs): A key support measure that has enabled WRUAs in the Ewaso Ng'iro North River Basin to become a showcase of best practice in the country is the strong capacity building programme. This has been designed to ensure continuous training to all WRUAs, irrespective of their status in terms of establishment and operation. The training programme is broadly designed to cover all important aspects that influence the smooth functioning of the WRUAs. These include basic legislative and policy frameworks, group dynamics, good governance practices and advocacy; resource use conflict management, resource mobilisation and management, project management; and participatory resource mapping and management. The training programme is jointly designed and offered in conjunction with the Water Resources Authority and the Laikipia Wildlife Forum.

Transfer of Water Resource Users Associations (WRUAs): The successful story of WRUAs in the Ewaso Ng'iro North Basin, and Kenya at large, has inspired many other regions and nations (see Chapter 1 – Kenya). After successful piloting and establishing fully functional WRUAs in the basin for over two decades, CETRAD transferred the same approach to one of the cross-borders catchments in the region, the Pangani Basin in Tanzania. The approach was relevant as the problems were familiar: the basin faced challenges of water use conflicts due to increased population, a surge in irrigation abstraction and increased numbers of livestock coupled with changing rainfall patterns and distribution – all of which led to an increased water demand. The IUCN reports that over 500 water use conflicts were identified in 2011 and that some major perennial tributaries started drying up (http://www.waterandnature.org/results/wani-basins/pangani). CETRAD, in collaboration with the Pangani Basin Water Office (PBWO),

Water conveyance furrow being lined to reduce water loss

Gold mining along the source of the Yongoma River in the Mkomazi sub-catchment

Figure 2.8: An exchange visit between Kenyan WRUAs and Tanzanian WUAs (Source: John Mwangi).

created awareness among the community about the need for a participatory, community-driven water management initiative. The outcome was the formation and institutionalization of five Water Users Associations (WUAs: equivalent to the WRUAs in Kenya) in five selected sub-catchments characterised by water conflict and degradation hotspots - covering approximately 80 villages with about 400,000 inhabitants.

Two WUAs were formed in Mkomazi (Hingilili and Yongoma) and three WUAs in Umba (Umba, Mbaramo and Mdando). The WUAs in the Hingilili and Yongoma river systems are dealing with multiple and interconnected challenges albeit with varying dimensions and magnitudes, notably: a) rapidly growing demand for water for domestic, livestock and irrigation use; b) water conflicts especially between upstream and downstream users; c) wanton degradation of water resources resulting from pollution, misuse and overuse due to inefficient irrigation practices; d) environmental degradation and catchment destruction due to cultivation within riparian zones and around water sources, and wildfires; e) unsustainable land use practices and inappropriate farming systems; f) growing socio-economic inequities related to water resources allocation and/or benefit sharing; and g) dysfunctional modern and traditional water governance structures (Mbeyale et al. 2012; Msuya and Kiteme 2012).

With support from the Pangani Basin Water Office and other stakeholders, these WUAs are advocating for the preparation and implementation of an Integrated Water Resources Management and Development Plan (IWRMDP); rehabilitation and maintenance of a hydrological monitoring network; establishment and strengthening of Water Resources Management institutions; empowerment of communities through education and awareness-creating campaigns - so as to foster sustainable water resources management; and assessment of, and adaptation to, climate change (Figure 2.8). They are also intent on drawing up and implementing a MoU between Kenya and Tanzania for joint management of the cross-border Umba River ecosystem. Since the formation and initiation of these WUAs, water use conflicts have decreased significantly after successful resolution at grassroots level.

The Basin-Wide WRUA Forum: The formation of a basin-wide WRUA Forum in the Ewaso Ng'iro North River Basin in 2012 provides a multi-stakeholder platform to address water issues that cut across sub-catchments and sub-regions, and to enhance vertical and horizontal integration among the WRUAs at different scales. In particular, the forum has become very popular as an effective platform to negotiate for water distribution and to resolve water conflicts between upstream small-scale farmers and commercial farmers practicing irrigated agriculture, and downstream pastoral communities. This has been possible through social learning platforms, under which the forum has facilitated various inter and intra-basin exchange visits with the aim of trading knowledge, sharing experiences and exposing WRUAs to various water management aspects – as well as alternative livelihood options. The WRUA Forum initiative has gained popularity across the basin, and indeed across the nation. Other stakeholders in the water sector, both public and private, have adopted the concept and implemented it widely: indeed it has now become a requirement under national government policy. There has been a proliferation of WRUA Forums at basin level initiated by the Water Resources Authority (WRA): these are commonly known as "catchment forums". The county governments have not been left behind, as they have started forming and initiating WRUA councils in their respective counties - including Kajiado and Nyeri. Furthermore, development partners and donor communities have formed forums such as the Lake Naivasha Umbrella WRUA Forum, Mara WRUA Forum, Nyando and Kuja–Migori Forums set-up by JICA (for flood management), and the Imarisha Naivasha Initiative formed by the government of Kenya. The difference with the Ewaso Ng'iro River North WRUA Forum is that these other forums only address issues within their own sub-basin; they are therefore not basin-wide. And since they are constituted at a lower level than the basin, there remains a need to develop structures that help to coordinate their activities, so that they are not seen just as expanded WRUAs.

II) Innovative information management tools for informed decision-making

The Sub-Catchment Directory and the Socio-Economic Atlas: A Sub-Catchment Directory of the Upper Ewaso Ng'iro River Basin was developed by CETRAD to document biophysical and socio-economic datasets for all the twenty-one sub-catchments within the upper basin – defined as the area upstream of Archers Post, and which covers about 15,200 km^2. Specifically, the directory depicts catchment characteristics such as land cover change, agro-climatic zones, drainage, soils, water abstraction points and population dynamics (Figure 2.9). Relevant data was extracted from National Census data of 2009, and presented spatially. The primary data used to compile this product was collected through a participatory approach involving the WRUAs in each respective sub-catchment. All the WRUAs were trained in state-of-the-art data capture and transmission technologies (use of GPS and smartphones).

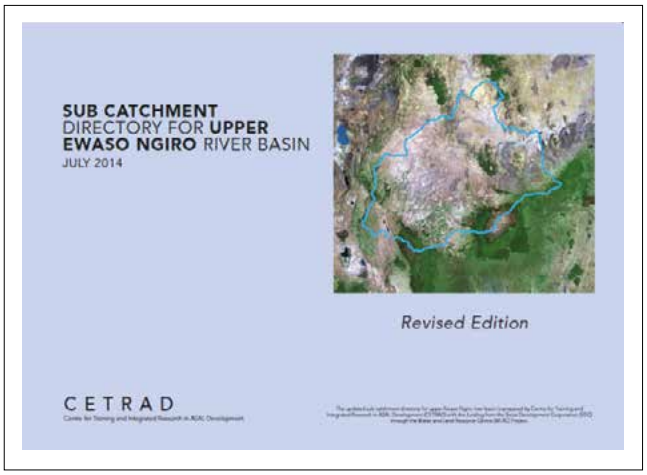


Figure 2.9: The Sub-Catchment Directory of Upper Ewaso Ng'iro River Basin developed through full participation of WRUAs.

Subsequently, and with a notable level of precision and consistency, those trained captured data from their respective sub-catchments and swiftly relayed it to a central database for analysis and presentation for the publication. This participatory process enhanced the ownership of research results - while making this huge task cheaper to accomplish within a relatively short period. WRUAs have used the directory to inform their decisions on critical issues like water distribution, as well as planning and implementation of water development interventions - and most importantly for fund raising for various activities, immensely contributing to sustainable management and governance in the basin. This water management tool is unique: it is believed that there has never been such before, at least not in East Africa.

At the national level, the Kenya's census data of 2009 was synthesised and compiled into the "Socio-Economic Atlas of Kenya". The atlas borrows largely from the spatial data presentation to facilitate easier visualization and comparison. This is the same design as that behind the sub-catchment directory, where various datasets such as water sources, sub-catchment boundaries, abstraction points, land use and land cover maps were presented spatially in the first version of the Socio-Economic Atlas of Kenya. The National Population Datasets were reviewed for quality control, cleaning and multilevel/scale aggregation and integration into hydrological and administrative/political units, and are therefore now available at sub-location, wards, constituency, county, basins, sub-basin, and catchment levels, where they can be easily accessed and all types of queries posted and feedback received in both relative and in absolute terms. This information is also available in the second online version, as well as a more advanced interactive version of the atlas - which can be accessed through: www.kenya-atlas.org (Figure 2.10).

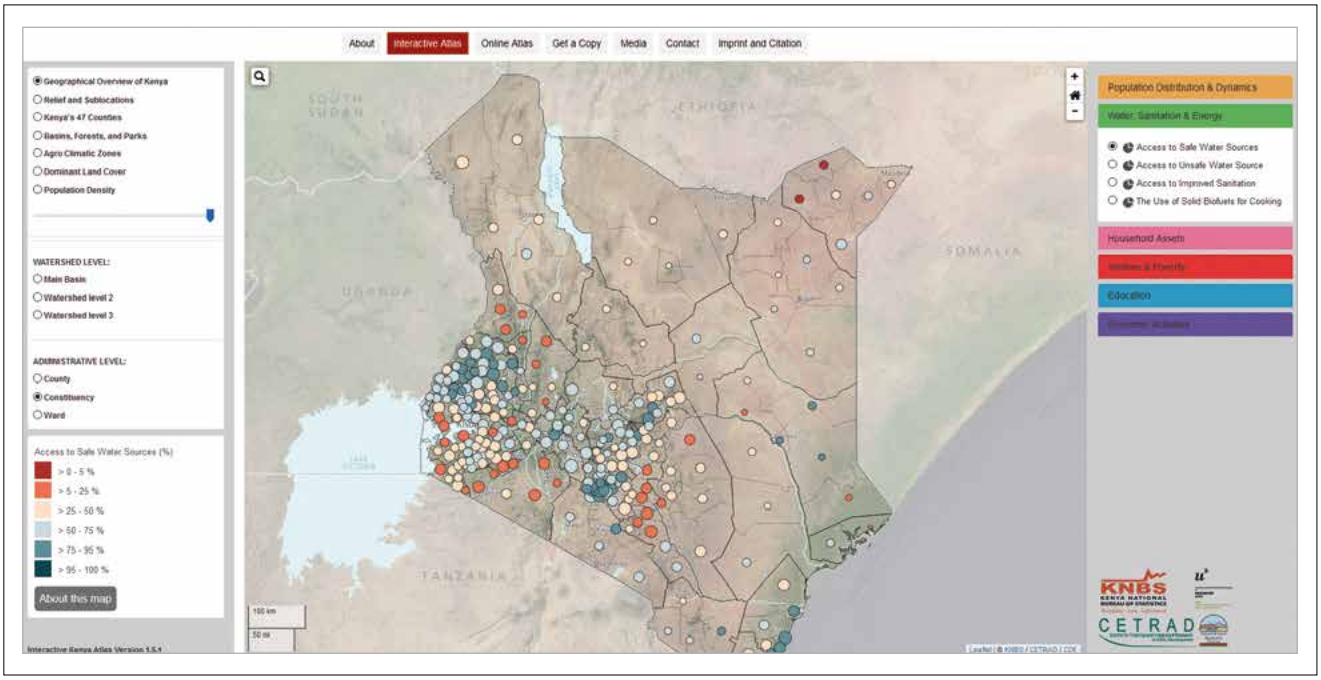
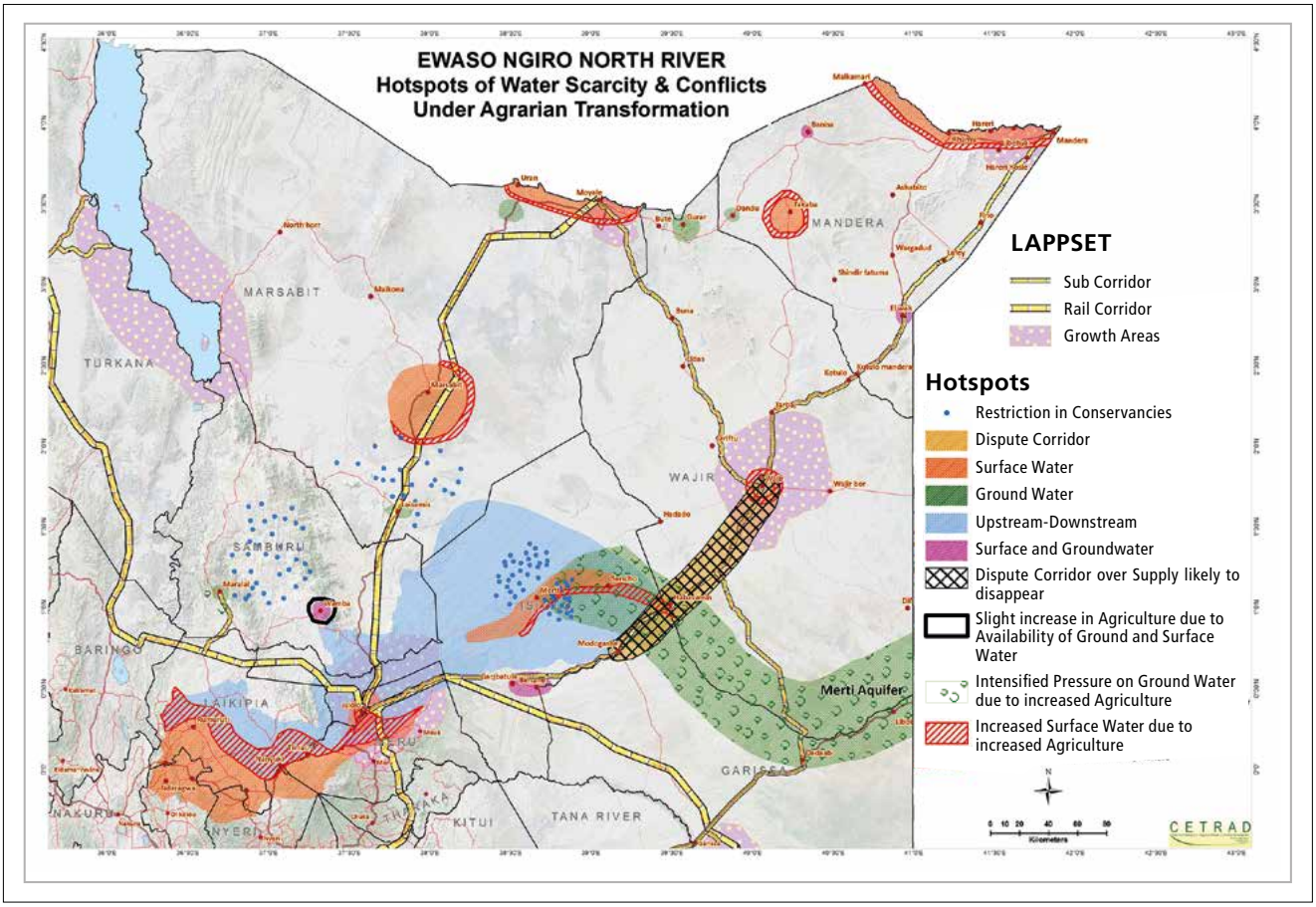


Figure 2.10: The online version of the Socio-Economic Atlas of Kenya (showing access to safe water sources).



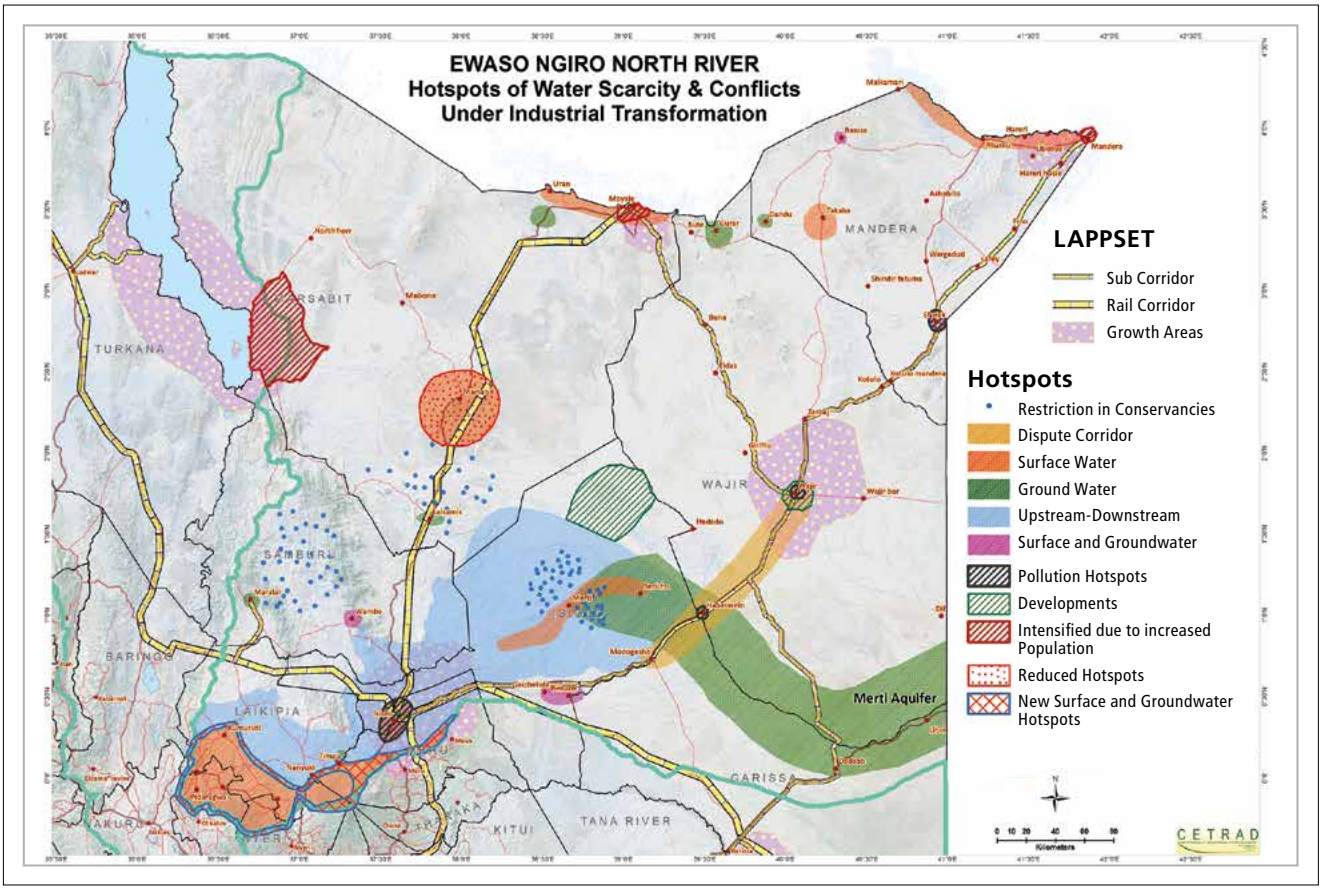


Figure 2.11: Three intensively negotiated scenarios for hotspots of water scarcity, namely: agrarian, industrial and peripheral transformations (Source: CETRAD).

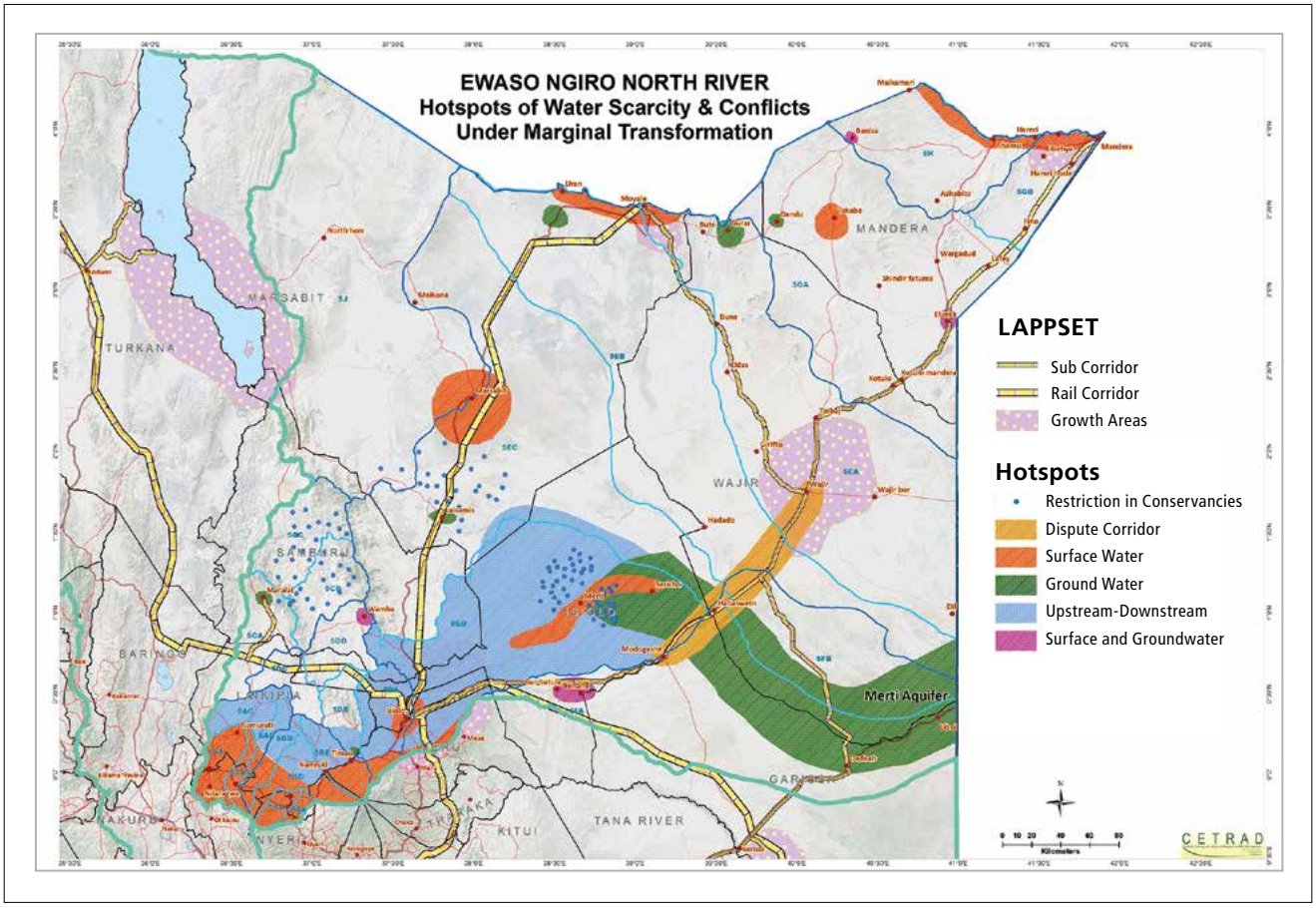


Figure 2.11 (continued): Three intensively negotiated scenarios for hotspots of water scarcity, namely: agrarian, industrial and peripheral transformations (Source: CETRAD).

Hydro-met monitoring network: CETRAD runs a comprehensive, high density and long-term functioning hydro-met monitoring network that transmits real-time data into dedicated servers that are well interfaced at different levels of application in the Ewaso Ng'iro North River Basin (see Chapter 1 – Kenya). The monitoring network comprises both meteorological and river gauging stations (RGS) with high-resolution data at 15 minutes intervals. Over the last decade, CETRAD has continued to automate, rehabilitate and maintain the network so as to ensure continuous data streaming. In addition, the scope of the network has been expanded for wider geographical and thematic coverage: it now extends to the lowlands of the basin, beyond Archer's Post, and includes monitoring of springs in order to determine their contribution to the dry season river flow downstream; ranging between 26 and 100% of total water flow in February in the Ewaso Ng'iro River (in the years 2016 to 2018). These form important sources of water for domestic use, livestock and irrigation to the pastoral and agro-pastoral communities, while simultaneously regulating the flow of the Ewaso Ng'iro River - especially the baseflow during dry seasons.

The data is available through the Social and Hydrological Information Platform (SHIP), http://www.wlrc-ken.org/, which is kept constantly updated. SHIP provides time series data (rainfall, evaporation, meteorology and river flow), GIS metadata, and digital repositories (technical reports, newsletters, guidelines, etc.). The observatories are interfaced with various databases at national, regional and local levels. This has ensured timely data-sharing and consequently timely decision-making at national, regional (basins and counties) and at local (WRUAs) levels. Not only is the data used for implementation of good water management at all levels of scale, but it is key to influencing policy – and effective policy development.

III) Innovative contributions to policy and planning

Hotspots of water scarcity and conflict: The magnitude and complexity of water management and governance challenges that face the Ewaso Ng'iro Basin require area and context specific approaches in order to deal with them effectively. In this respect, participatory identification and mapping of hotspots of water scarcity and conflict in the basin, and subsequent designing of mitigation measures to deal with those hotspots, are paramount. This was established by holding two participatory workshops, where the participants comprised experts in the water sector with long-standing experience - over 15 years - of the basin. This process identified the status quo, and predicted how major developments in various sectors could transform the identified hotspots of water scarcity and the respective interactions over the next twenty years, based on three intensively negotiated scenarios, namely: agrarian, industrial and peripheral transformations (Figure 2.11). Through the workshops, and inspired by the projections emerging from three scenarios, the public and private institutions concerned with water manage-

ment and governance at national and county level have agreed to support implementation of the most promising mitigation measures to deal with the hotspots. This process can be replicated in other basins with similar challenges in Kenya, and indeed across Africa.

Policy briefs: Analysis and synthesis of trends and variations in various research areas gave birth to important findings, which can support policy processes when simply, concisely and clearly documented. These policy briefs highlight key findings and messages that have the potential to inform the policy formulation process. Often, communities have varying perspectives which can mislead the process, and therefore facts need to be presented in order to guide the process and to 'triangulate' findings. On the north-western slopes of Mt. Kenya for example, there has been a proliferation of large-scale horticulture over the last three decades, greatly increasing demand for irrigation water and consequently putting severe pressure on the available river water. It was not surprising that the expansion of this thirsty horticultural enterprise was blamed for decreased river flow by the surrounding local community - as well as policy makers. Fortuitously, the current and previous water laws (Water Act of 2016; Water Act of 2002; and Chapter 372 laws of Kenya) required that every water abstractor installs water harvesting and storage facility with 90 days bridging capacity, in order to minimise river water abstraction during the dry season. Most of the commercial horticultural growers have complied - as evidenced by recent research in this area that revealed a 30% decrease in reliance on river water in favour of boreholes and harvested surface runoff. These revelations are highlighted in a recently published policy brief (Lanari et al. 2016), which was widely disseminated in order to feed-back to policy makers, implementers and the local community the changing status of water use by the commercial horticultural farms.

Conclusion and Outlook: Promise for the Future

This chapter has demonstrated how, in a period spanning over more than three decades, CETRAD has built a rich data and information base and developed innovative tools and approaches to achieve stronger integration, and to bridge the disconnect between science, policy and society for more ecological sustainability in river basins. Innovative institutional development was achieved through formation and institutionalisation of WRUAs and the basin-wide WRUA Forum. This provided the institutions (WRUAs) with legitimacy and greatly enhanced grassroots participation in co-knowledge creation and policy processes as well as co-design and implementation of mitigation measures for resolving the water crisis in the basin and beyond. Their participation has greatly improved efficiency and effectiveness, as well as the sustainability of corrective actions in the water sector. The innovative tools, approaches and products developed using the rich data and information base – including the "Sub-Catchment Directory of the Upper Ewaso Ng'iro River Basin" and the "Socio-Economic Atlas of Kenya" – have facilitated evidence-based decisions. They can be said to have fertilized the policy processes and its implementation at national and sub-national level, while at the same time informing practice at local level. Throughout, the mechanisms have promoted structures that guarantee transparent and seamless access to and exchange of data and information, as well as effective communication.

The processes described in this chapter cannot be an undertaking that depend on externally financed projects and programmes that are time-bound: in most cases not going beyond 3-5 years (exceptionally 10 years). Another consideration is that the agenda for such projects and programmes are, inevitably, donor-influenced. Recognising the important role north-south cooperation has played in achieving the impressive results in this particular case, it is stressed that this kind of process requires long-term engagement and true partnership that is built on a common vision and agenda that has been negotiated. The process should be continuous, consistent, well-resourced, and embedded in a dedicated institutional structure that guarantees sustainability. And just as it became necessary to institutionalise the grassroots governance structures (WRUAs and WRUA Forum) it also calls for design and institutionalisation of science-society-interfacing mechanisms that ensure legitimate participation of, and cooperation among, different players in co-production of knowledge and subsequent application in policy design and implementation.

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CHAPTER 3

Web-Platforms as Enablers for Guiding Negotiations and Shaping Landscape Transformation

3

The increasingly urgent need for planning and decision-making in river basins of East Africa and the Horn of Africa calls for more accurate and up-to-date information and knowledge to better inform the process. In this context web-platforms have an important role to play. Access to digital data and information delivery has greatly improved over the past decade in developing countries. More and more web-platforms are being used as data hubs, providing access to available and relevant information related to water and land management for specific target groups. The role of knowledge centres and web-platforms has been tested under WLRC - and this pioneering methodology has given a boost to the overall process. In this chapter we look at how web-platforms have been set-up in both Ethiopia and Kenya, how they have been managed, and what has been their overall impact. Web-platforms typically offer access to information about the host centre, their current activities, and links to more detailed information and data sources, as well as an information system consisting of spatial and non-spatial data and interactive maps.

As highlighted throughout this document, the competing claims on diminishing resources from a growing number of different actors pose a severe threat to sustainability of landscapes in East Africa and the Horn of Africa. Government and non-governmental actors at national and sub-national levels are faced with the challenge of having to take decisions and conduct planning in the context of accelerating socio-economic dynamics. There is no "one-size-fits-all" solution. Each local context is different and a context-specific approach is required to design and implement successful interventions. These decisions require ever-more accurate and up-to-date information and knowledge bases, which governments and other key stakeholders often lack. To make this information readily and rapidly available, knowledge centres supported by data web-platforms can be established. There are multiple potential advantages of this powerful tool in terms of offering different ways of data-sharing, management, integration, and visualisation.

Chapter 3 illustrated two different examples – from Ethiopia and Kenya - where CDE and its regional partners have established web-platforms as enablers for integrated decision-making in the domain of land and water. The first example illustrates how a web-platform is established and used in Ethiopia, and the second example illustrates the same for Kenya.

Weather station near Isiolo, Kenya (Isabelle Providoli).

Web-Platforms for Integrated Decision-Making within the Domain of Land and Water in Ethiopia and Kenya

ISABELLE PROVIDOLI, AMARE BANTIDER, BONIFACE KITEME, YOHANNES ARAGIE, KASPAR HURNI, TIBEBU KASSAWMAR, JÜRG KRAUER, TATENDA LEMANN, MILTON MUTUMA, JOHN MWANGI, EVANS NJUGUNA, SAMUEL TESFAYE, JAMES WANJAU AND GETE ZELEKE

Evaluation of various land use maps of Anjeni catchment, Ethiopia (Jürg Krauer).

Challenges and Issues

River basins in East Africa and the Horn of Africa are increasingly under threat, and there is a clear need for more accurate and up-to-date data and knowledge to better inform the process of planning and decision-making. Web-platforms have a role to play, for the reason that, currently, knowledge is fragmented, out-dated, not easily accessible across different sectors, and also usually not available in digital format or as near-real-time information. The result is that decisions and interventions are often not evidence-based. Associated with this is the consequence that dominant stakeholder groups determine decisions based on their power. In this process, science can provide knowledge that is capable of guiding negotiations and shaping transformations towards sustainable development. Generating and systematising long-term regional data and information bases, checking their quality, documenting them, and making them available to a wide range of stakeholders is important. But a further problem is that the available data are rarely used to their full potential: statistical analyses are seldom undertaken. In this context, as we have seen, transformative research can serve as a catalyst to break thematic silos, start social learning processes, and the co-production of knowledge, by bringing a broad range of strategic actors together. Web-platforms can make this process more powerful.

Web-platforms provide contextualised cross-sectoral knowledge and serve as a means to assemble the main actors. They contribute to knowledge exchange, awareness raising and informed, integrated, and cross-sectoral decision-making. In the domain of land and water, web-platforms are seen as data hubs that increase transparency with respect to natural resource dynamics and development processes. This is achieved by providing timely access to available and relevant information, which can be directly relevant for supporting decision-making, monitoring, and local empowerment. Hence, these platforms support governance (planning and priority setting), transparency (awareness creation and lobbying), monitoring (impact assessments), forecasting (scenario formulation and outcomes of decisions), and advocacy (empowerment and support of litigation processes). They are designed for a mixed range of stakeholders (policy makers, development groups, scientific community, and land users), who serve as intermediaries while using the data. The available data and knowledge therefore has to be user-friendly and tailored to their needs. Besides, the web-platforms need to be co-produced and co-owned by the key actors, which is essential to build trust and foster dialogue.

While web-based platforms can be implemented in a variety of forms depending on scope and data types, the focus on natural resource management requires that certain demands for data integration, sharing, visualisation, and access are fulfilled. First, the data need to be multi-sectoral so that analyses of the information can cover all aspects of natural resource use. This requires the integration of a variety of information from the ecological, social, political, and economic domain and, ideally, data from different institutions are hosted and shared on the same web-platform. Second, the data should not be static but need to constantly be updated – that is multi-temporal - so that dynamic processes can be analysed and

understood. Analysis of past and current dynamics is the route to strategic foresight for planning. Third, the data need to be spatially-explicit so that specific local contexts can be understood and vertically integrated across scales. Through the embedding of local processes within sub-national, national, regional, and global contexts, unavoidable resource trade-offs, but also co-benefits, can be identified and quantified across scales. With regard to water and land management and governance in Ethiopia and Kenya, web-platforms, which are well embedded in local and regional decision-support processes, therefore need to provide tools and technical solutions to provide access to information within the following three domains:

Time-series of measured near-real-time environmental data

In times of climate change and increasing speed of development processes, long time-series of point-based measured environmental data (e.g. precipitation, discharge, sediment load and temperature) provide an invaluable source for the analysis and quantification of change processes and for the calibration and validation of spatial models, with the goal of obtaining spatially continuous information on environmental processes. Recent developments in communications technologies, however, also allow for faster integration of measured data into web-platforms, providing the potential of quick response to environmental processes. By comparing near-real-time data with past measurements, early warning systems for water shortage (for example) can be developed and provided to user groups for the negotiation of trade-offs at round table meetings. Furthermore, web-platforms minimise costs related to data loss and data retention when compared with their storage on individual computers.

Contextualising spatio-temporal environmental and socio-economic data

To negotiate development trade-offs and to identify co-benefits of development interventions, spatially explicit and contextualised information on environmental and socio-economic characteristics and dynamics needs to be accessible. In web-platforms, such data can be provided through map viewers, allowing for flexible visualisation and combination of selected topics (e.g. land-cover in combination with socio-economic data). These data have usually already been pre-processed (e.g. land-cover derived from remote sensing images, population and household census data for specific administrative units and selected topics), but still need to be interpreted and analysed. The provision of such pre-processed data is thus very useful for researchers and development partners for the production of high-level outputs – including policy recommendations and the definition of development interventions (e.g. where to build which types of irrigation schemes). Furthermore, the provision of maps and the possibility of aggregating information for different administrative units allows for the analysis and interpretation of data across all spatial scales: from local to global.

Targeted knowledge products with interpreted and contextualised information

Outputs from research activities, as well as experiences from development interventions, result in publications, reports, guidelines, or policy briefs, which present tangible documentation from targeted analyses within specific contexts. These documents with interpreted and contextualised information in the form of texts, tables, figures and maps are, in contrast to unprocessed data, "ready to use" and do not require any specific expertise (e.g. GIS/RS, statistics). In the web-platforms, this "knowledge for all" can be accessed from the document repository through keyword, location, or time-based search functions. Document repositories thus provide high-level products with specific foci that are valuable for a vast range of users - from technical staff to high-level decision-makers.

Web-Platforms to Support Water and Land Management and Governance through Integrated Decision-Making in Ethiopia and Kenya

Both centres, the WLRC in Ethiopia and the CETRAD in Kenya, have co-produced data related to water and land management and governance together with various partner institutions. Long time-series of point-based measured environmental data, and spatially explicit and contextualised information on environmental and socio-economic characteristics and dynamics, have been generated. These data can be translated into spatially explicit knowledge products, which can be shared with a broad range of stakeholders and used for informed decision-making. The provision of pre-processed data has proved very relevant for researchers, and development partners, to help them in the production of high-level outputs - including policy recommendations and the definition of development interventions.

In order to make this knowledge available to a broad range of stakeholders, both centres established web-platforms, tailored and designed for different stakeholder groups. The web-platforms are well embedded in local and regional decision-support processes. The main aim of these platforms is to provide access to accurate and up-to-date information and knowledge about water and land management and governance. In doing so the web-platforms raise awareness, bring key actors from different sectors together and foster dialogue among different institutions and sectors.

The web-platforms offer different ways of data access and are structured as follows. They have three different components: i) a **centre web page**, which serves as entry point for all stakeholder groups and contains relevant information about the centre, their current activities, and links to more detailed information and data sources; ii) an **information system** that consist of spatial and non-spatial data; and iii) **interactive maps** such as the MapServer Ethiopia and the Socio-Economic Atlas of Kenya.

Training on the use of WALRIS in Ethiopia (Jürg Krauer).

Ethiopian WLRC web-platform

Aim

In Ethiopia, research in general, and collection and dissemination of comprehensive data in the field of water and land resources is relatively recent. This is connected to the advent of the first higher learning institutions in the country in the 1950s. The aim of these efforts is to facilitate sound planning and judicious decision making in the field of natural resource management. Large amounts of data and information collection became possible with the establishment of the Ethiopian Institute of Agricultural Research (EIAR) in 1966 and the Soil and Water Conservation Research Project (SCRP) in the 1980s. This was further supported by specialised data collection by institutions from different sectors (e.g. Valley Development Authority since the 1980s, National Meteorological Agency since the 1980s, and the Ministry of Agriculture, and Ministry of Water and Irrigation over a longer period of time). Furthermore, university departments of hydrology, agriculture and natural resource management have grown considerably, and currently over 40 universities and dozens of agricultural and natural resource-based research institutions have mushroomed in the country. These educational institutions, coupled with federal and regional sector development institutions, are mandated to undertake diversified research on water and land resources. However, digital documentation of data, updating and sharing has been a major bottleneck in the country. Furthermore, the dissemination of water and land resource information through web-based platforms rarely responds to the need of decision-makers, planners, researchers, development practitioners and students. This implies that whatever monitoring and research is conducted in the field, the information is only available in a fragmented manner: this impedes integrated analyses, across sectors, scales, or time. Obtaining access to such data is also time-consuming and frustrating. It is often difficult to know which institution is working on which products. To address this gap, the WLRC web-platform was initiated and developed in 2013 by the WLRC (Ethiopia) in collaboration with CDE, University of Bern (Switzerland). Prior to the design of the database, the WLRC conducted a thorough assessment of potential data user groups, types of data they require and suggested data sharing protocols. The user groups were broadly categorised into four, namely (i) policy makers, (ii) development group including planners, (iii) scientific community (research and academia), and (iv) land users.

The web-platform consists of three parts: the WLRC webpage, the Water and Land Resources Information System (WALRIS), and the MapServer Ethiopia (Figure 3.1). Each is populated with a variety of different datasets and products, tailored to suit the needs of the different target groups.

The **WLRC web page** (http://wlrc-eth.org) serves as an entry point for all interested stakeholder groups. It provides information about the centre, the thematic working areas and the different projects. It also contains an overview of all established observatories and "learning watersheds" (see Chapter

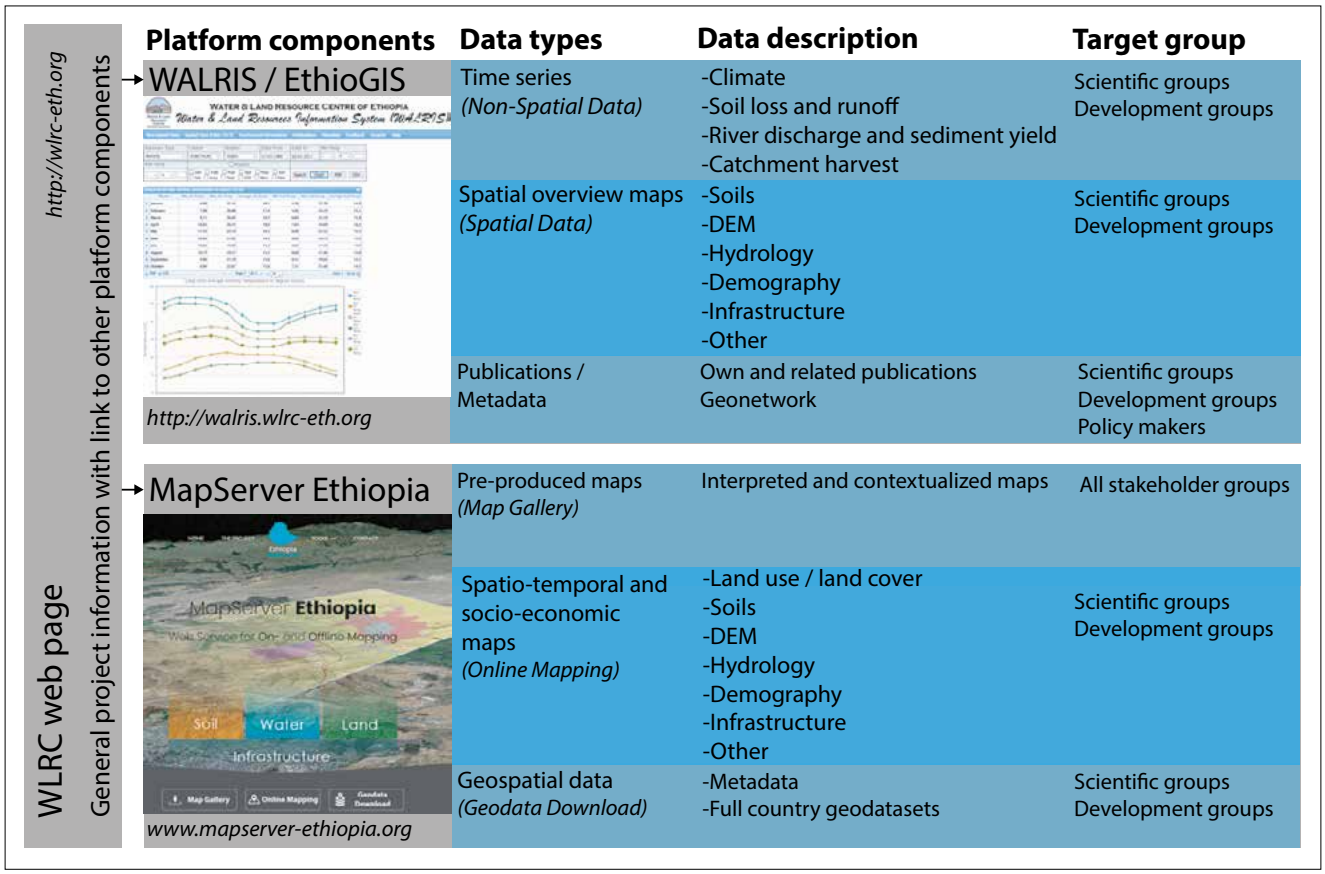


Figure 3.1: Different components and content of the Ethiopian WRLC web-platform (Source: Tatenda Lemann).

1 – Ethiopia). Furthermore, it lists key publications produced by the WLRC such as briefs, research reports, posters, and watershed guidelines. Links bring interested stakeholders to the Water and Land Resources Information System (WALRIS) and the MapServer Ethiopia.

The **Water and Land Resources Information System (WALRIS)** (http://walris.wlrc-eth.org) was launched in 2014. It facilitates the compilation, archiving, and exchange of water and land related data and information, which have been generated by WLRC and its partners. The WALRIS is structured by different components and it contains time-series, spatially explicit and contextualised data and publications. The following are details of processes and products:

- The measurement of available **time series (non-spatial data)** of point-based environmental and socio-economic data started 1982 in observatories and learning watersheds established by WLRC (formerly under SCRP). But data collected from different secondary sources and from other projects under WLRC and collaborative institutions are also regularly uploaded.

- The **spatio-temporal and socio-economic datasets (spatial data)** are based on EthioGIS version 1, 2 and 3 (released in 1999, 2015 and 2019 respectively), produced by WLRC, and are available on an interactive map interface. WALRIS enables the users to make different levels of analyses within the system and to prepare graphs, summaries, and maps of the area of interest, which can then be downloaded or directly printed. For each dataset, metadata is provided using the Geonetwork, which is the most popular and powerful catalogue application to manage spatially referenced resources. It provides powerful metadata editing and search functions as well as an interactive map viewer.

- **Publications** on a wide range of topics from different organisations such as WLRC, FAO, the Ministry of Agriculture, Addis Ababa University, or ILRI are available - starting from 1982. A filter helps the user narrow down a search.

The information is specifically compiled for the scientific community and other interested stakeholders, who need data about the sustainable management of land and water resources. Until now, these data have been widely used by the scientific community, for example to assess the impact of sustainable land management practices, or for a variety of modelling studies at different spatial and temporal scales (see examples in Figures 3.2 and 3.3). Data from WALRIS have been used in many research studies and are cited in several hundred peer reviewed articles.

Over the last four years, the web-platform was visited by 9020 users from 110 countries. The national and international users included Universities, River Basin Authorities, Agricultural Research Institutions, development and consultant firms, Ministries (of Agriculture, Water, etc.), NGOs engaged in natural resource management, Regional Bureaus of Agriculture, etc.

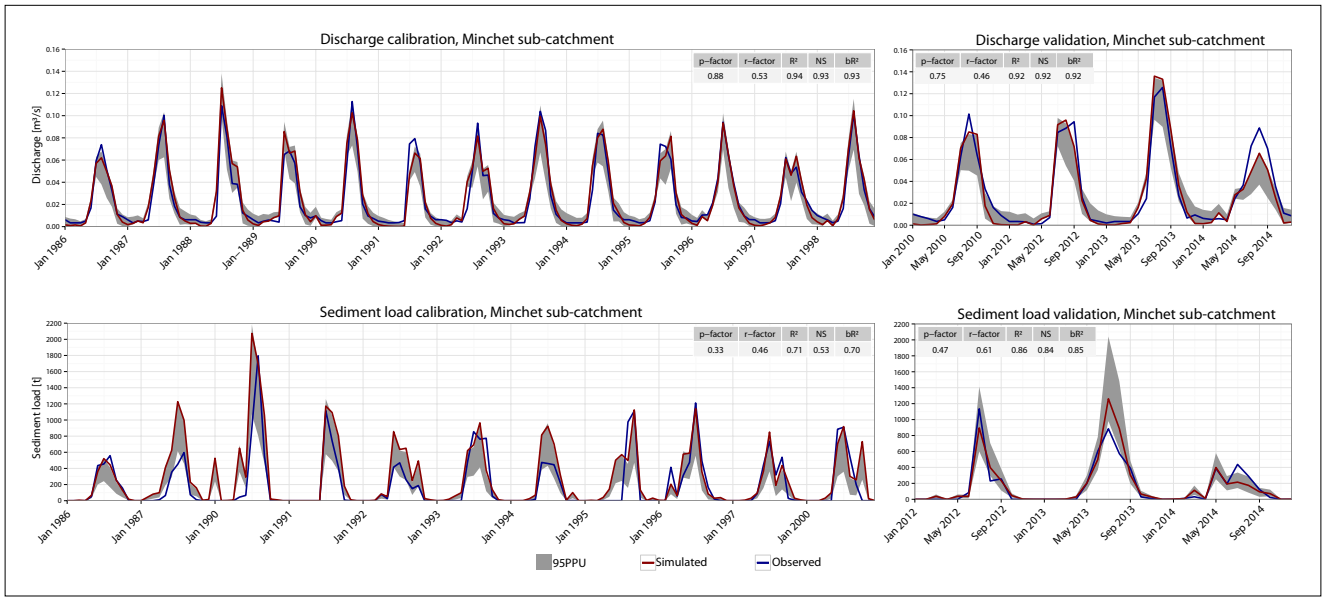


Figure 3.2: Modelling the effects of soil and water conservation on discharge and sediment yield (Source: Tatenda Lemann).

Examples where data from WALRIS were used by the scientific community

EXAMPLE 1

Modelling the effects of soil and water conservation on discharge and sediment yield

Data from WALRIS were used in a PhD research study under the Centre for Development and Environment. Soil and land use maps, as well as meteorological and hydro-sedimentology data were used to calibrate and validate different soil erosion and deposition models (Figure 3.2). In addition, scenarios were developed that showed the effect of soil and water conservation on discharge and sediment yield. The results of the study demonstrated that water availability for downstream stakeholders did not change significantly as a result of new soil and water conservation measures, however the average annual sediment yield of the study area was reduced from 37 t/ha to 17 t/ha (Lemann et al. 2016).

The study was able to show the potential of SWC measures in the Wet Wenya Dega agro-climatic zone to reduce sediment yield and increase "green water" productivity (i.e. transpired productively by plants) without decreasing "blue water" availability (i.e. drinking water) for downstream stakeholders.

EXAMPLE 2

Modelling Blue and Green Water in the upper Blue Nile Basin

On a larger scale, data from WALRIS were used in a PhD research study under the Centre for Development and Environment to model the spatial and temporal availability of blue and green water for upstream and downstream stakeholders (Figure 3.3). Detailed analyses of the drainage behaviour of the Upper Blue Nile Basin showed that steep slopes, shallow soils, and cultivated areas increase the share of precipitation that leaves a catchment. This is mainly due to high surface runoff, low soil moisture content, and a smaller share of evapotranspiration (Lemann et al. 2019). This study was able to contribute to the understanding of hydrological processes and availability of blue and green water in the Upper Blue Nile Basin. This knowledge is crucial for analysing future changes, and improving sustainable and integrated watershed management from which upstream and downstream stakeholders will benefit.

EXAMPLE 3

The Economics of Land Degradation Ethiopia Case Study

The Economics of Land Degradation (ELD) Initiative focuses on the economics of land degradation and sustainable land management at the global level. The ELD commissioned a study in Ethiopia, which was carried out by the WLRC and the Centre for Development and Environment (CDE). The ELD Ethiopia Case Study provides a spatially explicit assessment of the extent and magnitude of land degradation (soil erosion by water) and models the costs and benefits of selected sustainable land management measures (conservation structures on sloping croplands, fertilizer use on croplands, and planting of fodder grass on conservation structures) within a time horizon of 30 years (2015-2045). The study was largely based on data and resources available at WLRC/WALRIS, e.g. time-series of sediment yield measurements across the rainfed agricultural areas of Ethiopia, time-series of plot-based measurements of soil erosion, time-series of precipitation measurements, a variety of reports available in the document repository of WALRIS, and a range of GIS datasets (e.g. watershed boundaries, topography, soil types). The study showed that crop production when continuing with the current land management practices will decline by more than 5% in the coming 30 years, but by building conservation structures on all sloping croplands and by applying fertilizer on all croplands, crop production can be increased by 10%. The study also showed that by planting fodder grass on the conservation structures, investments in the building of conservation structures on all sloping croplands and applying fertilizer is economically viable within a 30-year horizon. Results, however, vary spatially and to determine the best combination of land management practices at specific locations, e.g. to maximise economic benefits or to minimize soil erosion, the spatially explicit database of the ELD Ethiopia Case Study provides an excellent source of data for the planning of development interventions.

Further reading: http://www.eld-initiative.org

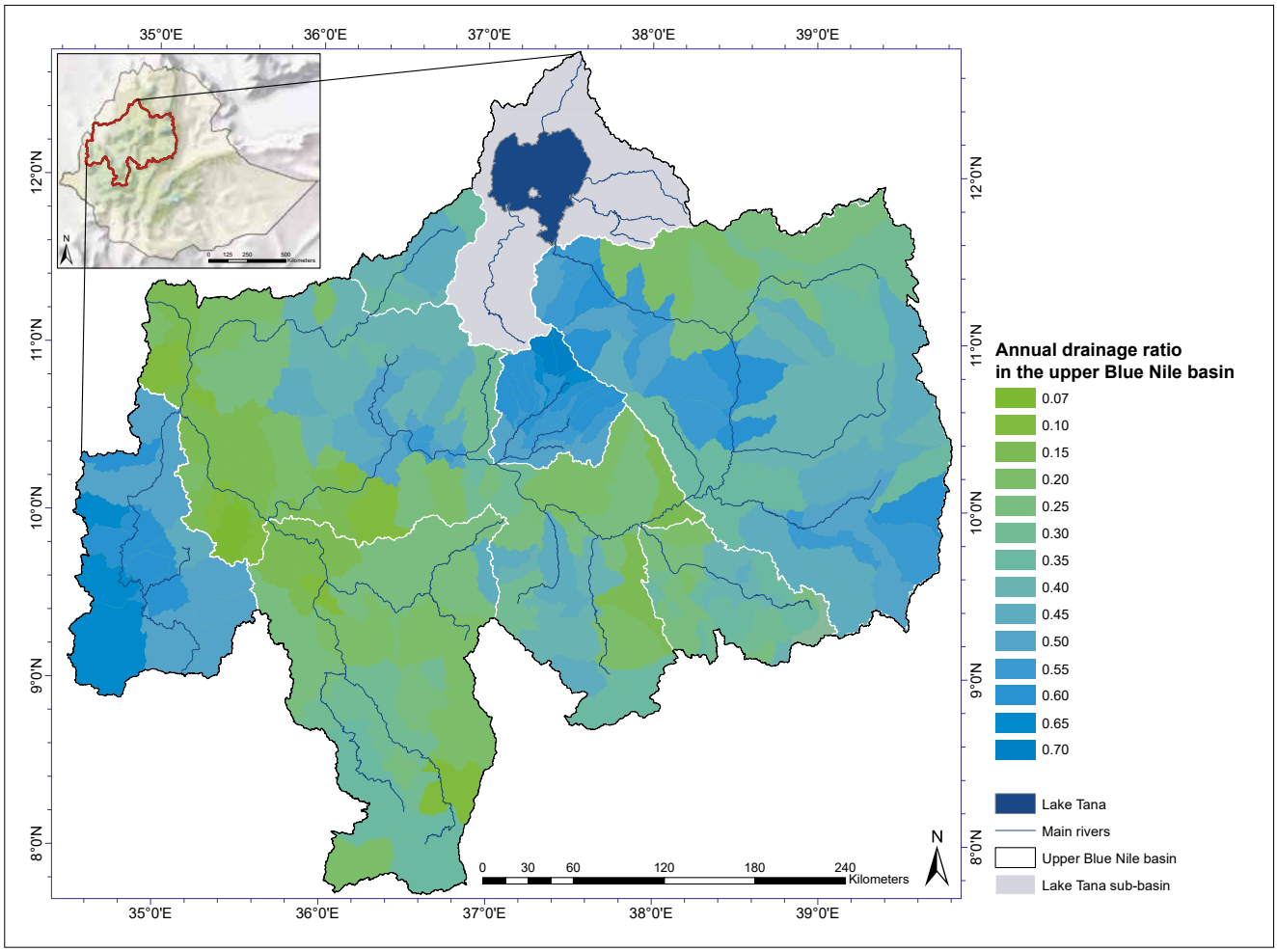


Figure 3.3: Modelling Blue and Green Water in the upper Blue Nile Basin (Source: Tatenda Lemann).

MapServer Ethiopia (www.mapserver-ethiopia.org) is a web-based platform for the dissemination of geospatial data maps and information about Ethiopia. The website contains three main web apps that enable mapping based on pre-produced maps, online mapping of selected information layers, and open geospatial data download. Its services are mainly designed for governmental agencies, NGOs, aid agencies, research institutions, and individuals with a keen interest in improving communication of spatial baseline data in the context of their work. Professional uses range from simple sketch-mapping to spatial modelling in a complex environment. Feedback provided by EthioGIS users and WLRC workshop participants were used to design the new platform and the geospatial layers used for mapping. Agricultural extension agents and WLRC field staff working on-site in WLRC's research and learning watersheds have been another important source of valuable comments on mapping apps. Use of online tools is not yet common in fieldwork in rural Ethiopia. Accordingly, hardcopy-based field mapping remains an important means of collecting and communicating data.

The data available through MapServer Ethiopia offer extraordinary potential for planning, decision support, and scenario modelling. Population projection, mapping of health centre accessibility, and visualisation of projected water level changes due to dam construction are among the key capabilities of the geospatial information provided by MapServer Ethiopia.

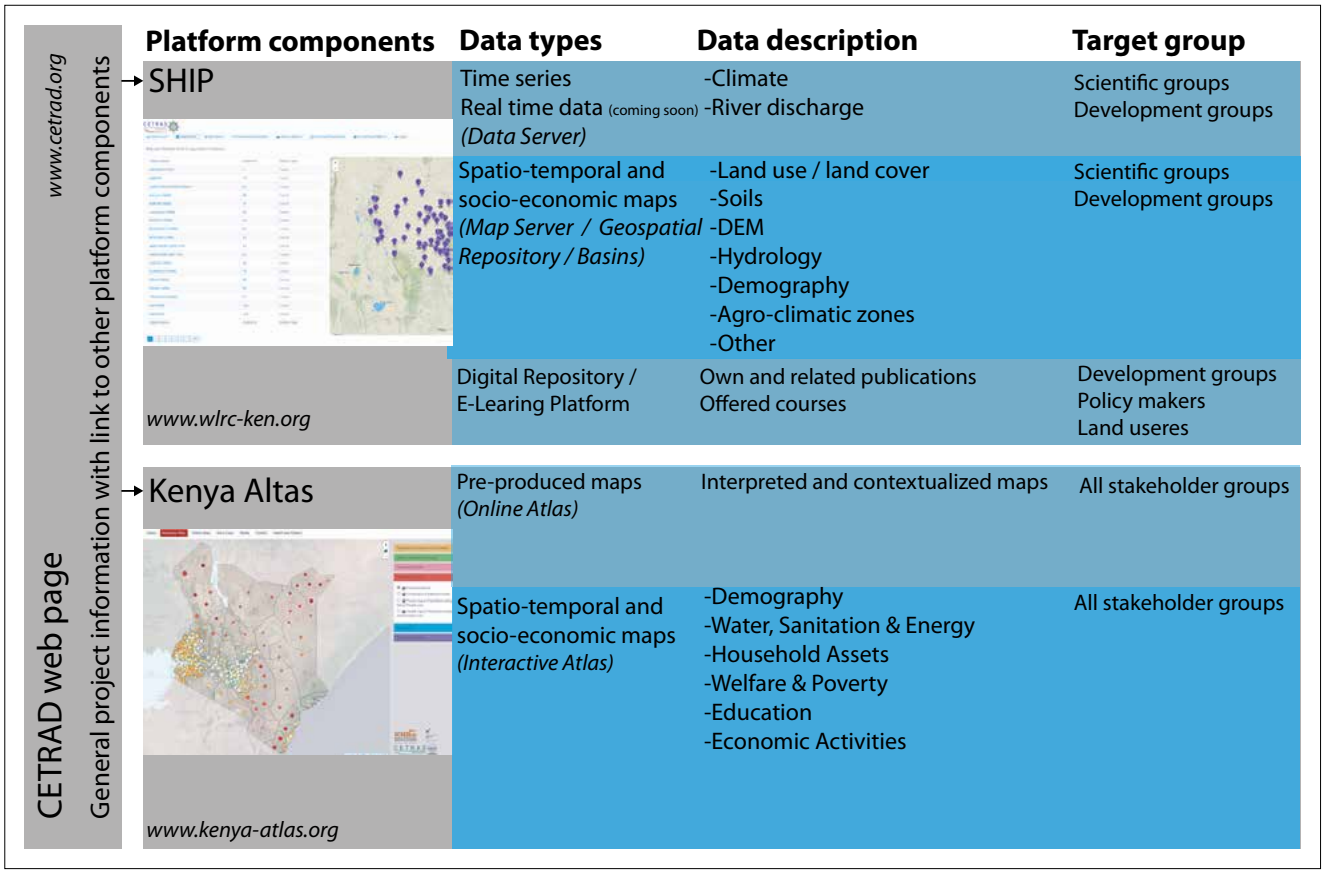


Figure 3.4: Different components and content of CETRAD's web-platform (Source: Tatenda Lemann).

CETRAD's web-platform (Kenya)

Aim

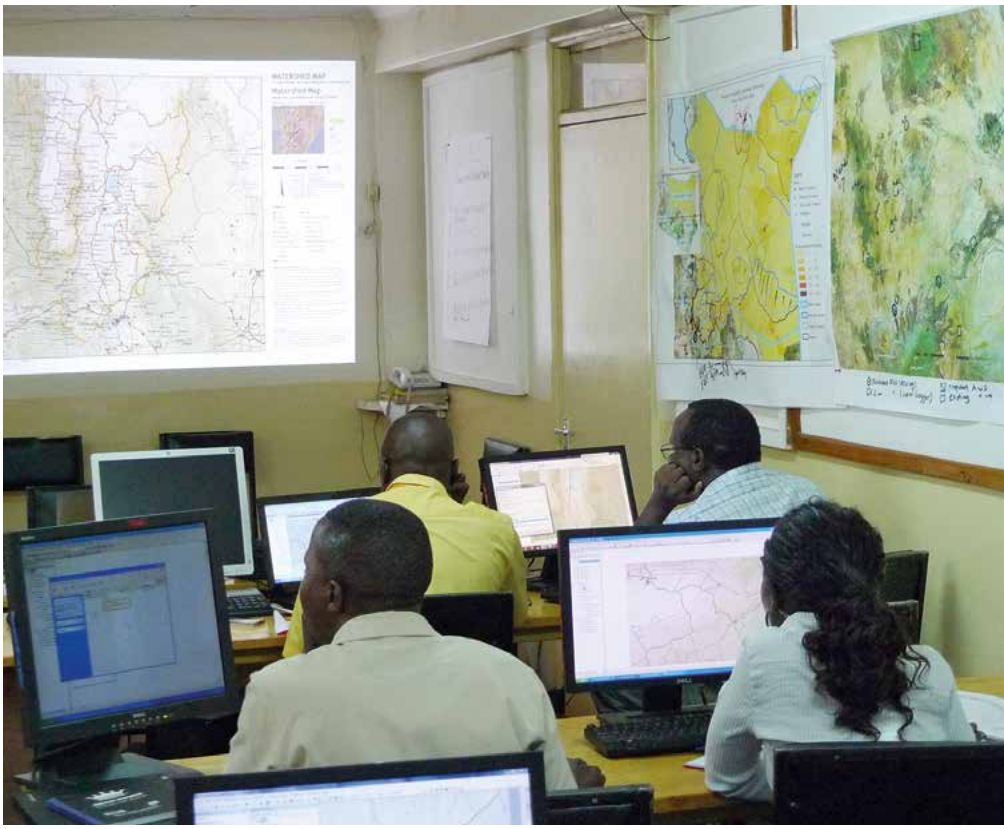
The north-eastern part of Kenya continues to face critical challenges with transboundary implications: a growing demand for water despite its scarcity is exacerbating the water crisis. These challenges call for continuous socio-economic and ecological monitoring and assessment in order to support knowledge-based interventions with the potential to restore ecological sustainability in the affected areas. In Kenya, devolved governance systems have been in force since the general elections of 2013. This has meant installing new institutions with fresh mandates and functions at the county level, as well as reviewing legislative and policy instruments to align them with the expectations of the new political system. The revised water law (Water Act 2016) is now operational and provides new institutional structures that will govern the water sector. Within the structure are the Basin Water Resources Committees (BWRCs) charged with the responsibility of advising the Water Resources Authority (WRA) and county governments on a diversity of technical issues. However, knowledge about water resource management and governance is very fragmented. This calls for urgent intervention to develop a web-platform, which provides access to water-relevant data and information from different sectors to the basin authorities and other water actors to inform decisions regarding innovative interventions, both for policy and practice.

To address this gap CETRAD/WLRC is processing data and information to generate knowledge and translate it into tailor-made products for decision-making and policy processes. This work was initiated in 2012, and builds on the knowledge and long-term data CETRAD has gathered since its start. A robust collaborative network of institutions with water and land resources databases in the region was established to help enrich the platform and strengthen data-sharing arrangements. Key players in the network include the regional office of Water Resources Authority (WRA), Ewaso Ng'iro North Development Authority (ENNDA), Mpala Research Center (MRC), and Laikipia Wildlife Forum (LWF). The platform also provides for data and information sharing and exchange with relevant public institutions at the national level, notably the Kenya Meteorological Department (KMD), Kenya Forest Service (KFS) and Kenya National Bureau of Statistics (KNBS). Most important to underline is the invaluable contribution to the platform by the Water Resource Users Associations (WRUA) and the WRUAs Forum through participatory resource mapping, monitoring and assessment at the sub-catchment level.

The web-platform consists of three parts, the CETRAD webpage, the Social and Hydrological Information Platform (SHIP), and the Kenya Atlas, which are populated with a variety of different datasets and products, which suit the needs of the different target groups (Figure 3.4).

The **CETRAD webpage** (www.cetrad.org) serves as an entry point for all interested stakeholder groups. It provides information about the centre, the thematic working areas and the different projects. It also provides information on available products and services. Links then guide the users to the information platform "SHIP" and the interactive Atlas of Kenya, among other innovative products.

The **Social and Hydrological Information Platform** (SHIP), (www.wlrc-ken.org) was launched in 2015. It provides open access to water and land related data, which have been generated by CETRAD and its projects within the Ewaso Ng'iro Basin and other river basins in Kenya. The SHIP is structured in different modules. It provides measured time series information on the **Data Server** and spatio-temporal and socio-economic maps in the **Map Server** and spatial data catalogue in the **Geospatial Repository**. More detailed data are available for the **Basins in Kenya**. A **Digital Repository** contains publications, photos, and best practices related to natural resource management and governance. A yet-to-be completed **E-Learning Platform** will offer courses, learning objectives and learning exercises.



Training course on spatial tools at CETRAD, Kenya (Matthias Fries).

- The measurement of available **time series** of point-based hydro-meteorological and socio-economic data started systematically in the 1980s in selected observatory watersheds established under the stewardship of the-then Laikipia Research Project (now CETRAD). Although the oldest hydrological measurement data can be traced back to the 1950s (then under the custody of some progressive large-scale ranching companies). These initial efforts were subsequently expanded (thematic and geographical scope) through the Swiss Priority Project Environment (ASP/NRM3) in the 1990s. Together with these data, more data are collected from different secondary sources and from other CETRAD projects and partner institutions, and are regularly uploaded.

- The **real-time river discharge data** captured since 2014, and already interfaced with some strategic WRUAs secretariats, will soon be linked to the SHIP. Datasets are currently uploaded monthly. These data are used for negotiating context specific river flow thresholds and to support an early warning system for water resources governance, especially during dry seasons. The availability of this data, at the right time and in the right format, has revolutionised water resource governance in the basin. Negotiations for, and key decisions on, water resource allocation and user schedules which were hitherto based on a "power first" approach, and informed by data generated on spot checks, are now guided by evidence. They are considered as objective, thus widely accepted and enforced by all. Five Water Resource Users Associations (WRUAs) have been interfaced with live data to act as robust learning platforms.

- The **spatio-temporal datasets** (Map Server/Geospatial Repository/Basins) are based on previous and current projects undertaken by CETRAD. The Map Server allows the user to explore spatial data layers (land cover, land use changes, agro-climatic zones, hydrology, soils, demography, digital elevation model: DEM) and perform simple map overlays to interrogate the data further.

- The **Geospatial Repository** is an online catalogue/metadata of spatial datasets that allow the user to know what is existing in the database and if needs be, to download layers of interest. Under Basins the user can access information about the five Kenyan river basins, the sub-basins and the 3rd level basins as interactive maps about access to water, education and the population density.

- The **Digital Repository** is an online e-library that facilitates knowledge transfer and dissemination of research findings and project outputs/outcomes reports in a convenient and easy access to all. The availability of publications by various researchers in various disciplines and collections of natural resources management has brought about information and knowledge access that has transformed the way local stakeholders are taking decisions.

Over the last two years the total visitors to the SHIP were 3191 (inclusive of new and revisits) from 55 countries. The list of institutions includes National and County Governments in infrastructure development (Water & Roads), LAPPSET project in development of Crocodile Jaw Mega Dam, Water rationing strategy development and enhancement by WRUA, Laikipia Wildlife Forum (LWF), Water abstraction permitting by WRA, large-scale horticulture farming, Lewa conservancy, and the Southwest Research Institution.

Examples where data from SHIP were used by land users and development groups

Most of the data coming from the monitoring network in the upper Ewaso Ng'iro North River Basin are now linked through a real-time transmission system and interfaced at different levels. The data are widely used by a broad range of professional and non-professional entities – academia, research, policy, development and consultants – at different levels and across scale. Demand for the data by these entities has continued to rise - going by the total number of requests processed annually. This demand is expected to grow even higher as more potential users become familiar with the services offered by the SHIP, and with the launching of the Early Warning Systems for the WRUAs. And while majority of the data from the SHIP are demanded by academia and research (including consultants) the proportion going to inform policy and support project planning and implementation is steadily rising as players at these level appreciate the value of these data to support their work. Below are three examples to help illustrate this:

EXAMPLE 1

Establishing context specific minimum river flow thresholds and Early Warning System

The design of a real-time data feedback and threshold values system has been mentioned severally elsewhere in this publication. The system aims to broaden the scale and scope of the dissemination as a way of fostering evidence-based decision making towards sustainable water resource management and governance in the Ewaso Ng'iro North River Basin. The system utilises real-time data generated from selected observatories (Automatic River Gauging Stations) and interfaced with CETRAD database and selected WRUA secretariats to compute negotiated minimal thresholds of river flows. These are in turn applied to inform decisions and appropriate actions to manage dry period river flow and ensure that water reaches the dry lowlands in the basin. These threshold values have also been used to design the yet-to-be launched Early Warning System (EWS) for the WRUAs. Essentially, the EWS is supported by a smartphone application – giving SMS messages with advice - and will be operationalised through five designated "Learning Sub-Catchments", via their respective WRUAs, to reach over 15,000 river water users in the sub-catchments. This is an initiative involving, among others, CETRAD, with the selected Water Resources Users Associations (WRUAs) and the Regional Office of Water Resources Authority (WRA), and will be expanded to cover more sub-catchments in the upper parts of the basin.

EXAMPLE 2

Water infrastructure design and development: responding to critical questions on Crocodile Jaw Mega Dam

The Crocodile Jaws Dam is one of the mega multi-purpose water reservoir the national government has prioritised in its Vision 2030 blueprint. Discussions on its construction have continued for some time regarding availability of adequate surface runoff to guarantee harnessing the dam's capacity, the time it will take to fill, questions of siltation and its effects on the dam's long term sustainability, and the potential socio-economic and environmental impacts, especially on the communities and ecosystems downstream. Several prefeasibility and environmental impact assessment studies were commissioned to help provide answers to these questions and inform final decision before actual construction commenced. One such study was commissioned by the Ewaso Ng'iro Basin Stakeholders Forum (ENBSF) and undertaken by Conservation Strategy Fund (CSF) in collaboration with CETRAD. CETRAD hydro-met data was key to the compilation of this study (Vilela T., Brunder A, 2017) (https://www.conservation-strategy.org/).

EXAMPLE 3

Design of a hydro-met monitoring system for the Lewa-Borana Landscape

The Lewa-Borana Landscape (LBL) hosts the Lewa Conservancy which is known for its famous annual conservation charity event, the Lewa Marathon. The conservancy (where wildlife are mixed with livestock under a specific management regime) implements research to generate data necessary for designing innovative conservation interventions for the conservancy and connected larger landscape. In expanding its thematic scope, the conservancy decided to include water resources management and governance in its focus. In this regard they wanted a system to support hydrological monitoring and evaluation of the Lewa-Borana Landscape. Such a system would generate data and information to deepen the understanding of the local water resources situation vis-à-vis the regional dynamics, identify main risks and challenges facing these water resources, and develop tools to better understand how to manage these water resources to ensure the future viability of the LBL wildlife preserve. The Southwest Research Institute (SwRI) based in San Antonio Texas USA was commissioned to design the system on behalf of the Lewa Conservancy. The SwRI used the publications and technical reports from the digital repository and hydro-met data from data server to compile the "Lewa-Borana Landscape Wildlife Preserve Water Resource Evaluation Status Report 2018" (in preparation). The development of the report greatly assisted round table discussions with CETRAD on the possibility of designing an investment framework for a joint hydro-met monitoring network within the landscape, and eventually integrating the databases of the two institutions. The process is underway.

The **Kenya Atlas** (www.kenya-atlas.org) was developed using the 2009 national population and housing census, supplemented by secondary data and information sourced from the CETRAD database and other existing national spatial layers. It is the first ever socio-economic atlas in Africa developed using a spatially high resolution dot method featuring diverse policy fields and topics that include population characteristics and dynamics, water and sanitation, household assets, levels of poverty and education, and economic activities. This socio-economic atlas represents an invaluable resource for different users at different levels for both public and private

(commercial and non-commercial) sectors. The combination of geographic and socio-economic data enables policymakers at all levels, development experts, and other interested readers to gain a spatial understanding of dynamics affecting Kenya. The atlas has, over the years, gained prominence as a very powerful planning and policy tool among key county policy makers and administrative personnel. Its use has sharply risen with the completion of the online interactive version that supports fast, user-friendly analysis of, and access to, responses to queries in different areas. For example, it indicates where the informal economic sector is most prominent, which areas have access to safe water and sanitation, where population growth is being slowed effectively or how education levels vary throughout the country. By supplying precise information at the sub-location tier and summarising it at the county level, the atlas facilitates planning that better accounts for local contexts and needs.

Conclusions: from Data Buckets to Living Platforms

The WRLC project in Kenya and Ethiopia has demonstrated that it is feasible to build and maintain completely locally-owned open data platforms on land and water resources, and to make accurate and up-to-date information and knowledge available for local evidence-based decision-making. Moving from data availability to public accessibility is important, not only in relation to the potential wider use of data but also in terms of data retention. This can support the securing of significant investments by governments or development partners in data collection, as it has been all too frequent in the past that such investment just became void, as crucial data was simply lost. However, data and information on web-platforms also need to be prepared for specific audiences (e.g. the scientific community) or processes (e.g. specific policy processes), which in the cases of the examples presented from Ethiopia and Kenya was achieved by the modular design of the platforms. Besides these specific audiences, such platforms have two more generic functions also, related to democratisation of data access in general, and serving as a tangible and illustrative nucleus that helps break sectional silos for more integrated spatial planning at different levels.

Rapid advancement of IT and web technology in the last decade has made it very simple to place any available data online – forming a "data bucket". This, however, is meaningless, and even dangerous. Sharing potentially flawed data does more damage than good, and can erode trust in data and evidence-based decision making. Thus, it is crucial to earmark sufficient resources in any such web-platform endeavour in quality checking and data enhancement activities: this crucial step is frequently underestimated in the planning stage.

Also, from a planning perspective, it is clearly paramount to involve key government actors/departments from the very beginning in the co-design of such platforms and related processes. Providing very tangible hands-on support in compiling, quality checking and enhancing available data has proven to be a very effective way towards making valuable data accessible online. Lack of trust in data, and the fear of the consequences of sharing potentially flawed data, is still a key hindrance towards open data environments in public administration around the globe.

As concrete and illustrative examples that show availing high quality data from different sectors is feasible, and by demonstrating the added value of making sense of multi-sectorial data for specific policy and development processes, the two platforms in Ethiopia and Kenya hold significant potential to serve as catalysts in facilitating debates - and finally processes towards national open data policies.

In Ethiopia, the positive experience gained from WALRIS of the WLRC web-platform has inspired the government to develop a National SLM Knowledge Management Information System aimed at serving the wider sustainable land management initiatives in the country. It has been developed for the Ministry of Agriculture based on the experiences gained during the construction of WALRIS. It was necessary to upgrade and add functions to facilitate planning and monitoring of watershed development activities, as well as its other roles as a repository of spatial and non-spatial data and information on the one hand, and a dissemination tool to different stakeholders on the other. Therefore, it is legitimate to claim that the national SLM Knowledge Management Information System was developed on the model established by the WLRC web-platform.

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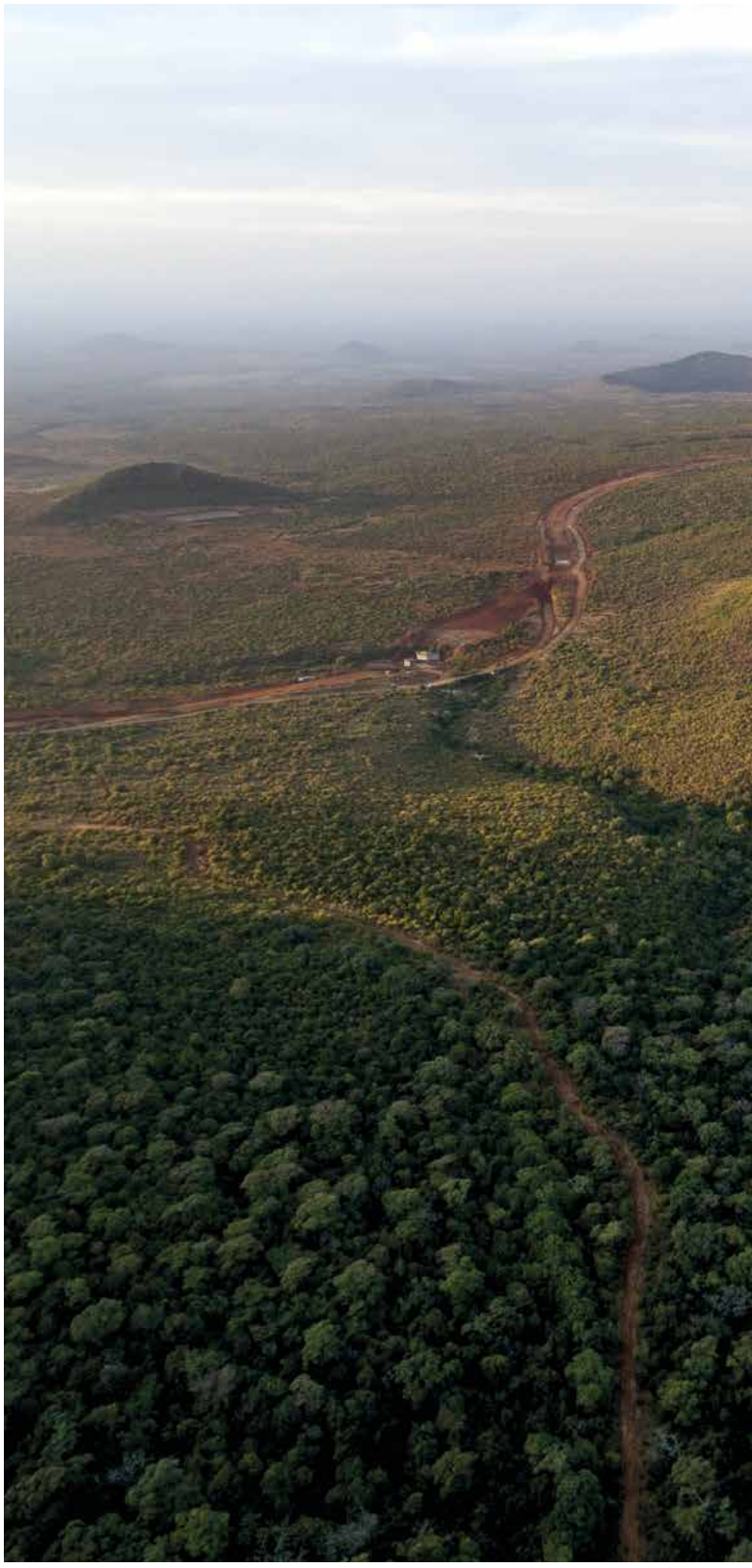
Conclusions and Key Messages for the Way Forward

ISABELLE PROVIDOLI, BONIFACE KITEME, GETE ZELEKE, AMARE BANTIDER AND JOHN MWANGI

This section summarises key messages that have emerged from the results of the long-term cooperation between the Centre for Development and Environment (CDE) and its partners in transformative research for sustainable development – focussing specifically on those based on the activities of the Water and Land Resource Centre (WLRC) project. The countries where the activities took place, namely Ethiopia, Kenya and Tanzania, depict highly diverse socio-ecological contexts, and experience a wide variety of interrelated and interconnected land and water management and governance challenges. In the following we look at what has been learned from our experiences and offer key insights from this transformative research endeavour. We hope that these reflections will be stimulating, thought-provoking and lead to better directed transformative research that helps to resolve ever-increasing sustainability challenges.



The need to address the 2030 Agenda for Sustainable Development calls for integrated approaches aimed at achieving coherence in policies and actions across scales, from local to global, and across multiple sectors. In this process, science is tasked to provide knowledge for negotiations, and for shaping transformations towards sustainable development. The standpoint of WLRC is that to have a significant and lasting influence on sustainable land and water management and governance, researchers, decision-makers, donors and the local community need to work together. It is only through committed efforts and, through coordinated collaboration, that true and lasting impact can be achieved.

We have selected three thematic areas to frame our conclusions. These are: first, increasing knowledge generation; second, making co-produced knowledge available and establishing dialogue; and third, creating awareness and strategic partnerships. Under each of these themes we cite specific examples from the field.

Increasing Knowledge Generation

Increasing availability of data through co-production

Scarcity of primary data at different spatial scales and temporal resolution about water and land resources is a major challenge in Ethiopia, Kenya, Tanzania and the broader East African region: it seriously compromises informed planning and implementation of related initiatives. The WLRC project co-produces data related to water and land management and governance together with different institutions. Long-term data time-series can be translated into spatially explicit knowledge products, which are then shared with a broad range of

Lower Ewaso Ng'iro Basin, Kenya (Hanspeter Liniger).

stakeholders. The provision of pre-processed data has proved very relevant for researchers, and development partners, for the production of high-level outputs - including policy recommendations and the definition of development interventions. It has also become clear that by comparing near-real-time data with past measurements, early warning systems for water shortages (for example) can be developed and provided to user groups for the negotiation of trade-offs.

The key data types, their functionality and importance are as follows:

- Long time-series of point-based measured environmental data (e.g. precipitation, discharge, temperature) provide an invaluable resource for the analysis and quantification of change processes, and for the calibration and validation of spatial models with the goal of obtaining spatially continuous information on environmental processes.
- Spatially explicit and contextualised information on environmental and socio-economic characteristics and dynamics needs to be accessible to negotiate development trade-offs, and to identify co-benefits of development interventions.

Continuous monitoring and assessment of ecological processes and socio-economic dynamics

The general need to improve monitoring in water and land management initiatives is widely acknowledged. Continuous socio-economic and ecological monitoring and assessment is needed to facilitate the formulation of knowledge-based interventions to restore ecological sustainability in the affected areas. For this, priority must also be given to developing tools for participatory monitoring with mixed stakeholder groups in order to be able to detect systematically whether conditions in the watersheds/landscapes have changed, over time, after specific interventions. Examples from the field include:

- *In Ethiopia, a "hybrid" set-up of hydro-sedimentology monitoring stations and learning watersheds has been established. These hybrids improve accessibility of knowledge and awareness raising for land users and other stakeholders. It is recommended to add extra monitoring stations to cover areas and agro-ecologies that are so far unrepresented (Chapter 1 – Ethiopia).*

- *In Kenya, a near-real-time hydro-met monitoring network has been established throughout the highland–lowland system of the Ewaso Ng'iro Basin. It provides crucial information and real-time data feedback to users, which informs the negotiation of critical thresholds that are linked to action in water management by users and users' associations (Chapter 2 – Kenya).*

Assessing and addressing upstream and downstream impacts

Soil and water conservation (SWC) has proven to be effective in improving ecological services. SWC structures considerably reduce soil erosion, improve soil fertility, increase biodiversity and vegetation cover, and are able to reduce peak discharge and improve the baseflow of rivers in the drier months within rehabilitated watersheds, as well as improving shallow ground water recharge.

Participatory Integrated Watershed management (PIWM) targets the twin objectives of achieving sustainable livelihoods for the watershed's residents through diversified livelihood options while ensuring healthy ecosystem function. Water and land management practices often have positive effects beyond the direct areas of their implementation, especially related to water quality and quantity. In typical upstream – downstream situations, investments in the upper river catchment can have a considerable effect downstream. The longevity of downstream water storage structures is also a very important off-site impact of watershed management.

- *In Ethiopia, the pioneering concept of the 'learning watersheds' was developed and implemented successfully. Homestead development was one of the components that helped families to have better access to water for vegetables and fruit production, honey production and small-scale animal production (Chapter 1 – Ethiopia).*

- *In Kenya, the WRUAs Forum improved basin-wide awareness, and enabled participatory assessment of the water use situation, as well as broadening the scope of intervention beyond conflict resolution to include catchment protection and adoption of water saving technologies. The WRUAs Forum provided a platform for negotiated water allocation schemes and conflict resolution approaches towards equity and peaceful coexistence among different water users of diverse economic and cultural backgrounds, in both the upstream and downstream segments of the basin (Chapter 1 – Kenya).*

Making Co-Produced Knowledge Available and Establishing Dialogue

Making knowledge available through web-platforms

Access to digital data and information delivery has greatly improved over the past decade in developing countries. More and more web-platforms are used as data hubs, providing access to available and relevant information related to water and land management for specific target groups. However the platforms need to be co-designed and co-owned by the key actors and embedded in local, regional and national decision support processes. They underpin governance (planning, priority setting), transparency (awareness creation, lobbying), monitoring (impact assessment), forecasting (scenario formulation, outcomes of decisions), and advocacy (empowerment, support of litigation processes). Besides their specific audiences, such platforms have two more generic functions also, related to (i) democratisation of data access in general, and (ii) helping to break sectional silos in favour of more integrated (spatial) planning at different levels.

- *Through the support of the WRLC project, two locally owned open data platforms on water and land management and governance were established in Ethiopia and Kenya, respectively. Making data accessibility public is important, not only related to potential wider use of data but also in terms of data retention. This can help justify huge investments by governments and/or development partners in data collection; as in the past, all too frequently such investment has been wasted with crucial data simply lost (Chapter 3).*

Establishing dialogue at the local level and empowering local stakeholders

The projects invested in setting up and facilitating participatory processes and in engaging stakeholders from different sectors and segments of the population, including communities - with their youth and women. Empowerment and raising awareness of local people was key throughout the whole process, allowing the evolution of fresh ideas and embracing new approaches. The projects established space for dialogue and collaboration across sectors at the district and communal level, and tested a variety of measures in the field to demonstrate their multiple benefits for people – and the environment – as well as to support their wider adoption by local communities.

- *In Ethiopia, one important component of the learning watersheds is the use of Farmer-Research-Extension Groups (FREG). These comprise platforms of the main agents in agriculture and natural resource management. The philosophy of FREG is to co-generate and co-learn technologies and approaches for effective adoption, transfer and dissemination to achieve sustainable land management and sustainable development. Experience-sharing visits of farmers within, and between, these learning watersheds were carried out and proved to be very fruitful (Chapter 1 - Ethiopia).*

- *In Kenya, negotiated context-specific river flow thresholds is an approach that includes water users in determining critical levels regarding water abstraction. Through these "negotiated river flow thresholds" Water Resource Users Associations (WRUAs) can determine type and quantity of water use to be permitted at different times of the season in order to ensure continuous availability, within all river segments, at all times. Water use decisions, underpinned by evidence-based data, were therefore facilitated and informed decisions could be made almost instantaneously (Chapter 1 - Kenya).*

Establishing dialogue and collaboration across sectors; empowering decision-makers

Research can help to steer processes and identify solutions jointly by establishing dialogue across scales, from local to regional to national, and across multiple sectors. This can be achieved by advancing inter- and transdisciplinary approaches that nurture dialogue between scientists and policy makers, foster evidence-informed decision, and set in motion joint learning processes for shaping alternative development pathways. Decision-makers will then be in a position to reconcile the often-competing demands of development and the environment.

Research is required not just to substantiate the scale of recent developments and changes by providing the basis about past and current challenges (i.e. systems knowledge) but also to help evaluate their ecological impacts, and to elaborate goals and shared visions to be achieved for a sustainable future (i.e. target knowledge), and the means to achieve these goals (i.e. transformation knowledge). Without this information, it is not possible for decision-makers to make evidence-based decisions in the future. To support hydro-political negotiations and decision-making, it is therefore crucial to have evidence-based information and knowledge, as well as powerful products for policy and practice, about water and land management and governance in the various basins.

- *In Ethiopia, the concept of "learning watersheds" (as noted above) was developed successfully building on active participation amongst stakeholders including the local community. It facilitated the establishment of live learning platforms, which accelerated scaling-up of Participatory Integrated Watershed Management (PIWM) both vertically (institutionally) and horizontally (spread on the ground). Through this, decision-makers have been convinced of the importance of emphasising SLM. Thus the research projects have directly, and indirectly, contributed to policy making. Confidence in the impacts of SLM (through a participatory integrated watershed management approach) has attracted investment from numerous international development partners – multinational and bilateral agencies as well as NGOs (Chapter 1 - Ethiopia).*

- *In Kenya, the consolidation of WRUAs into a basin-wide forum provided a platform to build mutual trust among users at different scales within the basin. The major outcome of this process was bringing communities together for a shared vision and joint intervention strategies. Meanwhile the concept of a basin-wide WRUA Forum became popular and was consequently mainstreamed into the national policy framework and replicated in other parts of the country (Chapter 1 – Kenya).*

Creating Awareness and Strategic Partnerships

Creating awareness and building capacities

An important pillar in water and land management and governance is the constant awareness creation and capacity development of key stakeholders across different scales and sectors. The projects were based on long-term programmatic cooperation, commitment and perseverance. The projects invested strongly in capacity building for multiple stakeholders and were able to build a solid research base supporting water and land management, and governance, in the countries, which served to develop:

- Comprehensive, long-term databases in sub-Saharan Africa: the knowledge accumulated has not only helped trigger the establishment of academic departments in universities, but it directly provides data for modelling and model calibration – and has formed the basis for a very large number of scientific articles;
- Substantial knowledge systems: including geo-spatial database and maps, which raised awareness at national and international levels and led to a series of large investments in NRM/SWC/SLM and watershed management in particular;
- Influential and comprehensive guides: technical guidelines, manuals, assessments, etc. which became key information for the respective stakeholders; and
- A widespread programme of capacity building: including the establishment of courses at colleges and universities, professional courses for technical staff, as well as adult education and exchange visits for farmers, WRUAs and on-the-job training for field practitioners, water users and the community.

Improving governance and social/institutional development

To achieve tangible and lasting results in water and land management, more strategic governance interventions are needed. Governance issues that may obstruct technical solutions have to be addressed, and social and institutional development is required. For this, sound analysis of the underlying policy and institutional challenges are necessary: this helps determine the changes that are needed in institutions, structures and processes to create a conducive environment for managing natural resources in a sustainable way.

- *In Kenya there was a focus on water-related institution building at the grassroots level, supporting the formation, functioning, and institutional anchoring of user-based water management institutions (in particular WRUAs and Water Forums). The institution building helped to voice local needs in water governance and to establish conflict resolution approaches and benefit-sharing mechanisms at the grassroots level in the Ewaso Ng'iro Basin and the Pangani/Umba Basin. The WRUA Forum serves as an independent platform for negotiations at both horizontal (between and within WRUAs) and vertical (at a higher level of administrative authority) levels regarding water sharing arrangements, and in particular conflict resolution between upstream and downstream users (Chapter 2 – Kenya).*

Strengthening strategic partnerships and opening new fronts of research collaboration

Closer collaboration among key stakeholders concerned with water and land management and governance is not only crucial to foster knowledge exchange and plan strategically future interventions, but also to lead to more synergetic action. The projects were able to strengthen partnerships with national/regional actors and raise awareness to enable effective management and governance of water and land resources.

- *In Ethiopia, the results of the landscape transformation study was widely shared at different forums, and build the basis for establishing dialogue and partnerships between scientists, practitioners and policy-makers (Chapter 2 – Ethiopia). The "learning watersheds" led to a series of large investments in NRM/SWC and watershed management in particular (e.g. by WFP, GIZ and the World Bank) (Chapter 1 – Ethiopia).*

- *In Kenya, successful development of the data sharing platform (SHIP) and the near real time data interfacing at different levels propelled CETRAD to a higher level of visibility, and attracted new fronts of research collaboration outside the traditional partners, both locally and abroad (Chapter 2 – Kenya).*

Outlook

To achieve the 2030 Agenda for Sustainable Development at the local/regional level, global-level targets have to be downscaled for devising local solutions to global challenges. The WLRC project has showed possible ways of how to develop sustainable development pathways through transformative research at the local level touching the various thematic areas of the SDGs, and how these lessons can be further up-scaled and out-scaled. Our experiences over the years have not always been smooth, but perseverance has paid dividends, and there is pride among all partners in what we have achieved together. Certainly the project has demonstrated that water and land management activities never come to an end: new issues are constantly evolving, and increasingly complex and intertwined sustainability challenges have to be confronted. To understand these emerging issues and then to address them accordingly, different knowledge types are needed, and continuous monitoring of the multiple aspects of natural resource management activities is vital. This includes responses of ecosystems and livelihoods; changes in the behaviour of land users; adaptation mechanisms to global changes; effectiveness of institutions, and so forth. This process can be readily guided by the decision support system for sustainability developed by WLRC - and other related initiatives. Enough evidence has been built up to show that transformative research is the way forward for enhanced technologies and innovative management approaches. The concept is now institutionally embedded, and we are confident that it will be continued in order to facilitate responses to emerging dynamics, and thereby help to optimally manage natural resources now, and in the future.

Graded bund and stone-paved waterway in Abagerima, Ethiopia (Isabelle Providoli).

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