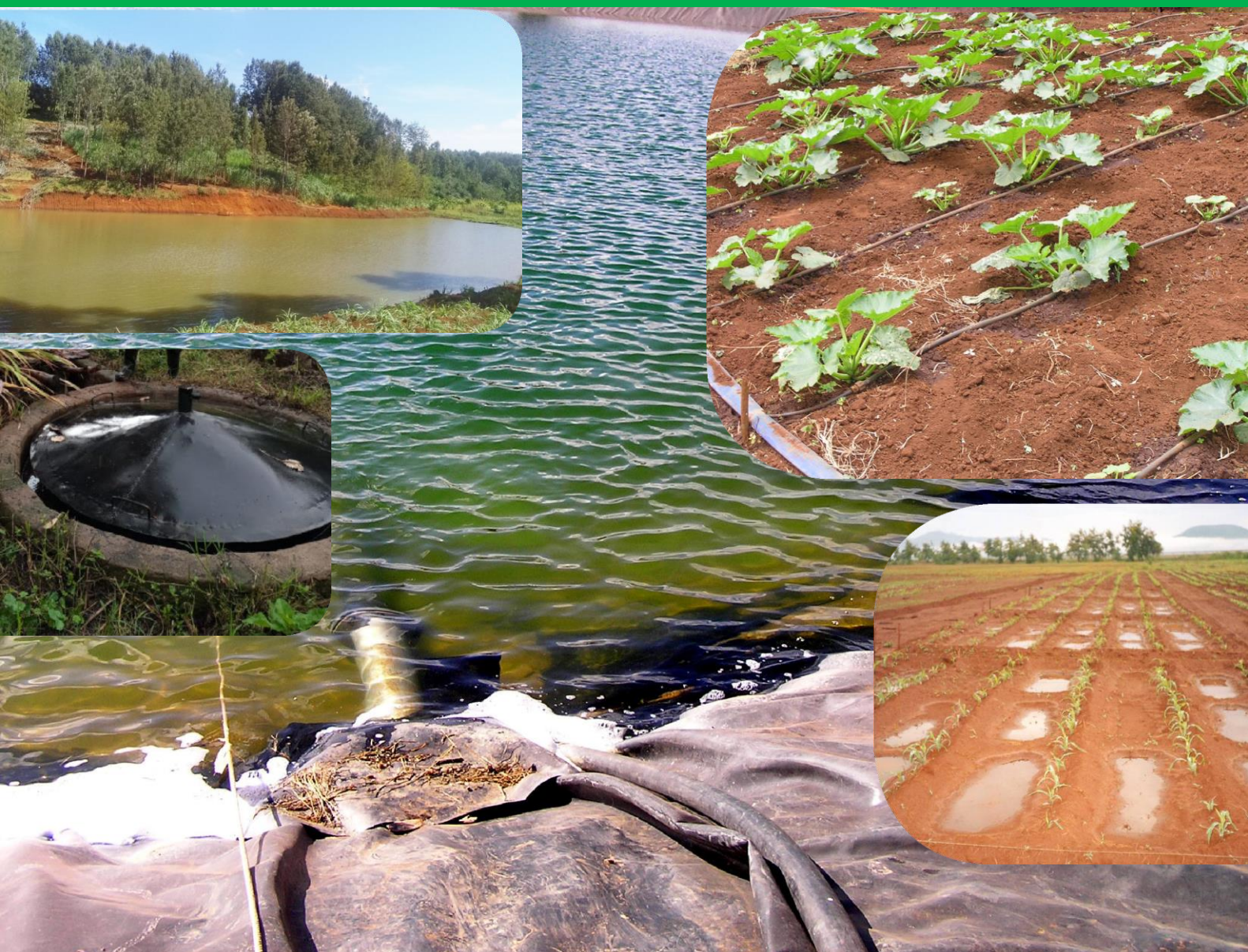




Kenya Climate Smart  
Agriculture Project

# Inventory of Climate Smart Agriculture Technologies, Innovations and Management Practices for Land, Water, Agroforestry and Bio-Energy



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OCTOBER 2022

## **DISCLAIMER**

The information presented in this inventory of Technologies, Innovations and Management Practices (TIMPs) book is for advisory use only. Users of this book should verify site specific details that relate to their agro-climatic zones from their area agricultural extension officers.

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### **Published by**

Kenya Agricultural and Livestock Research Organization

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## **FOREWORD**

Kenya Climate-Smart Agriculture Project (KCSAP) tasked the Kenya Agricultural and Livestock Research Organization (KALRO) with the implementation of the project's Component 2 on 'Strengthening Climate-Smart Agricultural Research and Seed Systems'. The component activities are geared towards the development, validation, adoption and delivery of context specific climate smart agriculture (CSA) technologies, innovation and management practices (TIMPs). It is also responsible for development of sustainable seed production and distribution systems of priority agricultural value chains to enhance availability and access improved seeds, animal breeds and fingerlings by target beneficiaries. Against this background, KALRO and her National Agricultural Research System (NARS) partners have developed, validated and availed CSA TIMPs for dissemination and adoption. This document provides a detailed inventory of TIMPs that have been developed for Land, water, agroforestry and bio-energy theme.

Extensive information from research and background data has been used to develop this TIMPs inventory. To disseminate the TIMPs, a Training of Trainers (ToT) manual has been developed. The design of the manual takes into consideration the delivery system, partners and their roles, duration of training and logical flow of the modules. The training modules have uniform outline that ensures every aspect of the TIMPs are fully covered in way that the trainees can absorb and relate to. Various delivery methods are deployed and where possible demonstrations and practical work are incorporated to enable the trainees learn by participating in the actual field activities. The use of this TIMPs inventory is expected to contribute to achievement of the envisaged KCSAP's project 'Triple Wins' of increased productivity, enhanced resilience and reduction of greenhouse gases emissions. Thus, this TIMPs inventory is to be used in conjunction with the ToT Manuals of the relevant crop and livestock value chains.

Finally, I am greatly indebted to all those who participated in the preparation of this inventory of TIMPs. It is expected to herald new ways of delivering training content that will enable realization of the project objectives and aspirations.

Eliud K. Kireger, PhD, OGW  
**Director General, KALRO**

## **PREFACE**

The Kenya Climate-Smart Agriculture Project (KCSAP) is a Government of Kenya project with support from both the World Bank and the government. The project runs for five years and implemented in 24 counties, mainly in the arid and semi-arid lands (ASALs), at an approximate cost of KES 25 billion. The project development objective (PDO) is “to increase agricultural productivity and build resilience to climate change risks in the targeted smallholder farming and pastoral communities and in the event of an Eligible Crisis or Emergency, to provide immediate and effective response.” This objective is to be achieved through the implementation of five key components, which are: 1) Upscaling Climate-Smart Agricultural Practices, 2) Strengthening Climate-Smart Agricultural Research and Seed Systems, 3) Supporting Agro-weather, Market, Climate and Advisory Services, 4) Project Coordination and Management and 5) Contingency Emergency Response.

Component 1 involves facilitating the empowering of farmers and communities to adopt technologies, innovations and management practices (TIMPs) to achieve the Climate Smart Agriculture (CSA) triple-wins of; increased productivity, enhanced resilience (adaptation), and reduced Greenhouse gas (GHG) emissions (mitigation). Component 2 is tasked with the responsibility of providing the TIMPs. Therefore, it supports the development, validation, and adoption of context specific CSA TIMPs to target beneficiaries under Components 1 and 3.

To catalyze uptake of TIMPs, Kenya Agricultural and Livestock Research Organization (KALRO) in conjunction with partners in the National Agricultural Research Systems (NARS) and Consultative Group for International Agricultural Research (CGIAR) compiled inventories of TIMPs for the prioritized value chains. The crop-based value chains are 19 and include roots and tubers (cassava, potato), pulses (dry beans, green gram and pigeon peas), vegetables (tomato, onion, indigenous vegetables, kale and mango), cereals (sorghum, millet, maize, teff), nuts (mango nut), fruits (banana, mango, water melon) and fibre (cotton). Those that are animal production based are five (5) and include apiculture, indigenous chicken (meat and eggs), dairy (cattle and camel), red meat (cattle, sheep and goats) and aquaculture. The land, water agroforestry and bio-energy TIMPs cut across crops and livestock. The TIMPs have been categorized into those ready for upscaling and those requiring validation. Furthermore, gaps that required further research and development of TIMPs have been identified. Training of Trainers’ (ToT) manuals focusing on TIMPs that are ready for upscaling for each of the value chains have been subsequently developed to form the basis of training county extension staff, service providers and lead farmers. Those trained are in turn expected to cascade the training to beneficiaries in the targeted smallholder farming, agro-pastoral and pastoral communities in the 24 project Counties of Marsabit, Isiolo, Tana River, Garissa, Wajir, Mandera, West Pokot, Baringo, Laikipia, Machakos, Nyeri, Tharaka Nithi, Lamu, Taita Taveta, Kajiado, Busia, Siaya, Nyandarua, Bomet, Kericho, Kakamega, Uasin Gishu, Elgeyo Marakwet and Kisumu.

KALRO, having the responsibility of implementing the activities under Component 2, has been instrumental in using its information resources and those of partners and collaborators to come up with the inventories of TIMPs and corresponding ToT manuals. Use of these information resources coupled with the accompanying training and contribution of the other project components will go a long way in enabling KCSAP to meet its development objectives.

The National Project Coordination Unit is grateful to all who participated in the development and production of this TIMPs inventory for land, water, agroforestry and bio-energy. It is my hope that counties and other users will put this resource to good use as they transform and reorient their agricultural systems to make them more productive and resilient while minimizing GHG emissions under the new realities of the changing climate.

Francis Muthami

**National Project Coordinator**

**Kenya Climate-Smart Agriculture Project**

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## ABBREVIATIONS AND ACRONYMS

<b>AEZs</b>	-	Agro Ecological Zones
<b>ASALs</b>	-	Arid and Semi-Arid Lands
<b>CA</b>	-	Conservation Agriculture
<b>CIGs</b>	-	Common Interest Groups
<b>CIAT</b>	-	International Center for Tropical Agriculture
<b>CGIAR</b>	-	Consultative Group for International Agricultural Research
<b>CSA</b>	-	Climate Smart Agriculture
<b>FAO</b>	-	Food and Agriculture Organization
<b>FFS</b>	-	Farmer Field School
<b>GHGs</b>	-	Green House Gases
<b>GMCCs</b>	-	Green Manure Cover Crops
<b>ICE</b>	-	Institute of Culture and Ecology
<b>ICRAF</b>	-	International Council for Research in Agroforestry (World Agroforestry)
<b>ICS</b>	-	Improved Cook Stoves
<b>ILRI</b>	-	International Livestock Research Institute
<b>IPR</b>	-	Intellectual Property Right
<b>ISFM</b>	-	Integrated Soil Fertility Management
<b>KALRO</b>	-	Kenya Agricultural and Livestock Research Organization
<b>KCSAP</b>	-	Kenya Climate Smart Agriculture Project
<b>KEFRI</b>	-	Kenya Forestry Research Institute
<b>KFS</b>	-	Kenya Forest Services
<b>MFI</b>	-	Micro Finance Institutions
<b>MoALF &amp;L</b>	-	Ministry of Agriculture, Livestock, Fisheries and Irrigation
<b>NARS</b>	-	National Agricultural Research System
<b>NGOs</b>	-	Non-Governmental Organizations
<b>PDO</b>	-	Project Development Objective
<b>PPP</b>	-	Public Private Partnership
<b>SMEs</b>	-	Small and Medium Enterprises
<b>SMMEs</b>	-	Small, Medium and Micro Enterprises
<b>TIMPs</b>	-	Technologies, Innovations and Management Practices
<b>ToTs</b>	-	Training of Trainers
<b>UNFCCC</b>	-	United Nations Framework Convention on Climate Change
<b>VMGs</b>	-	Vulnerable and Marginalized Groups

## 1.0 INTRODUCTION

### 1.0 Definition of terms and summary tables of Mango Technologies, Innovations and Management Practices (TIMPS)

#### 1.1 Definition of terms

Technology: This is an output of a research process which is beneficial to the target clientele (mainly farmers for KCSAP's case), can be commercialized and can be patented under intellectual property rights (IPR) arrangements. It consists of research outputs such as tools, equipment, genetic materials, breeds, farming and herding practices, gathering practices, laboratory techniques, models etc.

Management practice: This is a recommendation on a practice that is considered necessary for a technology to achieve its optimum output. It includes different agronomic practices (seeding rates, fertilizer application rates, spatial arrangements, planting period, land preparation and watering regimes), crop protection for crops, and feed rations and disease control for livestock.

Innovation: This is a modification of an existing technology for an entirely different use from the original intended use. (e.g., fireless cooker modified to be used as a hatchery)

#### 1.2 Summary of Inventory of TIMPs in Natural Resource Management and Sustainable bio- energy

The inventory process resulted into 29 TIMPs including 9 technologies, 3 innovations and 17 management practices distributed among the 5 sub-themes, as indicated in Table 1.

**Table 1: TIMPS in the Natural Resource Management and Sustainable Bio-energy**

<b>Thematic area</b>	<b>Sub-Theme</b>	<b>Technologies</b>	<b>Innovations</b>	<b>Management practice</b>
Land, water & agroforestry (Natural Resource Management)	Soil fertility management	1	1	2
	Soil & water management	3	1	9
	Irrigation and drainage	2	1	1
	Agroforestry systems	-	-	5
Sustainable Bio-energy	Bio-energy systems	3	-	-
<b>Totals</b>		<b>9</b>	<b>3</b>	<b>17</b>

#### 1.3 Summary of Status of TIMPs in Natural Resource Management and Sustainable Bio- energy

The inventory process resulted in a total of 11 TIMPs that are ready for up scaling, 8 TIMPs that require validation and 6 TIMPs that require further research in the sub-themes, as indicated in Table 2.

**Table 2: Number of TIMPs ready for up-scaling, require validation or further research**

Thematic area	Sub-Theme	Ready for up-scaling	Require validation	Further Research
Land, water & agroforestry/Natural Resource Management	Soil fertility management	-	4	-
	Soil & water management	11	1	1
	Irrigation and drainage	1	3	-
	Agroforestry systems	2	2	1
Sustainable bio-energy	Bio-energy systems	3	-	-
<b>Totals</b>		<b>17</b>	<b>10</b>	<b>2</b>

**Table 3: Inventory of Natural Resource Management and Sustainable Bio-energy TIMPs by Category and Status**

TIMPs Theme	Sub-Theme	TIMPs Title	TIMPs Category	Status
Soil fertility management		Integrated soil fertility management	Management practice	Requires validation
		Integrated manure management	Management practice	Further research
		Low cost composting	Technology	Requires validation
		Rapid soil testing services	Innovation	Requires validation
Soil and water management		Conservation agriculture	Management practice	Ready for up scaling
		Intercropping	Management practice	Further research
		Mulching	Management practice	Further research
		Zai pits	Technology	Ready for up-scaling
		Bench terraces	Management practice	Ready for up scaling
		Stone lines	Management practice	Ready for up scaling
		Contour bunds	Management practice	Ready for up scaling
		Fanya juu terraces	Management practice	Ready for up scaling
		Grass strips	Innovation	Ready for up scaling
		Tied ridges	Technology	Ready for up scaling
		Roof catchment	Management practice	Ready for up scaling
		Green manure cover crops	Technology	Ready for up-scaling
		Participatory range land management	Management practice	Ready for up-scaling
Irrigation and drainage		Solar for small scale irrigation	Innovation	Requires validation
		Drip irrigation	Technology	Ready for up scaling

<b>management</b>	Hydroponics systems	Management practice	Requires validation
	Sensor based drip irrigation	Technology	Requires validation
<b>Agroforestry systems</b>	Agroforestry for fodder	Management practice	Ready for up scaling
	Agroforestry for fruit trees	Management practice	Further research
	Agroforestry for soil fertility	Management practice	Requires validation
	Woodlots for energy	Management practice	Ready for up scaling
	Windbreaks and live hedges	Management practice	Requires validation
<b>Bio-energy systems</b>	Improved Cooking Stoves	Technology	Ready for up scaling
	Biogas	Technology	Ready for up scaling
	Briquettes	Technology	Ready for up scaling

## 2.0 SOIL FERTILITY MANAGEMENT TIMPs

### 2.1 Integrated Soil Fertility Management (ISFM)

<b>TIMP name</b>	<b>Integrated Soil Fertility Management (ISFM)</b>
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Declining soil fertility, low organic matter, poor soil structure and limited available moisture in crop production.
What is it? (TIMP description)	A set of soil fertility management practices that include the use of fertilizers, locally available organic inputs and improved seed and good agronomic practices to adapt to local conditions. ISFM places emphasis on the importance of using often scarce resources such as fertilizer and organic inputs efficiently through techniques such as fertilizer banding (field application of fertilizer directly in area of root-zone to increase the potential for uptake) and micro dosing (applying small quantities of fertilizer with the seed at planting time and a few weeks after emergence)
Justification	Soils within the farming system are heterogeneous due to spatial variability in soil fertility. These inherent differences arise from the parent material from which the soil has evolved, and the position in the landscape that influences how soil develops. A large proportion of soils in the KCSAP target project counties are derived from some of the oldest land surfaces which, due to weathering and cropping, have

	<p>low nutrients. Where younger, volcanic soils occur these are inherently richer in nutrients, but may have other soil fertility problems such as fixation of some critical nutrients such as phosphorus. Past management of the soils also has a major influence on soil fertility which in turn influences productivity.</p> <p>These challenges call for an integrated soil fertility management (ISFM) approach that combines appropriate interventions on soil management that include fertilizer use and crop agronomy. The aim of ISFM is therefore to optimize agronomic use efficiency of the applied nutrients for improved crop productivity.</p>
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers
Approaches used in dissemination	<ul style="list-style-type: none"> <li>• Training in workshops</li> <li>• On-farm visits</li> <li>• Farmer field schools (FFS)</li> <li>• On-farm demonstrations (during FFS)</li> <li>• Digital media</li> <li>• Farmer Innovation platforms</li> </ul>
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Availability of affordable and quality manure, fertilizers and clean planting materials</li> <li>• Take into account variability between farms, in terms of farming goals and objectives, size, labour availability, ownership of livestock, importance of off-farm income;</li> <li>• Availability of clean/certified seed</li> <li>• Availability of novel crop protection practices, and</li> <li>• Take into account amount of production resources (i.e. land, money, labour, crop residues) that different farming families are able to invest in</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• County government extension services - Provide linkage with farmers.</li> <li>• Community farmer groups - play coordination role for ease in problem identification and dissemination.</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Machakos, Busia, Siaya, Kisumu, Kakamega, Tharaka Nithi, Isiolo, Nyeri, Uasin Gishu, Elgeyo Marakwet
Counties where TIMP will be promoted	Bomet, Kericho, West Pokot, Taita Taveta, Lamu, Nyandarua, Tana River, Baringo, Marsabit, Garissa, Kajiado, Laikipia
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Change of mindset in some regions/cultures that organic manures cannot be applied on crops</li> <li>• Lack of guidelines on how to combine manures/organic materials with modest amounts of mineral fertilizers.</li> <li>• Misconceptions that chemical fertilizer damage the soils</li> </ul>

Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Awareness trainings on role of organic manures in crop cultivation</li> <li>• Training and awareness creation on the usefulness of fertilizer applications to clear the misconceptions about fertilizers</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• For ISFM to succeed, good germplasm/seed/seedlings, etc is required since farmers tend to re-use previous planted materials.</li> <li>• Knowledge of how to combine organic and inorganic fertilizers is required.</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Practice is socially acceptable,</li> <li>• Environmentally friendly,</li> <li>• Increased productivity will provide supply to the markets,</li> <li>• Supporting frameworks/policies are available</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Cost not yet determined and is dependent on agro ecological zone and value chain of interest
Estimated returns	Farmers who have adopted ISFM technologies have more than doubled their agricultural productivity and increased their farm-level incomes by 20 to 50 percent
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• The practice integrates participation of male and female gender roles during field activities. Female gender is disadvantaged where application of heavy loads of manure is to be incorporated in the field.</li> <li>• Adoption and scaling up of ISFM technologies could be affected by:</li> <li>• Ownership of the farm, that are mainly male owned but the implementer of the ISFM in most cases is female</li> <li>• Quality inputs and their availability in time</li> </ul>
Gender related opportunities	Apart from the inorganic fertilizers and good seed, the practice adopts other locally available materials that save on cost which benefits all gender in the farm household.
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• VMGs are physically disadvantaged for a practice that seeks to incorporate manures, and chemical sprays in the farm.</li> <li>• They are also resource poor and may not have the resources to purchase seed and fertilizers as required for successful implementation of the practice</li> </ul>
VMG related opportunities	The technology if well practised can increase farm incomes of VMGs by up to 50%.
<b>E: Case studies/profiles of success stories</b>	
Success stories	ISFM successes have been reported in maize in central and western Kenya highlands. Successes have also been

	reported for sorghum and millet value chains in Machakos where the productivities have been improved
Application guidelines for users	<ul style="list-style-type: none"> <li>• Always use well-adapted, disease- and pest-resistant germplasm/seed to make efficient use of available nutrients.</li> <li>• Ensure that good agronomic practices are upheld</li> <li>• For sustainability, use of pure inorganic or organic materials should be avoided but should be used in recommended combinations.</li> <li>• Adapt the practice to local conditions</li> </ul>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	2 =Requires validation
<b>G: Contacts</b>	
Contacts	Centre Director, KALRO Kabete P. O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: <a href="mailto:cd.narl@kalro.org">cd.narl@kalro.org</a>
Lead organization and scientists	KALRO; E. Gikonyo, C. Kibunja, A. Muriuki, D. Kamau, A. Esilaba, J. Ndufa, C. Kundu and S. Kimani
Partner organizations	County governments, NGOs, CIGs, KEFRI

### Research Gaps

1. Validation of the ISFM technology in Counties where technology has not been tested.
2. Testing (fertilizer types, rates, frequencies) and combination with manures for different value chains

## 2.2 Integrated Manure Management (IMM)

<b>TIMP name</b>	<b>Integrated Manure Management (IMM)</b>
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Land degradation characterized by the declining soil fertility, low yields, increased soil moisture stress, increased soil erosion and poor soil health Poor manure management and handling leading to increased Green House Gases (GHG) emissions
What is it? (TIMP description)	Integrated Manure Management (IMM) is the optimal, site-specific handling of livestock manure from collection, through treatment and storage up to application to crops. Manure is obtained from different animals (poultry, cow, goat, horse) on the farm, but it can also be bought from other farmers or at the market. When managed properly, it provides plant nutrients, builds soil organic matter, and improves soil physical properties



Source: J. Oyoo, Tigoni

all of which are important for soil quality and crop production.

**Justification**

The decline in soil fertility in smallholder system is a major factor inhibiting agricultural development on farms. It is estimated that soils are depleted at annual rate of 22kg/ha for nitrogen, 2.5kg/ha for phosphorous, and 15kg/ha for potassium. Manure plays an essential role in the nutrient cycle where crops grow on land to feed livestock, which in return feeds the land with their manure. Recycling the (macro and micro) nutrients in manure reduces the need for additional fertilizer purchase. In general, adding manure to soils enhances soil fertility and soil health that leads to increased agricultural productivity, improved soil structure and biodiversity. Given the acute poverty and limited access to mineral fertilizers, manure has the potential providing the limiting nutrients and improving the soil health. The efficient use of manure is enhancing the capacity of the soil to conserve and accumulate soil organic carbon; maintain or improve crop yield by supplying nutrients when required by plants and reduce effects of climate change through sequestration of carbon.

**B: Assessment of dissemination and scaling up/out approaches**

**Users of TIMP**

- Farmers
- Public and private practitioners

**Approaches used in dissemination**

- On-farm and on-station demonstrations
- Open and Field days
- Agricultural shows
- MoA/Extension officers/Partners
- Farmer to farmer peer learning
- Mass media- e.g Mkulima programme, Smart Farmer and Seeds of Gold
- Workshops, Seminars, Meetings, trainings
- Promotional materials (posters/brochures/leaflets)
- Social Media platforms
- Exchange visits

Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Training on feeding, management and use of manure</li> <li>• Dissemination approach used to reach target farmers</li> <li>• Model demonstration plots using several crops</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• Ministry of Agriculture, Livestock, Fisheries &amp; Irrigation (MoALF &amp; I)-National and County level -extension services and link with farmers</li> <li>• CIGs (Common Interest Groups)- co-ordination roles and back stopping at grass root levels</li> <li>• ILRI- technical backstopping</li> <li>• NGOs (Non-governmental organizations)- promotion, micro financing etc.</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Tharaka Nithi, Kajiado, Uasin Gishu
Counties where TIMP will be promoted	Bomet, Kericho, Laikipia, West Pokot, Taita Taveta, Nyandarua, Lamu, Tana river, Baringo, Marsabit, Garissa, Siaya, Kisumu
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Limited model demonstration farms</li> <li>• Cultural challenges -Lack of interest by pastoral communities</li> <li>• Lack of continuity in training of extension and farmers in the skill for manure management</li> <li>• Lack of proper mobilization mechanism for reaching many farmers</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Establishment of many demonstration plot by counties</li> <li>• Capacity building of pastoral communities on manure management and its benefit</li> <li>• Continuous capacity building of demonstration farmers and extension workers</li> <li>• Use of approaches to mobilize farmer to attend demonstration forums</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Proper use of manures improves soil fertility</li> <li>• Use of manures enhances crop productivity</li> <li>• Skills in manure preparation, storage and application</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Applying manure to soils saves on purchase of inorganic fertilizer, increases crop yield and saves water.</li> <li>• Propagation of invasive species when the seed is ingested by the animal and passed to crop field</li> <li>• Manure can harbour pathogens which can cause disease outbreaks to livestock</li> <li>• Contamination of water sources by leaching of nutrients</li> </ul>

	<ul style="list-style-type: none"> <li>Organic manures when poorly handled increase GHG emissions. However, IMM provides practices that are able to minimize GHG emissions.</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	<ul style="list-style-type: none"> <li>Proper handling of manure needs labour for collecting the manure, building a compost heap, maintaining it and finally transporting and applying it field which take a lot of effort and time. Manure costs are dependent on types e.g.cow, goat, sheep, poultry</li> <li>Using locally available manure/composts saves on purchase of inorganic fertilizer.</li> </ul>
Estimated returns	Returns dependent on crop and crop varieties in the value chain where IMM is practised
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>It is labour intensive in terms of handling and application (often by broadcasting) hence may disadvantage women and youth</li> </ul>
Gender related opportunities	<ul style="list-style-type: none"> <li>Manure is locally available for farm households who keep livestock, hence opportunities available for both men and women.</li> </ul>
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>It is labour intensive in terms of handling and application hence may disadvantage VMGs.</li> <li>The VMGs are also resource poor, hence may not have access adequate manures, e.g. need large livestock herds</li> </ul>
VMG related opportunities	Manure is locally available for those farm households with livestock and can build on what they already own
<b>E: Case studies/profiles of success stories</b>	
Success stories	Farmers who adopt manure management practice have reported improved soil health and increased crop yield, and sustainable source of income e.g. keeping one steer in a smallholder farm measuring 0.45ha in central Kenya produces manure equivalent to 112kgN/ha/year of whole farm area when optimum collection and manure composting strategies are followed.
Application guidelines for users	<p>The guideline focus on the following areas:-</p> <ul style="list-style-type: none"> <li>Animal feeds</li> <li>Livestock housing and manure collection</li> <li>Manure storage to preserve nutrient and avoid loses</li> <li>Manure treatment for ease of transport and application in the field</li> <li>Timing of application for maximum utilization by the crop</li> <li>Anaerobic digestion for biogas production</li> <li>Regular analysis of manure to ascertain the quality</li> </ul>

	<ul style="list-style-type: none"> <li>• Manure/Composts take a long time to cure, hence need good planning prior to use</li> <li>• IMM is always site specific and users advised to only use information relevant to local circumstances</li> </ul>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	2 =Requires validation
<b>G: Contacts</b>	
Contacts	Director, Environment & Natural Resource Systems KALRO Secretariat P.O. Box 57811-00200 +254 722 206986/8, Ext 2316
Lead organization and scientists	KALRO S. Kimani, E.Mutuma, D. Kamau, M. Okoti, J. Wamuongo, A.O. Esilaba
Partner organizations	County government, Private Public Partnerships, CIGs

### Research gaps

Promote IMM management practice

1. in counties that have not practised it.
2. Conduct nutrient budget study on selected farms utilizing manures (including composts) in each of the 24 Counties.

### 2.3 Low Cost Composting technology

<b>TIMP name</b>	<b>Low Cost Composting technology</b>
Category (i.e. technology, innovation or management practice)	Technology
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Organic wastes constitute the highest percentage of waste flow in Kenya leading to big landfills especially near the urban centres. However, there is low awareness on appropriate low cost composting technologies and lack of supporting policies. Moreover, lack of proper composting management and handling leads to increased GHG emissions.
What is it? (TIMP description)	Composting is the biological decomposition of organic waste such as food or plant material by bacteria, fungi, worms and other organisms under controlled aerobic conditions resulting in an accumulation of partially decayed organic matter called humus. Composting is thus one of the most effective process for recycling organic wastes intended for use in agriculture

Justification	<p>The decline in soil fertility in smallholder system is a major factor inhibiting agricultural development on farms. It is estimated that soils are depleted at annual rate of 22kg/ha for nitrogen, 2.5kg/ha for phosphorous, and 15kg/ha for potassium.</p> <p>Compost contain the nutrients nitrogen, phosphorus and potassium and that are found in most chemical fertilizer and even secondary and trace elements (such as zinc, iron and magnesium) that are not, and which are useful to the roots of growing plants. The compost also adds balanced nutrients to soil in an easily assimilated form, and helps improving soil structure by lightening heavy clays and improving water retention properties in porous sands</p>
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers
Approaches used in dissemination	<ul style="list-style-type: none"> <li>• On-farm and on-station demonstrations</li> <li>• Open and Field days</li> <li>• Agricultural shows</li> <li>• MoA/Extension officers/Partners</li> <li>• Farmer to farmer peer learning</li> <li>• Mass media- e.g Mkulima programme, Smart Farmer and Seeds of Gold</li> <li>• Workshops, Seminars, Meetings, trainings</li> <li>• Promotional materials (posters/brochures/leaflets)</li> <li>• Digital Media platforms</li> <li>• Exchange visits</li> <li>• Agricultural Innovation Platforms</li> </ul>
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Training on feeding, management and use of manure</li> <li>• Dissemination approach used to reach target farmers</li> <li>• Model demonstration plots using several crops</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• Ministry of Agriculture, Livestock, Fisheries &amp; Irrigation (MoALF &amp; I)-National and County level -extension services</li> <li>• CIGs (Common Interest Groups)- co-ordination roles and back stopping at grass root levels</li> <li>• ILRI- technical backstopping</li> <li>• NGOs (Non-governmental organizations)- promotion, micro financing etc.</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Tharaka Nithi, Kajiado, Nyeri, Bomet, Uasin Gishu, Kakamega, Busia, Machakos
Counties where TIMP will be promoted	All 24 KCSAP Counties

Challenges in dissemination	<ul style="list-style-type: none"> <li>• Lack of model demonstration farms</li> <li>• Cultural challenges -Lack of interest by pastoral communities</li> <li>• Lack of continuity in training of extension and farmers in the skill for manure management</li> <li>• Lack of proper mobilization mechanism for reaching many farmers</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Establishment of many demonstration plot by counties</li> <li>• Capacity building of pastoral communities on manure management and its benefit</li> <li>• Continuous capacity building of demonstration farmers and extension workers</li> <li>• Use of approaches to mobilize farmer to attend demonstration forums</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Proper use of manures improves soil fertility</li> <li>• Use of composts to enhance crop productivity</li> <li>• Skills in composting, storage and application</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Composting requires care when handling wastes that would normally contain heavy loads of pathogens and aim at removing non-biodegradable and hazardous waste and controlling odours and flies. Also compost pits if not well managed can also be a source of contamination through leaching of nutrients.</li> <li>• Generally, composting saves on purchase of inorganic fertilizer, increases crop yield and saves water when used on the farm, hence socially and environmentally acceptable.</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Preparation of composts require labour for building a compost heap, maintaining it and finally transporting and applying it field which take a lot of effort and time
Estimated returns	Returns dependent on crop and crop varieties in the value chain where composting is practised
Gender issues and concerns in development, dissemination, adoption and scaling up	It is labour intensive in terms of handling and application (often by broadcasting) hence may disadvantage women and youth
Gender related opportunities	Composting resources are locally available for farm households who keep livestock, hence opportunities available for both men and women.
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• It is labour intensive in terms of handling and application hence may disadvantage VMGs.</li> <li>• The VMGs are also resource poor, hence may not have access adequate resources</li> </ul>
VMG related opportunities	Materials for compost making include household wastes and only require one to be trained on composting techniques to ensure compost quality.

<b>E: Case studies/profiles of success stories</b>	
Success stories	Farmers who use composts in quickly maturing crops have reported 3 to 5 times increased production due and better income to improved soil health
Application guidelines for users	The guidelines for users focus on the following areas: <ul style="list-style-type: none"> <li>• Need to mix the compost with the soil to ensure adequate nutrition in the rooting zone.</li> <li>• Compost storage to preserve nutrient and avoid loses.</li> <li>• Timing of application for maximum utilization by the crop.</li> <li>• Regular analysis of compost to ascertain the quality including contaminants like heavy metals and pathogens.</li> <li>• Type of composts and quality that will determine the application rates.</li> <li>• Materials that cannot be used for composts include, charcoal ash, dog/cat manure, meat/animal fat, leaves or biomass from certain tree species that have toxic compound levels for microbes, e.g. <i>eucalyptus</i> and <i>cassia</i> spp.</li> </ul>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	2 =Requires validation
<b>G: Contacts</b>	
Contacts	Director, Environment & Natural Resource Systems KALRO Secretariat P.O. Box 57811-00200 +254 722 206986/8, Ext 2316
Lead organization and scientists	KALRO S. Kimani, B. Mugo, E.Mutuma, D. Kamau, M. Okoti, J. Wamuongo, A.O. Esilaba
Partner organizations	County government, NGOs

### Research gaps

1. Promote composting technology in Counties that have not practised it.
2. Conduct nutrient budget study on selected farms using composts in the 24 Counties
3. Efficiency of composting types available to farmers

### 2.4 Rapid Soil Testing Services

<b>TIMP name</b>	<b>Rapid Soil Testing Services</b>
Category (i.e. technology, innovation or management practice)	Innovation
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Conventional methods for soil testing are expensive for farmers, results take long and are not reproducible.

	<p>Further, conventional methods have not provided solutions for paired soil and leaf testing to determine health of soil and crop simultaneously.</p> <p>Current methods do not provide a framework for large scale assessment of geo-referenced sampled points using standardized protocols.</p> <p>Limited access to soil testing services (centralized soil testing laboratories and cost).</p>
What is it? (TIMP description)	<p>This is a dry method for soil testing using the interaction of electromagnetic radiation with matter to characterize biochemical composition of a soil and/or plant tissue. It does not require the routine laboratory analysis using chemicals.</p> <p>When a sample is run through a scanner, soil testing results are generated with accompanying recommendations instantly.</p> <p>However, the method requires partners involved (ICRAF, iSDA and SoilCares) to work closely with KALRO and county agricultural officers to sensitize farmers to embrace the testing method.</p> <p>This innovation will involve working closely with agronomists to generate specific fertilizer recommendation driven by soil and crop data obtained.</p>
Justification	<p>Soil testing is the basis for good fertilizer management that maintains the productivity of soil and improves the quality of crops. It promotes more efficient fertilizer use and prevents environmental pollution from excess fertilizer application, and cost efficiency.</p> <p>However, limited access to soil testing services is depriving the farmers' ability to make informed decisions with regard to soil management and fertilizer use.</p>
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers, Extension officers
Approaches used in dissemination	<p>Farmer visits</p> <p>Training in workshops</p> <p>Publicity campaigns done at County levels</p>
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Availability of the necessary equipment (Scanner and accessories) for rapid on-site soil testing.</li> <li>• Established rapport between farmers and the technical personnel involved in soil testing.</li> <li>• Adequate qualified staff to cover the large number of samples from the target 24 Counties before the planting season begins.</li> <li>• A well-designed information storage system for data obtained at farm level including (GPS readings, physical description of the locations, raw measured scanned data, fertilizer</li> </ul>

	<p>recommendation according to crop type suitability).</p> <ul style="list-style-type: none"> <li>• Farmers must understand, trust, and be willing to act upon the information provided</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• County government extension services; Providing the link to farmers.</li> <li>• Soilcares; Provides soil scanners technology and capacity building in collaboration with KALRO and ICRAF,</li> <li>• ICRAF and iSDA; Tests and validate the recommendations obtained in collaboration with SoilCares and KALRO.</li> <li>• Fertilizer companies; To provide fertilizer blends according to soil health status</li> <li>• Agro dealers to stock required fertilizers that is readily available to farmers</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Technology has not been promoted though testing has been ongoing in a few counties
Counties where TIMP will be promoted	All 24 KSAP Counties
Challenges in dissemination	<ul style="list-style-type: none"> <li>• It requires continuous updating of methods to improve recommendations.</li> <li>• Lack of awareness on the importance of regular testing of soil quality</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Awareness creation, intensive farmer field training (capacity building)</li> <li>• Make the whole process cost efficient. Use of scanners (spectroscopy) and less wet chemistry analysis.</li> <li>• Automated methods for updating existing recommendations by generating local soil libraries.</li> </ul>
Lessons learned if any	Timely affordable soil information will guide on fertilizer use. Farmers have reported frustration when they apply the wrong fertilizers and see no results because they did not take the first step to understand what the soil demand in terms of macro, micro nutrients and trace elements like Zinc and Copper.
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Socially acceptable-brings income, increases food production, nutrition security and family cohesion.</li> <li>• Environmentally friendly; -Recommendations provided ensures that farmers only apply the required amounts of fertilizers. No excess nutrients to contaminate ground and surface water.</li> <li>• Market will absorb the increased productivity</li> <li>• Supporting frameworks/policies are available.</li> </ul>

	<ul style="list-style-type: none"> <li>• Training of personnel at national and County levels</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	<ul style="list-style-type: none"> <li>• Soil testing equipment and License, sampling and packaging materials (Kes 650,000/=), personnel and logistics (will depend on site/location).</li> <li>• Shipping selected soil and plant materials for further testing and results verification in a certified lab.</li> <li>• There are other additional costs on professional consultation.</li> </ul>
Estimated returns	At least 30% profit for soil testing business venture using the scanner. Farmers end up getting higher returns on the crops grown and amounts depend on specific value chain. High value crops will give higher returns compared with subsistence crops.
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• By bringing services closer to the users saves farmers (men, women and youth) time and resources.</li> </ul>
Gender related opportunities	<ul style="list-style-type: none"> <li>• Offers employment especially for the youth where soil sampling champions will be trained to help the local community in sampling.</li> <li>• The scanner equipment is light and women and youth can easily transport and operate it.</li> </ul>
VMG issues and concerns in development, dissemination, adoption and scaling up	Willingness to adopt and scaling up technology by VMGs given that farmers have not adopted current soil testing services due to distances and costs
VMG related opportunities	This is a TIMP that will bring soil testing services nearer to this group of farmers and therefore is a saving and is also expected to improve productivity
<b>E: Case studies/profiles of success stories</b>	
Success stories	Has been tested used successfully by other organizations like ICRAF, SoilCares & former Kenya Sugar Research Foundation. It has been adopted at Kenya cane testing centre for checking maturity level and quality of sugar cane
Application guidelines for users	<ul style="list-style-type: none"> <li>• A handheld scanner to test soils and crops in the field</li> <li>• Community soil sampling champions are identified and trained on good soil sampling procedures.</li> <li>• Soil and crop is analysed and the results including fertilizer recommendation generated on site.</li> </ul>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	2 =Requires validation
<b>G: Contacts</b>	

Contacts	Director, Environment & Natural Resource Systems KALRO Secretariat P.O. Box 57811-00200 +254 722 206986/8, Ext 2316
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Partner organizations	County governments in the 24 counties, SoilCares, ICRAF and iSDA

### Research gaps

1. Testing paired soil and crop samples to determine nutrients in the soil and what is available to plant.
2. Determine nutrient deficiency and make recommendation for the type of fertilizer to use and at what rate.
3. Developing a fertilizer recommendation system with options for new blends.
4. Working with fertilizer companies to produce fertilizer blends packaged in smaller quantities as per farmer needs.
5. Using scanners at farm level to undertake fertilizer quality analysis, e.g. quantitative and qualitative analysis, major and trace elemental analysis, and chemical and physical analysis.
6. Updating existing soil maps with newly acquired soil data to provide current soil fertility status in the country

## 3.0 SOIL AND WATER MANAGEMENT TIMPs

### 3.1 Conservation Agriculture

<b>TIMP name</b>	<b>Conservation Agriculture</b>
Category (i.e. technology, innovation or management practice)	Management Practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Land degradation characterized by the declining soil fertility, low yields, increased soil moisture stress, increased soil erosion and loss of biodiversity
What is it? (TIMP description)	Conservation agriculture is an approach to farming in which the various practices follow key principles that aim to conserve the soil, soil moisture, and soil-nutrients, and stabilise land production while reducing production costs. Conservation agriculture principles include minimal soil disturbance, permanent ground cover - maintenance of a mulch of carbon-rich organic matter covering and feeding the soil (e.g. straw and/or other crop residues including cover crops) and crop rotation or sequences and associations of crops including trees, which could include nitrogen-fixing legumes. Conservation agriculture can sustainably increase crop yields

Justification	<p>Crop yields are declining due to decreasing Land productivity. Continuous tillage continues to emit more GHGs (Carbon) responsible for the climatic changes.</p> <p>Conservation agriculture (CA) has potential to:</p> <ul style="list-style-type: none"> <li>• enhance management of soil fertility and organic matter, and improve the efficiency of nutrient inputs, helping to produce more with proportionally less fertilizer.</li> <li>• increase nitrogen-fixation through crop rotations and crop associations that include legumes; this contributes to optimum plant growth without increased GHG emissions induced by fertiliser production</li> <li>• minimise occurrence of net losses of carbon dioxide by microbial respiration and oxidation of the soil organic matter. This builds soil structure and biopores through soil biota and roots</li> <li>• shields the soil surface from heat, wind and rain, keeps the soil cooler and reduce moisture losses by evaporation through improved soil cover</li> <li>• reduce soil compaction and plough pans and regenerates degraded lands</li> </ul>
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers, Extension Agents, Researchers
Approaches used in dissemination	Agricultural shows, Mass media, Exhibitions, Farmer field Schools (FFS), On-farm and on-station demonstrations, Field Days, Extension Officers, Partners, Farmer to farmer peer learning, Workshops, Seminars, Meetings, trainings, Promotional materials (posters/brochures/leaflets)
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Training on principles and benefits of CA</li> <li>• Model demonstration using crops</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• County Extension officers - Dissemination of information, capacity building</li> <li>• NGO's (African Conservation Network, One Acre Fund)- Capacity Building, Dissemination of information</li> <li>• CIAT, FAO – capacity building</li> <li>• County Governments - Funding CA activities, support capacity building, enabling environment and supportive policies</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Bungoma, Meru, Embu, Tharaka Nithi, Laikipia, Kakamega
Counties where TIMP will be promoted	Bungoma, Meru, Embu, Tharaka Nithi, Laikipia, Kakamega, Machakos, Makueni

Challenges in dissemination	<ul style="list-style-type: none"> <li>• Non-availability of crop residue in suitable quantities</li> <li>• Competition for crop residues with other uses like wood fuel and livestock</li> <li>• Land tenure (farmers reluctant to invest in CA where they do not have clear land rights)</li> <li>• Limited knowledge on the incremental benefits of CA</li> <li>• Limited access to CA implements</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Enhance Public Private Partnerships (PPP) to support increased production and market access</li> <li>• Improve KALRO and county government capacity to train and re-tool technical team so as to enhance dissemination of the technology</li> <li>• Allocation of more funds for continued research and dissemination of this technology would aid increased</li> <li>• uptake of CA with agro forestry</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Uptake of CA technology increases with the realized incremental benefits over time</li> <li>• Continuous capacity building increases CA technology uptake</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Reliable technology adoption and suitable price and market access for produce under CA</li> <li>• Continuous capacity building of the community on the benefits of CA technology</li> <li>• County policies that support households investing in CA with inputs like implements</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Costs related to ripping services and herbicides amount to KES 5000/acre. This is apart from the normal inputs of seed and fertilizer when establishing. But the costs reduce over the years, while the returns increase
Estimated returns	Reduction of costs associated with tillage-induced soil erosion and degradation i.e. 40% reduction in land degradation Returns on conserving soil exceeding 150 ton/hectare annually and associated increased productivity
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• CA with trees is a management practice that that can be easily adopted by women</li> <li>• Reduces labour demands across all gender, hence good for all gender</li> <li>• Land ownership is mainly by men therefore reducing wider adoption</li> <li>• Women are usually left out of decision making thereby reducing uptake</li> </ul>
Gender related opportunities	CA with agro forestry provides opportunities for Small Medium Enterprises (SMEs) e.g. tree nurseries.


	The technology therefore renders itself to easy adoption by women.
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Limited decision making on land use may limit the adoption by VMGs</li> <li>• Limited access to CA inputs like planting implements may limit the VMGs adopting</li> </ul>
VMG related opportunities	Opportunity to run SMEs such as tree nurseries for increased resilience
<b>E: Case studies/profiles of success stories</b>	
Success stories	Farmers and agro-pastoralists who adopt the technology have had sustainable source of income and increased resilience
Application guidelines for users	<p>When implementing the 3 principles of CA, one needs to note the following</p> <ul style="list-style-type: none"> <li>• Timely Operations - preparing the land in good time before the rains start; planting soon after an effective rainfall event; weeding at appropriate times and intervals; doing effective pest and disease control before either spread too widely.</li> <li>• Precise Operations - Precise measurements of row and plant spacing, evenness of depth and placement of soil amendments and covering of seed are also important. Planting should be done on the same lines each season</li> <li>• Inputs – Equipment, seeds, herbicides, manures/fertilizers – use the right inputs</li> <li>• Livestock - try to keep livestock out of the fields, even after harvesting the crop.</li> </ul> <p><b>References</b></p> <ul style="list-style-type: none"> <li>• Okoba, B. (2018), Climate-Smart Agriculture: Training Manual for Agricultural Extension Agents In Kenya.</li> <li>• Esilaba, E.O (2019), KCEP-CRAL CSA Extension Manual</li> <li>• SUSTAINET EA 2010. Technical Manual for farmers and Field Extension Service Providers: Conservation Agriculture. Sustainable Agriculture Information Initiative, Nairobi</li> </ul>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up scaling
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Partner organizations	County governments, Private public partnerships

### Research gaps

1. Identification of the most suitable diversified crop rotations and suitable crops for biomass for the different counties.
2. Development of suitable CA implements/field equipment prototypes.
3. Capacity building on the benefits and operationalization of Conservation Agriculture systems – both among extension and technical staff, and at decision-making levels:

### 3.2 Intercropping

TIMP name	Intercropping
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Decreased yields, hence low farm returns, Declining soil fertility, due to soil degradation, Soil erosion problems, weeds infestation and vulnerability to crop pests. The practice helps slow the proliferation of pests and protect yields
What is it? (TIMP description)  <p><i>Source: S. Kimani</i></p>	Intercropping is the growing of two or more <a href="#">crops</a> in close proximity (in the same row or bed, or in rows or strips that are close enough) for biological interaction. It also includes the growing of two or more cash crops together. The practice offers the potential to increase yields, enhance soil fertility and minimize the effects of climate change.
Justification	Climate change is negatively impacting agricultural production. Farmers are experiencing low yields, crop failures, declined soil fertility and generally low farm returns from their investments. Intercropping is one of the potential management practices for enhancing climate change adaptation. It offers the potential to increase crop yield, enhance soil fertility/biodiversity and minimize the effects of climate change. <p>The practice is known to build healthy soils, control pests and harness a variety of benefits to increase yields. Intercropping of compatible plants encourages <a href="#">biodiversity</a> by providing a habitat for a variety of <a href="#">insects</a> and <a href="#">soil organisms</a> that would not be present in a single-crop environment.</p> <p>The practice has several advantages. First, an intercrop may use resources of light, water, and nutrients more efficiently than single crops planted in</p>

	<p>separate areas, and this can improve yields and income. Secondly, crop mixtures frequently have lower pest densities, especially of insect pests. This occurs both because the mixture confuses the insects and, if chosen carefully attracts beneficial predators. Finally, intercropping may allow more effective management of cover crops.</p>
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers and wide range of users in the rural and urban areas
Approaches used in dissemination	Demonstrations, Agricultural shows and Extension services
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Awareness creation on the benefits and contribution of the practice to all stakeholders.</li> <li>• Easy access of crop varieties that are compatible with associated crops planned for intercrop.</li> <li>• Technical packages describing appropriate schedules of planting intercrops.</li> <li>• Package on fertilizer rates and regimes under the practice</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• County governments – to provide extension services, farmer mobilization and policy formulation</li> <li>• NGOs – to provide support on capacity building and micro- financing services</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Most Counties in the medium to high rainfall areas & Arid and semi-arid areas
Counties where TIMP will be promoted	All the 24 KCSAP Counties
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Limited access and wide distribution of clean planting materials (intercrop varieties)</li> <li>• Inadequate access to technical materials on the establishment, operations and management of intercrop management practice by farmers</li> <li>• The increased effects of climate change hindering adoption.</li> <li>• Farmer high poverty levels coupled with illiteracy especially in deep rural areas of Kenya limits know-how.</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Enhance access to clean planting materials across the counties. Work closely with certified seed merchants, research institutions</li> <li>• Train and sensitize farmers on the basic principles of intercropping, their benefits and types suitable to their contexts. Use farmer field schools and demonstrations</li> <li>• Develop a comprehensive manual on the practice to guide the farmers during the adoption</li> </ul>

Lessons learned if any	<ul style="list-style-type: none"> <li>• The practice is very important in pest management. Farmers can use a trap crop to attract pests, keeping them away from the main crop. Therefore, farmers can easily adopt this method to significantly cut down on pesticides input costs</li> <li>• The number of ecological benefits provided by this practice can also accelerate up scaling. Intercropping promotes interactions between crops and pollinators, thus supporting biodiversity and wildlife species</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Socially accepted by both male and female gender.</li> <li>• The practice is environmentally friendly as it enhances biodiversity, controls erosion and minimizes use of pesticides</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	This is a low cost management practice though technically demanding especially where the objective is to control pest through intercropping
Estimated returns	Dependent on the value chain intercrop
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• The practice integrates participation of both male and female gender roles during field implementation</li> <li>• It is important to know the demands of the technology product end users for ease of acceptability</li> <li>• Gender disparities in access to information may impact on</li> <li>• adoption decisions. Access to information is a pre-requisite for informed decisions on adoption.</li> </ul>
Gender related opportunities	<ul style="list-style-type: none"> <li>• Intercropping offers good opportunities to both men and women to grow diverse crops for economic gains and at the same time offers enhanced biodiversity benefits</li> </ul>
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• The technology can be practised using locally available and low cost materials and hence enhances adoption by the vulnerable and marginalized farmers/users. However, for optimized benefits, the availability of the required inputs like clean planting materials and appropriate fertilizers can be a challenge to this vulnerable group of people</li> </ul>
VMG related opportunities	Intercropping places emphasis on the importance of using available land space to grow a diverse of food, increase biodiversity, pest management thus the practice is economically viable. The practice is available and cost effective to the advantage of VMG
<b>E: Case studies/profiles of success stories</b>	



Success stories	Farmers have reported improved soil conditions, reduced run off and nutrient loss, soil moisture retention in the soil and generally an increased crop production following application of this widely used and readily available management practice.
Application guidelines for users	<ul style="list-style-type: none"> <li>• Intercropping scheme is aimed at improving the overall economics of the farm. It is for this reason any new intercropping idea should first be tested on a relatively small area for evaluation</li> <li>• Observe careful timing of field operations (sometimes necessitating special interventions) to keep competition between the intercropped species in balance</li> <li>• A crop mix that works well in one year may fail the next if weather favors one crop over another.</li> <li>• A mixture of crops with different growth forms or timing of development may make cultivation and use of mulches more difficult and less effective</li> <li>• Planting crops in alternate rows or strips greatly simplifies management and captures some of the benefits of intercropping for pest control</li> <li>• Intercropping poses a special problem for crop rotation. This is because if plants from two families are mixed in the same bed or field, achieving a substantial time lag before replanting either of those families may be difficult</li> <li>• Intercropping requires extra care and effort in planning and maintaining a viable crop rotation.</li> </ul>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	3 =Requires further research
<b>G: Contacts</b>	
Contacts	Director, Environment & Natural Resource Systems KALRO Secretariat P.O. Box 57811-00200 +254 722 206986/8, Ext 2316
Lead organization and scientists	KALRO; P. Ketieme, E. Mutuma, M. Okoti, D. Kamau, E Mutuma, J. W. Wamuongo, M W. Gichuhi
Partner organizations	County governments, KCEP-CRAL project

### Research gaps

1. Major information gaps on intercropping performances in specific areas of Kenya. For example there hasn't been much research on optimal levels of fertilizer use for intercropping sorghum and peanuts in some areas – the need for site specific validation.
2. Little information on the interactions of various crop intercrops especially in the arid and semi- arid areas (ASALs).

3. Limited knowledge on resource-use efficiency particularly in regions with impoverished soils (ASALS) and economies where measured benefits are greatest.

### 3.3 Mulching

TIMP name	Mulching
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Accelerated loss of soil moisture-water stress in the soil, weed infestation, loss of organic matter, managing salinity in ASALS and low crop yields.
What is it? (TIMP description)   <i>Source: S. Kimani</i>	The practice of covering the soil/ground with natural materials such as straw, dead leaves and compost to make more favourable conditions for plant growth, development and efficient crop production. Plastics like polythene, and row covers are also used as mulch. Benefits: retain moisture in the soil; suppress weeds; lowers soil temperature; and help improve soil fertility (as the mulches decompose).
Justification	Mulching facilitates retention of soil moisture and helps in control of temperature fluctuations, improves physical, chemical and biological properties of soil, as it adds nutrients to the soil and ultimately enhances the growth and yield of crops. It minimizes weed problems and nutrient loss. It also improves soil; structure directly by preventing raindrop impact and indirectly by promoting biological activity.
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers
Approaches used in dissemination	<ul style="list-style-type: none"> <li>• Farmer field schools</li> <li>• On-farm demonstrations during farmer field schools</li> <li>• Training in workshops</li> </ul>
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Availability of plant or crop residues.</li> <li>• Size of the land.</li> <li>• Competing uses of crop residues.</li> <li>• Type of the crops</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• County government extension services; Provide link with farmers</li> <li>• Community farmer groups; play coordination role for ease in problem identification and dissemination</li> </ul>
<b>C: Current situation and future scaling up</b>	

Counties where already promoted if any	Baringo, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos.
Counties where TIMP will be promoted	All the other 17 Counties
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Lack of enough plant and crop residues due to competing uses</li> <li>• Possibilities of insect build up categorized as pest or disease vectors</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Crop diversification to increase availability of residues.</li> <li>• Establish and follow a good integrated pest control management program for the particular crop.</li> <li>• Adapting alternative mulching materials like high absorbance polymers in fruit trees like mangoes and Bananas, as well as plastic mulches and row covers in vegetables</li> </ul>
Lessons learned if any	There is need to adapt alternative mulching technologies in addition to use of organic materials like crop, plant residues, and agricultural processing wastes.
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Practice is socially acceptable</li> <li>• Environmentally friendly</li> <li>• Increased productivity will provide supply to the markets</li> <li>• Supporting frameworks/policies are available.</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Organic mulch is low cost but labour intensive practice during the initial application. Such costs are dependent on value chain and plant spacing. However, plastic mulch is costly and needs to be used for high value crops.
Estimated returns	Dependent on the type of value chain and mulch used
Gender issues and concerns in development, dissemination, adoption and scaling up	The practice uses remnants from previous crops/plants that may offer competition in terms of fuelwood and livestock thus bringing a conflict for those performing the specific tasks, e.g. women in case of fuelwood and men for livestock feed. This will negatively affect the adoption and scaling up.
Gender related opportunities	Women who mainly perform the weeding tasks will get a relief and spend their efforts elsewhere. Similarly, the improved productivity will benefit both gender in terms of higher earnings.
VMG issues and concerns in development, dissemination, adoption and scaling up	Though easy to use, it is be a bit labour intensive for VMGs, hence its adoption and scaling up
VMG related opportunities	Mulch is locally available on-farm, and thus has very low costs implying that all including VMGs can take advantage of the practice.

<b>E: Case studies/profiles of success stories</b>	
Success stories	Farmers in different value chains have reported improved soil conditions, reduced runoff and nutrient loss, soil moisture retention in the soil and generally increased crop production following application of mulching technology.
Application guidelines for users	User guidelines are dependent on value chain. However on management, pull or kill weeds that grow out of the mulch, rake the mulch occasionally to prevent it from getting packed down. This is because compacted mulch prevents oxygen from passing through and can starve your crop roots. Mulch should be replenished once a year.
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up scaling (Organic mulch) 2 and 3= Requires validation and further research(plastic mulch)
<b>G: Contacts</b>	
Contacts	Centre Director KALRO Kabete. P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: <a href="mailto:cd.narl@kalro.org">cd.narl@kalro.org</a>
Lead organization and scientists	KALRO, E. Mutuma, P. Kitiem, J. Mwaura, A. Esilaba, D. Kamau and S. Kimani
Partner organizations	County governments Public-Private-Partnerships

### Research gaps

1. Research on mulching using plastics, factory/industrial wastes, e.g. mushroom, tea, coffee, etc. in different value chains is required

### 3.4 Zai Pits

<b>TIMP name</b>	<b>Zai Pits</b>
Category (i.e. technology, innovation or management practice)	Technology
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Unreliable water to sustain a crop as a result of high seasonal rainfall variability leading to total crop failures. Decreased yields leading to food insecurity
What is it? (TIMP description)	Zai Pits are small planting pits typically measuring 15-30 cm in width, 10- 20 cm deep and spaced 60-80 cm apart. Zai Pits harvest and store water for prolonged crop use. Farmers plant seeds into the pits after filling one to three handfuls of organic material such as manure, compost, or dry plant biomass. The technology is highly suitable for areas with



Source: S. Kimani

unpredictable rains especially the drought-prone areas (ASALs)

Justification

The impacts of climate change such as low and erratic rainfall continue to threaten agricultural production, food security and livelihoods especially in the ASALs. Zai Pits technology has the potential to harvest and store rain water for prolonged crop use. This technology also contributes to improving the management of degraded lands, reducing soil erosion, vegetation loss and biodiversity as well as grains yield.

**B: Assessment of dissemination and scaling up/out approaches**

Users of TIMP Farmers

Approaches used in dissemination Approaches to be used in the dissemination include: On-farm demonstrations during farmer field schools Training in workshops, Extension information materials which will be distributed to farmers through farmer groups, Agrovets and the county extension offices

Critical/essential factors for successful promotion

- Availability of labour as the technology is labour intensive.
- Farmers and extension service with skills to design and construct Zai pits.
- Availability of affordable organic matter i.e manure, compost.

Partners/stakeholders for scaling up and their roles

- County government extension services –delivery of information inputs to farmers.
- Community farmer groups – Provide on-farm demonstration plots to hold farmer field schools
- NGOs – capacity building, policy support in soil and water conservation issues

**C: Current situation and future scaling up**

Counties where already promoted if any Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru

Counties where TIMP will be promoted Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu.

Challenges in dissemination The greatest challenge is that the technology is labour intensive and many farmers may find it difficult to implement at large scale.

Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Farmers need to be supported with appropriate equipment for preparation of Zai Pits for efficiency and increased output per man hour.</li> <li>• Training youthful farmers to be champions of Zai pits construction at the Ward level/village level.</li> </ul>
Lessons learned if any	The technology has huge potential to increase farmers' resilience especially in ASALs. Similarly, when the farmers are adequately trained and sensitized on the technology, many of them would be willing to invest.
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Enforce policies on soil and water conservation at the County level</li> <li>• Create awareness on the importance of soil and water conservation</li> <li>• Avail low cost technologies for soil and water conservation</li> <li>• Policies that support individual land tenure systems</li> <li>• Provide support in the establishment of the Zai pits</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	The main input cost is the labour for Zai pit preparation. It is estimated at KES 40 to 100 per Zai Pit
Estimated returns	One acre of land can provide a total of 30 bags of maize (accommodate 1,778 plant pits each measuring 75 x 75 cm which gives plant population of 16,000.). One Zai pit yields a minimum of 1.5 kg of maize
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Ownership of or access to land, farming inputs and credit is an important gender issue in the adoption of Zai pits.</li> <li>• Making decisions on land use, what to grow, expenditures and savings is an important gender consideration in Zai Pits. This may disadvantage women</li> <li>• Differing accessibility of the technology between men and women because of gender norms that place access to new information and technologies in the hands of male heads of households is big gender concern in adoption</li> <li>• Ownership of or access to land, farming inputs, information technologies (radios, cell phones) and credit will affect adoption and</li> <li>• scaling up.</li> </ul>
Gender related opportunities	<ul style="list-style-type: none"> <li>• Increased agricultural produce will increase access to food and income among women, male and youth.</li> <li>• Youthful male and women will provide labour during the implementation of the technology.</li> </ul>

<p>VMG issues and concerns in development, dissemination, adoption and scaling up</p>	<ul style="list-style-type: none"> <li>• Limited access to information due to factors like physical disability affects technology access</li> <li>• Failure to attend awareness and sensitization campaigns due to physical body challenges or insecurity challenges.</li> <li>• The technology is labour intensive and may be difficult for the VMG to implement in the field.</li> <li>• The labour cost of adopting this technology might be out of reach for the VMGs thus affecting adoption and scaling up.</li> <li>• The technology demands proper training and access to information to enable proper implementation. This might be lacking among the VMGs</li> <li>• Competing priorities and household decisions might hinder adoption and scaling up.</li> <li>• The technology involves carrying of heavy manure to the field during establishment which may be difficult for the physically weak VMGs.</li> </ul>
<p>VMG related opportunities</p>	<p>Application of Zai pits is expected to improve agriculture production thus, more food and income for the VGMS.</p>
<p><b>E: Case studies/profiles of success stories</b></p>	
<p>Success stories</p>	<p>Two women groups in Kiliki, Matungulu sub-county of Machakos County through a representative Janet Ndunge reported having started using the Zai pit farming technology in 2013 after attending a farming workshop by the Institute for Culture and Ecology (ICE). “Ever since we started using Zai pits, we have seen an increase in our harvests as compared to the conventional methods of farming,” she said.</p> <p>Farmers in Kathonzweni, Makueni County increased dug pits from 170 to 500 pits for crop production due to initial observed benefits.</p> <p>Communities in ASALs have also rehabilitated degraded lands and increased production by many folds.</p>
<p>Application guidelines for users</p>	<p>Zai pits are 5-15 cm deep, 15-50 cm wide and 80-100 cm apart. In dry areas the size of planting pits can be enlarged. Compost or manure is placed in the pits before planting to improve soil fertility. It is not necessary to follow the contour when constructing pits. Compost or manure is placed in the pits before planting to improve soil fertility. It is not necessary to follow the contour when constructing pits. Below are steps to follow in establishing Zai pits sorghum, millet and maize as examples:-</p> <p><b>Sorghum and Millet.</b> The zai pits are dug during the dry season when labour constraints are minimal. Each</p>


	<p>pit is 20-30 cm wide, 10-30 cm deep, with the soil from the pit thrown downhill to form a crescent shaped dam. The spacing of the pits within a row, as well as the space between the rows of pits varies between 60 and 100 cm. At the beginning of the rains, 200-600 g of dung or compost (two handfuls of organic matter are approximately 300 g) are added to the pits. The organic matter is mixed, in the bottom of the hole, with approximately 5 cm soil. Each pit is then sown with 8-12 millet or sorghum seeds.</p> <p><b>Maize.</b> The Zai pits is made of circular or square holes 30 cm deep. A square hole measuring 75 x75 x 30 (cm) will accommodate nine maize plants. The top soil is mixed with farm yard manure at the ratio of 4:1 and returned. Manure ratio can be reduced while growing maize in Zai pits in Kenya depending on soil quality and use of artificial fertilizers.</p>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up scaling
<b>G: Contacts</b>	
Contacts	Centre Director KALRO Kabete. P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: <a href="mailto:cd.narl@kalro.org">cd.narl@kalro.org</a>
Lead organization and scientists	KALRO, E. Mutuma; J. Wamuongo; M. Wairimu; P. Kitiem, J. Mwaura; D. Kamau and S. Kimani
Partner organizations	County Governments extension offices.

### Research gaps

1. Validation of the economic viability of the technology in counties where it has never been used

### 3.5 Bench Terraces

<b>TIMP name</b>	<b>Bench Terraces</b>
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	The risk of soil erosion and increased run off; low soil water retention capacity in most soils


<p>What is it? (TIMP description)</p>  <p><i>Source: S. Kimani-Bench terraces in Mbooni, Makueni County Kenya</i></p>	<p>Trench terraces consist of a series of beds which are more or less level running across a slope at vertical intervals, supported by steep banks or risers (walls or bunds). The flat beds created by bench terraces enable the cultivation of crops on medium to steep slopes. The technology is highly suitable for Semi-arid to humid regions of rainfall, 700 mm or more; medium to steep slopes (12- 47%) (Bench terraces are not recommended for slopes less than 12%; soil depth of greater than 50 cm; and areas with no gullies, nor stones</p>
<p>Justification</p>	<p>Agricultural production is threatened in many parts of the Kenya by soil erosion and limited soil moisture. Conservation of soil and moisture through construction of terraces has led to better and more reliable crop yields especially in the ASAL counties of Kenya.</p>
<p><b>B: Assessment of dissemination and scaling up/out approaches</b></p>	
<p>Users of TIMP</p>	<p>Farmers</p>
<p>Approaches used in dissemination</p>	<ul style="list-style-type: none"> <li>• On-farm demonstrations during farmer field schools</li> <li>• Training in workshops.</li> <li>• Extension information materials which will be distributed to farmers through farmer groups and the county extension service providers.</li> </ul>
<p>Critical/essential factors for successful promotion</p>	<ul style="list-style-type: none"> <li>• Availability of labour as the technology is labour intensive.</li> <li>• Farmers and extension service with skills to design and construct Bench terraces.</li> <li>• Land tenure systems that allows individual ownership</li> </ul>
<p>Partners/stakeholders for scaling up and their roles</p>	<p>County government extension service providers – delivery of information to farmers, technology access, capacity building  Community farmer groups – Provide on farm demonstration plots to hold farmer field schools.  External service providers – capacity building and access to technology</p>
<p><b>C: Current situation and future scaling up</b></p>	
<p>Counties where already promoted if any</p>	<p>Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru</p>
<p>Counties where TIMP will be promoted</p>	<p>Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu.</p>
<p>Challenges in dissemination</p>	<ul style="list-style-type: none"> <li>• Increased risk of soil erosion if terraces are improperly laid out</li> <li>• Labour intensive during construction and maintenance and many farmers may find it difficult to implement at large scale</li> </ul>

	<ul style="list-style-type: none"> <li>• Land tenure systems – communal land ownership, or in places where individuals don't have land title deeds</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Farmers need to be supported with appropriate equipment for preparation of Bench terrace for efficiency and increased output per man hour.</li> <li>• Training youthful farmers to be champions of making bench terraces construction at the Ward level/village level.</li> <li>• Training on site specific designs and construction of bench terraces</li> <li>• Fast track land registration</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Terracing is popular due largely to the rapid benefits it gives in terms of improved crop performance.</li> <li>• Existence of well-developed self-help groups can lead to successful soil and water conservation activities</li> <li>• Conducting publicity campaigns has been found to add to the success of soil and water conservation.</li> <li>• Similarly, when the farmers are adequately trained and sensitized on the technology, many of them would be willing to invest.</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Enforce policies on soil and water conservation at the County level</li> <li>• Create awareness on the importance of soil and water conservation</li> <li>• Avail low cost technologies for soil and water conservation</li> <li>• Policies that support individual land tenure systems</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	The main input cost is the labour for <i>Bench terrace</i> preparation. The cost will depend on the land size, labour costs and the landscape terrain/slope
Estimated returns	Bench terraces broadly provide ecosystem services, through conservation of soil and water. Economic returns depend on the value chain being addressed.
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Making decisions on land use may limit specific gender</li> <li>• Differing accessibility between men and women because of gender norms places access to new information and technologies in the hands of male heads and this will affect adoption and scaling up.</li> </ul>

	<ul style="list-style-type: none"> <li>• Ownership of or access to land and credit will affect adoption and scaling up</li> </ul>
Gender related opportunities	<ul style="list-style-type: none"> <li>• Increased agricultural production will increase access to food and income among all gender.</li> <li>• Both men and women will provide labour during the implementation of the technology.</li> </ul>
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• The labour cost of adopting this technology might be out of reach for the VMGs thus affecting adoption and scaling up.</li> <li>• The technology demands proper training and access to information to enable proper implementation. This might be lacking among the VMGs</li> <li>• Lack of access to information will limit the VMG accessing and adopting the technology</li> <li>• Competing priorities and household decisions might hinder adoption and scaling up</li> </ul>
VMG related opportunities	Application of bench terraces is expected to improve agriculture production thus, more food and income for the VGMs
<b>E: Case studies/profiles of success stories</b>	
Success stories	Mukethe Mbithi is a member of the Kyungu Mwethya group in machakos "Before making the bench terraces we didn't have good harvests because the soil was eroded. When we applied fertilizer the water washed it into the river and the maize grew short. But when we made terraces the soil erosion stopped and we got good crops.
Application guidelines for users	<p>Terraces draining in one direction should run across the whole farming area where possible. The width of the bench (flat part) is determined by soil depth, crop requirements, and tools to be used for cultivation. Optimum width of terrace benches ranges from 2.5 to 5 m for manually constructed ones and from 3.5 to 8 m for machine built and tractor-cultivated ones.</p> <p>Terraces should drain runoff along the horizontal gradient of the slope, either in outward or reverse direction. The outward gradient can range from 0.5% in arid or semi-arid regions to 3% in humid regions with clay soils. Maximum gradients can be 5% for reverse terraces. In high rainfall areas (more than 1000 mm annually), it is necessary to make additional drainage provisions off the terraces – although this has a risk of causing erosion on very steep slopes. These additional drainage channels should be trapezoidal in shape and planted with grass to prevent erosion. Machine construction is possible on slopes of 12-36% while manual construction can be used on slopes of 12-47%.</p>
<b>F: Status of TIMP readiness</b>	1 =Ready for up scaling

(1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	
<b>G: Contacts</b>	
Contacts	Centre Director KALRO Kabete. P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: <a href="mailto:cd.narl@kalro.org">cd.narl@kalro.org</a>
Lead organization and scientists	KALRO, E. Mutuma; J. Wamuongo; M. Wairimu; P. Kitiem, J. Mwaura; D. Kamau and S. Kimani
Partner organizations	County Governments extension offices.

### 3.6 Stone Lines

<b>TIMP name</b>	<b>Stone Lines</b>
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	The risk of soil erosion and increased run off; low soil water retention capacity in most soils
What is it? (TIMP description)	Stone lines are stones placed along contour lines to slow down runoff. With time, the soil builds up on the upslope side of the stone line and a natural terrace is formed. The technology is suitable in gentle to moderate slopes (less than 10%); areas with low annual rainfall areas (200 – 750 mm); and stony areas
	
<i>Source: S. Kimani</i>	
Justification	The impacts of climate change such as low and erratic rainfall continue to threaten agricultural production, food security and livelihoods especially in the ASALs. Agricultural production is threatened in many parts of the Kenya by soil erosion and limited soil moisture. Stone lines can help in the conservation of soil and moisture
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers
Approaches used in dissemination	<ul style="list-style-type: none"> <li>• On-farm demonstrations during farmer field schools</li> <li>• Training in workshops.</li> <li>• Extension information materials which will be distributed to farmers through farmer groups and the county extension service providers</li> </ul>

Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Availability of labour as the technology is labour intensive.</li> <li>• Availability of stones, of the right size within or close to the farms where the TIMP will be implemented.</li> <li>• Farmers and extension service with skills to design and construct stone lines.</li> <li>• Land tenure systems that allows individual ownership</li> </ul>
Partners/stakeholders for scaling up and their roles	<p>County government extension service providers – delivery of information to farmers, technology access, capacity building</p> <p>Community farmer groups – Provide on farm demonstration plots to hold farmer field schools; provide collective labour.</p> <p>External service providers – capacity building and access to technology</p>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru
Counties where TIMP will be promoted	Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu.
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Increased risk of soil erosion if stone lines are improperly laid out</li> <li>• Labour intensive and many farmers may find it difficult to implement at large scale</li> <li>• Land tenure systems – communal land ownership, or in places where individuals don't have land title deeds</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Farmers need to be supported with appropriate tools for preparation and laying of stones lines for efficiency and increased output per man hour.</li> <li>• Training youthful farmers to be champions of laying stone lines and maintenance.</li> <li>• Training on site specific designs and laying of stone lines</li> <li>• Fast track land registration</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Existence of well-developed self-help groups can lead to successful construction of stone lines.</li> <li>• Conducting publicity campaigns has been found to add to the success of soil and water conservation.</li> <li>• Similarly, when the farmers are adequately trained and sensitized on the technology, many of them would be willing to invest.</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Enforce policies on soil and water conservation at the County level</li> <li>• Create awareness on the importance of soil and water conservation</li> <li>• Avail low-cost technologies for soil and water conservation</li> <li>• Policies that support individual land tenure systems</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Depends on cost of stones, transport and labour.
Estimated returns	The returns are long-term and depend on the value chain being addressed

Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Limited ownership of or access to land may limit women from technology implementation</li> <li>• Limited decision-making powers on land use may limit women in technology adoption</li> <li>• The technology is labour intensive and may limit implementation by women</li> <li>• Differing accessibility to information between men and women because of gender norms that place access to new information and technologies in the hands of male heads will affect adoption and scaling up.</li> <li>• Limited access to appropriate tools and credit may limit application of technology among specific gender e.g. women</li> </ul>
Gender related opportunities	<ul style="list-style-type: none"> <li>• Increased agricultural production will increase access to food and income among all gender.</li> <li>• Men and women will provide labour during the implementation of the technology</li> </ul>
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Limited access to information will limit access to information and adoption</li> <li>• Limited decision making power on land use may limit VMG in accessing and adopting the technology</li> <li>• May not be in attendance during awareness and sensitization campaigns due to physical body challenges or insecurity challenges.</li> <li>• The technology is labour intensive and may be difficult for the VMG to implement in the field.</li> <li>• The labour cost of adopting this technology might be out of reach for the VMGs thus affecting adoption and scaling up.</li> <li>• The technology demands proper training and access to information to enable proper implementation. This might be lacking among the VMGs</li> </ul>
VMG related opportunities	Application of stone lines is expected to improve agriculture production thus, more food and income for the VMGs
<b>E: Case studies/profiles of success stories</b>	
Success stories	<p>In Burkina Faso farmers have reported doubled cereal production when stone lines are used in combination with greater use of compost as fertilizer.</p> <p><a href="https://www.rural21.com/fileadmin/_migrated/content_uploads/Stone_lines_against_desertification_01.pdf">https://www.rural21.com/fileadmin/_migrated/content_uploads/Stone_lines_against_desertification_01.pdf</a></p>
Application guidelines for users	<p>Stone lines are built along the contours. The lines are between 0.5 and 1.5 metres high, depending on the gradient of the slope. The distance between stone lines ranges from 25 to 40 metres. Each hectare needs between 30 and 50 tonnes of stones, which are built into contour lines about 300 metres long. The amount of work involved is considerable: to quarry the stone, load it onto lorries and line it on the fields. The stones should be of different sizes and when arranging them there should be no wide open spaces which will allow the runoff to pass through. The stone lines slow the fast-flowing rainwater, thereby reducing erosion. When the runoff water flow is controlled, the stone lines allow up to 200 more litres of water to percolate the soil per square metre.</p>

<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up scaling
<b>G: Contacts</b>	
Contacts	Centre Director KALRO Kabete. P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: <a href="mailto:cd.narl@kalro.org">cd.narl@kalro.org</a>
Lead organization and scientists	KALRO, E. Mutuma; J. Wamuongo; M. Wairimu; P. Kitiem, J. Mwaura; D. Kamau and S. K. Kimani
Partner organizations	County Governments extension offices.

### 3.7 Contour bunds

<b>TIMP name</b>	<b>Contour bunds</b>
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	High soil erosion and increased run off; low soil water retention capacity in most soils
What is it? (TIMP description)	Contour bunds are stone or earthen walls built across a slope to prevent run off. Making furrows parallel to the contours ensures that rainfall and run off are spread evenly over a field. The earthen bund is formed by excavating a channel and creating a small ridge on the downhill side. Thus contour bunds resemble narrow channel terraces commonly referred to as “fanya chini” terraces. The technology is highly suitable for areas with unpredictable rains especially the drought-prone areas (ASALs).
Justification	The impacts of climate change such as low and erratic rainfall continue to threaten agricultural production, food security and livelihoods especially in the ASALs. Contour bunds resemble narrow channel terraces commonly referred to as “fanya chini” terraces. The aim of contour bunds and hedgerows is to concentrate moisture into the ridge and furrow area where the crops are planted by trapping run off water from the catchment area between them. This also reduces the risk of erosion. Plants with higher water requirements, such as peas or beans, can be planted on the higher side of the furrow

	whereas cereal crops requiring less water, such as sorghum or millet, can be planted on the ridges
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers
Approaches used in dissemination	On-farm demonstrations during farmer field schools Training in workshops. Extension information materials which will be distributed to farmers through farmer groups and the county extension service providers
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Availability of labour as the technology is labour intensive.</li> <li>• Farmers and extension service with skills to design and construct contour bunds.</li> <li>• Land tenure systems that allows individual ownership</li> </ul>
Partners/stakeholders for scaling up and their roles	County government extension service providers – delivery of information to farmers, technology access, capacity building Community farmer groups – Provide on farm demonstration plots to hold farmer field schools. External service providers – capacity building and access to technology
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru
Counties where TIMP will be promoted	Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Increased risk of soil erosion if contours are improperly laid out</li> <li>• Labour intensive and many farmers may find it difficult to implement at large scale</li> <li>• Land tenure systems – communal land ownership, or in places where individuals don't have land title deeds</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Farmers need to be supported with appropriate equipment for preparation of Contour for efficiency and increased output per man hour.</li> <li>• Training youthful farmers to be champions of Contour bunds construction at the Ward level/village level.</li> <li>• Training on site specific designs and construction of contour bunds</li> <li>• Fast track land registration</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Terracing is popular due largely to the rapid benefits it gives in terms of improved crop performance.</li> </ul>

	<ul style="list-style-type: none"> <li>• Existence of well-developed self-help groups can lead to successful soil and water conservation activities.</li> <li>• Conducting well publicised campaigns has been found to add to the success of adoption of soil and water conservation practices.</li> <li>• Similarly, when the farmers are adequately trained and sensitized on the technology, many of them would be willing to invest.</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Socially acceptable technology but needs awareness creation on its importance</li> <li>• Current national policies on soil and water conservation need to be enforced at the County level</li> <li>• Require policies that support individual land tenure systems</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	The main input cost is the labour for contour preparation. The cost will depend on the land size and the landscape terrain/slope
Estimated returns	The returns depends on the value chain being addressed
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Ownership of or access to land may limit women in some regions</li> <li>• Making decisions on land use may limit women in some region where decision making is men dominated</li> <li>• Differing accessibility of the technology and information may disadvantage different gender</li> <li>• The technology is labour intensive hence may disadvantage women and members who cannot procure labour services</li> <li>• Differing accessibility of information between men and women because of gender norms that place access to new information and technologies in the hands of male heads will affect adoption and scaling up.</li> <li>• Ownership of or access to land and credit will affect adoption and scaling up.</li> </ul>
Gender related opportunities	<ul style="list-style-type: none"> <li>• Increased agricultural production will increase access to food and income among all gender.</li> <li>• Potential for employment creation - youthful male and women will provide labour during the implementation of the technology.</li> </ul>
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Limited access to information may bias the VMG from technology access and use</li> <li>• Limited attendance during awareness and sensitization campaigns due to physical body challenges or insecurity challenges limits use of technologies.</li> </ul>

	<ul style="list-style-type: none"> <li>• The technology is labour intensive and may be difficult for the VMG to implement in the field.</li> <li>• The labour cost of adopting this technology might be out of reach for the VMGs thus affecting adoption and scaling up.</li> <li>• The technology demands proper training and access to information to enable proper implementation. This might be lacking among the VMGs</li> <li>• Competing priorities and household decisions might hinder adoption and scaling up</li> </ul>
VMG related opportunities	Application of contour ridge is expected to improve agriculture production thus, more food and income for the VGMs
<b>E: Case studies/profiles of success stories</b>	
Success stories	Mukethe Mbithi is a member of the Kyungu Mwethya group in machakos "Before making the terraces we didn't have good harvests because the soil was eroded. When we applied fertilizer, the water washed it into the river and the maize grew short. But when we made terraces the soil erosion stopped and we got good crops
Application guidelines for users	Soil is excavated up-slope of the bund to a depth of 50 cm. Contour bunds should drain in one direction and can be manually or machine constructed. The length of a bund across a slope should be between 400 to 500 m. The height of a bund should be at least 25 cm and have an approximate spacing of 1-2 m. In arid areas, the distance between bunds can be increased to 5- 10 m. Hedgerows grown to stabilize bunds should be spaced at 4 to 8 m across the slope.
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up scaling
<b>G: Contacts</b>	
Contacts	Centre Director KALRO Kabete. P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: <a href="mailto:cd.narl@kalro.org">cd.narl@kalro.org</a>
Lead organization and scientists	KALRO, E. Mutuma; J. Wamuongo; M, Wairimu; P. Kitiem, J. Mwaura; D. Kamau
Partner organizations	County Governments extension offices.

### Research gaps

1. Develop site specific designs for construction and validation in other regions
2. Conduct trade off analysis (economic analysis) of contour bunds as a soil and water management technology in the various AEZs and along specific value chains

3. Develop low cost mechanized tools to ease labour demands in contour construction and maintenance
4. Develop a suitable model that guides technology type and costing

### 3.8 Fanya Juu Terraces


TIMP name	Fanya Juu Terraces
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	The risk of soil erosion and increased run off; low soil water retention capacity in most soils.
What is it? (TIMP description)  <p><i>Source: C. Kundu</i></p>	Fanya juu terraces (juu is Swahili word for ‘up’) are constructed by excavating soil and throwing it up-slope to make an embankment. The embankment forms a runoff barrier and the trench (ditch) is used to retain or collect runoff. The embankments are usually stabilized with fodder grasses. Crops, such as bananas, pawpaws, citrus and guava, are grown in the ditches. Through gradual redistribution of soils within the field, levels off the terraces. The technology is highly suitable in low annual rainfall areas (less than 700 mm); moderate slopes (less than 20%); deep soils (more than 60 cm); and hilly areas that are subject to widespread erosion.
Justification	The impacts of climate change such as low and erratic rainfall continue to threaten agricultural production, food security and livelihoods especially in the ASALs. Agricultural production is threatened in many parts of the Kenya by soil erosion and limited soil moisture. Conservation of soil and moisture through construction of terraces has led to better and more reliable crop yields especially in the ASAL Counties of Kenya
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers
Approaches used in dissemination	On-farm demonstrations during farmer field schools Training in workshops. Extension information materials which will be distributed to farmers through farmer groups and the county extension service providers
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Availability of labour as the technology is labour intensive.</li> <li>• Farmers and extension service with skills to design and construct contour bunds.</li> <li>• Land tenure systems that allows individual ownership</li> </ul>

Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• County government extension service providers – delivery of information to farmers, technology access, capacity building</li> <li>• Community farmer groups – Provide on farm demonstration plots to hold farmer field schools.</li> <li>• External service providers – capacity building and access to technology.</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru
Counties where TIMP will be promoted	Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu.
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Increased risk of soil erosion if terraces are improperly laid out</li> <li>• Labour intensive and many farmers may find it difficult to implement at large scale</li> <li>• Land tenure systems – communal land ownership, or in places where individuals don't have land title deeds</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Farmers need to be supported with appropriate equipment for preparation of terraces for efficiency and increased output per man hour.</li> <li>• Training youthful farmers to be champions of fanya juu terraces construction at the Ward level/village level.</li> <li>• Training on site specific designs and construction of fanya juu terraces</li> <li>• Fast track land registration</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Fanya juu terracing is popular due largely to the rapid benefits it gives in terms of soil and water conservation.</li> <li>• Existence of well-developed self-help groups can lead to successful soil and water conservation activities.</li> <li>• Conducting well publicised campaigns has been found to add to the success of soil and water conservation.</li> <li>• Similarly, when the farmers are adequately trained and sensitized on the technology, many of them would be willing to invest.</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Enforce policies on soil and water conservation at the County level</li> <li>• Create awareness on the importance of soil and water conservation</li> <li>• Avail low cost technologies for soil and water conservation</li> </ul>

	<ul style="list-style-type: none"> <li>• Policies that support individual land tenure systems</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	The main input cost is the labour for terrace preparation. The cost will depend on the land size and the landscape terrain/slope
Estimated returns	The returns depends on the value chain being addressed
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Ownership of or access to land may limit women in implementing the technology</li> <li>• Limited decision making power on land use may limit women in accessing and adopting the technology</li> <li>• Differing accessibility of the technology and information may disadvantage women and in some instances men</li> <li>• Limited access to credit will affect adoption and scaling up among women</li> </ul>
Gender related opportunities	<ul style="list-style-type: none"> <li>• Increased agricultural production will increase access to food and income among all gender.</li> <li>• Youthful male and women will provide labour during the implementation of the technology</li> </ul>
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Limited access to information will limit access to information and adoption</li> <li>• Limited decision making power on land use may limit VMG in accessing and adopting the technology</li> <li>• May not be in attendance during awareness and sensitization campaigns due to physical body challenges or insecurity challenges.</li> <li>• The technology is labour intense and may be difficult for the VMG to implement in the field.</li> <li>• The labour cost of adopting this technology might be out of reach for the VMGs thus affecting adoption and scaling up.</li> <li>• The technology demands proper training and access to information to enable proper implementation. This might be lacking among the VMGs</li> </ul>
VMG related opportunities	Application of contour ridge is expected to improve agriculture production thus, more food and income for the VMGs
<b>E: Case studies/profiles of success stories</b>	
Success stories	Over 50,000 smallholder farmers in lower eastern counties of Kenya are recording a more than doubling of yields and reduced soil erosion after embracing a soil conservation scheme that involves digging of trenches in hillside to trap runaway water and soil.

Application guidelines for users	The 'fanya juu' trench is 60 cm wide by 60 cm deep, and the bund 50 cm high by 150 cm across 19. In arid regions the trenches can be enlarged to 150 cm deep and 100 cm wide. Distance between bunds can be from 5 m on steep slopes to 20 m on gentle slopes. Stone terrace walls can be built to reinforce the bunds on very steep slopes to allow surplus water to pass between the stones without damaging the terrace. Excess water can be drained from the trenches using cut-off drains
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up up scaling
<b>G: Contacts</b>	
Contacts	Centre Director KALRO Kabete P. O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: <a href="mailto:cd.narl@kalro.org">cd.narl@kalro.org</a>
Lead organization and scientists	KALRO, E. Mutuma; J. Wamuongo; M. Wairimu; P. Kitiem, J. Mwaura; D. Kamau and S. Kimani
Partner organizations	County Governments extension service

### 3.9 Grass Strips


TIMP name	Grass Strips
Category (i.e. technology, innovation or management practice)	Innovation
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	The risk of soil erosion and increased run off
What is it? (TIMP description)	Grass strips are dense rows or columns of grass planted up to a meter wide, along a contour. With time, silt builds up above the strip and benches are formed. Grass strips can be planted along ditches to stabilize them, or on the rises of bench terraces to prevent erosion. They are a popular and easy way to terrace land, especially in areas with relatively good rainfall. The technology is suitable in regions with fairly gentle slopes (0 - 6%); grass is needed for fodder; and high rainfall areas
 <i>Source: C. Kundu</i>	
Justification	Agricultural production is threatened in many parts of the Kenya by soil moisture stress and serious soil erosion. Conservation of soil and moisture through construction of grass strips has led to better and more reliable crop yields
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers

Approaches used in dissemination	<ul style="list-style-type: none"> <li>• On-farm demonstrations during farmer field schools</li> <li>• Training in workshops.</li> <li>• Extension information materials which will be distributed to farmers through farmer groups and the county extension service providers</li> </ul>
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Availability of labour</li> <li>• Availability of land, apart from crop land.</li> <li>• Farmers and extension service with skills to design and construct stone lines.</li> <li>• Land tenure systems that allows individual ownership</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• County government extension service providers – delivery of information to farmers, technology access, capacity building</li> <li>• Community farmer groups – Provide on farm demonstration plots to hold farmer field schools; provide collective labour.</li> <li>• External service providers – capacity building and access to technology</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru
Counties where TIMP will be promoted	Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu.
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Labour intensive for maintaining and controlling grass from becoming a weed</li> <li>• Reduced land area for crop production</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Farmers need to be supported with appropriate tools and suitable grass varieties.</li> <li>• Capacity building on the maintenance of grass strips</li> <li>• Training on site specific designs and layout</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Establishment of grass strips induces a process of natural terracing on slopes as soil collects behind the grass barrier, even in the first year.</li> <li>• Grass strips can be very appropriate for farmers who cut and carry fodder for their animals.</li> <li>• Grasses are also used as mulch for crops by farmers</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Enforce policies on soil and water conservation at the County level</li> <li>• Create awareness on the importance of soil and water conservation</li> <li>• Avail low cost technologies for soil and water conservation</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	The main input cost is the labour for establishing grass strips. The cost will depend on the type of grass

	to be planted, land size and the landscape terrain/slope
Estimated returns	The returns depends on the value chain being addressed and also type of grass
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Limited ownership of or access to land may limit women from technology implementation</li> <li>• Limited power in making decisions on land use may limit women in technology adoption</li> <li>• The technology is labour intensive and may limit implementation by women</li> <li>• Differing accessibility to information between men and women because of gender norms that place access to new information and technologies in the hands of male heads of will affect adoption and scaling up.</li> <li>• Limited access to appropriate tools and credit may limit application of technology among specific gender e.g. women</li> </ul>
Gender related opportunities	<ul style="list-style-type: none"> <li>• Increased agricultural production will increase access to food and income among all gender.</li> <li>• Youthful male and women will provide labour during the implementation of the technology</li> </ul>
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Limited access to information will limit access to information and adoption</li> <li>• Limited decision making powers on land use may limit VMG in accessing and adopting the technology</li> <li>• May not be in attendance during awareness and sensitization campaigns due to physical body challenges or insecurity challenges.</li> <li>• The technology is labour intense and may be difficult for the VMG to implement in the field.</li> <li>• The labour cost of adopting this technology might be out of reach for the VMGs thus affecting adoption and scaling up.</li> <li>• The technology demands proper training and access to information to</li> <li>• enable proper implementation. This might be lacking among the VMGs</li> </ul>
VMG related opportunities	<ul style="list-style-type: none"> <li>• Utilization of grass strips is expected to improve agricultural production thus more food and income for the VGMs.</li> </ul>
<b>E: Case studies/profiles of success stories</b>	
Success stories	Over 50,000 smallholder farmers in Kenya are recording a yield increases and reduced soil erosion after embracing grass strips. The strips also offer fodder for livestock thus enhanced feed at household levels. The fodder is sometimes sold thus earning extra income.

Application guidelines for users	Spacing between grass strips depends on the slope of the land. It can be 20- 30 m on gentle slopes and 10-15m on steep land. Grass strips can be planted along ditches to stabilize them, or on the rises of bench terraces to prevent erosion. The grass needs to be trimmed regularly, to prevent shading and spreading to cropped areas. Various grass species are used, e.g., Vetiver, Napier, Guinea and Guatemala depending on what is locally available. Vetiver grass is drought resistant and good for reducing erosion
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up scaling
<b>G: Contacts</b>	
Contacts	Centre Director KALRO Kabete, off Waiyaki way, P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: <a href="mailto:cd.narl@kalro.org">cd.narl@kalro.org</a>
Lead organization and scientists	KALRO, E. Mutuma; J. Wamuongo; M. Wairimu; P. Kitiem, J. Mwaura; D. Kamau and S. Kimani
Partner organizations	County government, Extension service

### 3.10 Tied Ridges

<b>TIMP name</b>	<b>Tied Ridges</b>
Category (i.e. technology, innovation or management practice)	Technology
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Crop water stresses in production; Increased water losses in the furrows
What is it? (TIMP description)	Tied ridges are small earthen ridges, 30 cm high, with an up slope furrow which accommodates water between the ridges. The technology consists of water flowing down the small trenches/furrows running parallel and infiltrates into crop root zones. Water is applied to the top end of each furrow and flows down the crop field under the influence of gravity
	
<i>Source: E. Njiru (Katumani)</i>	
Justification	With limitations in soil moisture due to decreasing rainfall occasioned by climatic changes, tied ridges helps conserve soil moisture. In combination with furrow irrigation, the technology has potential to improve agricultural productivity and increase crop

	yields and cropping intensities. As a result, household food security, incomes and livelihoods are enhanced.
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers
Approaches used in dissemination	Demonstrations; Farmer field schools
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Proximity to water sources - close to permanent water sources</li> <li>• Suitable topography of area (level land)</li> <li>• Technical capacity for maintenance</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• County government – capacity building</li> <li>• Private sector – access to credit, capacity building</li> <li>• NGOs (Kenya Red Cross (KRC), Action Aid, World Vision, and OXFAM) – capacity building, credit facilities, facilitate technology access</li> <li>• National Irrigation Board – technology access and capacity building</li> <li>• Water Resources Management Authority – Water resources use management</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru
Counties where TIMP will be promoted	Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu, Siaya
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Can be labour intensive during establishment phase</li> <li>• Poor management may lead to water use inefficiencies</li> <li>• Limited access to credit may limit uptake</li> <li>• Land tenure insecurity in some counties limits adoption and investments</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Enhancing farmers' capacity to see benefits</li> <li>• Enhance access to credit</li> <li>• Implement policy on land use and tenure</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Use of tied ridges with furrow irrigation significantly increases yields</li> <li>• Poor management and designs may often result in flooding of low areas</li> <li>• Assessment of soil erosion and sediment is key to sustainability</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• The economics of furrow irrigation needs to be well articulated</li> <li>• Enhanced land quality control to mitigate against soil salinity</li> <li>• Adequate policies and guidelines regarding water abstraction from the main water sources to</li> </ul>


	<p>minimize resource conflicts especially along river downstream.</p> <ul style="list-style-type: none"> <li>• Market for the crops produced under irrigation should be identified early enough to minimize losses and increase profitability from the system</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Dependent on labour costs per region
Estimated returns	Depends on investment and the type of value chain undertaken
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Being labour intensive, there is likelihood for male dominance hence development prototypes benefit specific gender</li> <li>• Gender differences in access to credit will limit technology uptake and utilization</li> </ul>
Gender related opportunities	Opportunities for women and youth to increase income through application of technology in production of specific value chains that favour them
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Adequate planning and apportioning of space in the irrigation system is necessary with special consideration for VMG to empower their opportunities</li> <li>• The cost can hinder the rapid adoption by the VMGs due to high poverty levels</li> </ul>
VMG related opportunities	VMGs can make business arising from the increased yields from furrow fields
<b>E: Case studies/profiles of success stories</b>	
Success stories	<p>There are successful model for such technology i.e. Mwea and Perkkera irrigation schemes where furrow irrigation systems have provided opportunities for local community to produce high value crops. Successfully applied in Machakos for crop production under sorghum, green gram production. A sound understanding of the roles and responsibilities of farmers and water user associations is a feature of successful system</p>
Application guidelines for users	<ul style="list-style-type: none"> <li>• Sijali I V. Drip irrigation: options for smallholder farmers in eastern and southern Africa. 2001. RELMA Technical Handbook Series 24. Nairobi, Kenya: Regional Land Management Unit (RELMA), Swedish International Development Cooperation Agency, (Sida). 60 p. + x p.; includes bibliography</li> <li>• FAO CSA Manual</li> <li>• FAO Irrigation Water Management: Irrigation Manual</li> <li>• GoK MoALFI: Training Manual for Water Users Association and farmers</li> </ul>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation;	1 =Ready for up scaling

3=Requires further research)	
<b>G: Contacts</b>	
Contacts	Director, Environment & Natural Resource Systems KALRO Secretariat P.O. Box 57811-00200 +254 722 206986/8, Ext 2316
Lead organization and scientists	KALRO, J. Mwaura, I. Sijali
Partner organizations	National Irrigation Board (NIB), Water Resources Management Authority

### Research gaps

1. The economic viability of the technology in different agro ecological zones

### 3.11 Rain water harvesting through Roof water catchment

<b>TIMP name</b>	<b>Rain water Roof water catchment</b>
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Water scarcity for crop and livestock use especially in the face of diminishing rainfall because of climate change
What is it? (TIMP description)	Rain water harvesting is a technique of collection and storage of rainwater into natural reservoirs or tanks, or the infiltration of surface water into subsurface aquifers (before it is lost as surface run off). A vast number of techniques allow flexibility and adaptability to site-specific situations to best fight water scarcity and make agricultural production more resilient. Examples of rainwater harvesting are rooftop harvesting and harvesting through earth dams.
 <p><i>Source: C. Kundu,</i></p>	
Justification	Water, especially in the ASALs, is the most limiting factor to land productivity. It is also a major driver of soil erosion and land degradation. Therefore, there is need to enhance water harvesting and storage By collecting, storing and utilizing water agricultural purposes, farmers are able to prevent soil erosion, stabilize water supply, and reduce reliance on other water sources. Smallholder farmers can also recoup initial investment costs in water harvesting by planting high- value crops, and extending their growing season through the entire year. Technology also slows water run off and increases yields with the additional water
<b>B: Assessment of dissemination and scaling up/out approaches</b>	

Users of TIMP	Farmers, pastoralists and agro-pastoralists
Approaches used in dissemination	Demonstrations on technology use; Farmer Field Schools; Technical training and re-tooling of extension personnel; Awareness creation through various platforms like local FM stations
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Avail resources (human, technical and financial) to support acquisition and establishment of water harvesting systems</li> <li>• Policy to support use of communal land to establish and manage the earth dams</li> <li>• Policies supporting Public-Private Partnerships in water harvesting</li> <li>• Sensitization of local communities to embrace the practice</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• Private sector – access to technology, access to credit, technology installation</li> <li>• County government – capacity building, policy support, credit facilities,</li> <li>• NGOs – access to technologies, capacity building, technology installation</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Most counties are investing on water harvesting technology at community level. More is required to increase uptake at household level
Counties where TIMP will be promoted	ASAL counties; Tana River, Marsabit, West pokot and Mandera
Challenges in dissemination	<ul style="list-style-type: none"> <li>• High costs related to technology access and management</li> <li>• Resource use conflicts where land is communally owned</li> <li>• Limited skills in technology installation and management</li> <li>• Limited community mobilisation policy for water related activities</li> <li>• Lack of suitable training programmes in rainwater harvesting</li> <li>• Lack of proper water usage and control measures</li> <li>• In the case of earth dams where there is a lot of siltation, regular de-siltation is required.</li> <li>• Threats to sustainability of established systems because of lack of community participation in systems monitoring and maintenance.</li> <li>• Vandalism</li> <li>• Some systems require high investment costs</li> </ul>

Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Resource mobilization through partnerships with private sector</li> <li>• Engaging a participatory process during the planning and implementation of the project.</li> <li>• User specific training programs water harvesting technologies, maintenance and operation skills</li> <li>• Cost of buying water harvesting structures is very high for most households and needs to be reviewed.</li> <li>• Securing systems to prevent vandalism</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Potential to caution community against water scarcity</li> <li>• Improved productivity where water harvesting has been implemented</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Devise systems that are gender sensitive – target different gender needs</li> <li>• Carry out environment and social impact assessment of the technology in specific Counties and cultures</li> <li>• Support structures that help access to credit for technology access and maintenance</li> <li>• Enact Policy frameworks to support water harvesting</li> <li>• Enact policies on land tenure systems to support water harvesting</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Cost dependent on the type of materials to use for harvesting and storage. Not readily affordable to most rural households
Estimated returns	<ul style="list-style-type: none"> <li>• Time saved fetching water from afar is channelled into other economic enhancing activities.</li> <li>• Money used to treat diseases related to poor water hygiene is used for other activities.</li> <li>• Healthy population will have energy to provide labour required in agricultural activities</li> </ul>
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• The distance from household need to be considered as women are the custodian of households in terms of domestic water demands.</li> <li>• The design of the water pans should take care of the Occupation, Health and Safety of the communities</li> <li>• The technologies will reduce time needed to fetch for water which will impact positively the women</li> </ul>
Gender related opportunities	Water harvesting facilities save the time spent to collect water from far off, usually by women. The saved time is channelled into other economic activities

VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Limited access to credit or financial services may limit access to technology</li> <li>• The land tenure systems may inhibit adoption of technology</li> </ul>
VMG related opportunities	<ul style="list-style-type: none"> <li>• Develop SME opportunities around water harvesting. Also do small food gardens and tree nurseries around water pans</li> <li>• VMG maximize can engage in n availability of water to engage in small IGAs around water harvesting</li> <li>• Livestock too easily access water and their market value likely to appreciate</li> <li>• The technology will reduce the time used to search for water</li> </ul>
<b>E: Case studies/profiles of success stories</b>	
Success stories	<p>Agro-pastoralists who adopted water harvesting technology have had sustained source of income and improved livelihoods</p> <p>A typical African Water Bank rainwater harvesting system collects 400,000 to 450,000 litres of rainwater within two to three hours of steady rain. It has an artificial roof of 900 to 1,600 square metres and storage tanks. The largest tank constructed in Narok County has a capacity of 600,000 litres.</p> <p>This amount of water can serve a community of 400 people for approximately 24 months without extra rain. The capacity can be added at a rate of 220,000 litres per year. The system is low cost and can be 100 percent maintained locally. It also uses local skills, labour, materials and technology. Apart from boosting access to water in arid and semi regions, rainwater harvesting contributes to water conservation thus reducing overexploitation of water resources.</p>
Application guidelines for users	<p>Agro-pastoralists and farmers in target counties need training and empowerment on the technology and attendant management practices.</p> <p><b>References</b></p> <p>Handbook on Rainwater Harvesting and Storage Options</p> <p>Manual for Rooftop Rainwater Harvesting Systems in the Republic of Yemen</p>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up scaling
<b>G: Contacts</b>	
Contacts	<p>Director, Environment &amp; Natural Resource Systems KALRO Secretariat P.O. Box 57811-00200</p>

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Lead organization and scientists	KALRO, Isaya Sijali, J. Mwaura, P. Ketiemi
Partner organizations	County government, PPPs

### Research gaps

1. Development of models of rain water harvesting for intensive agricultural production and household use

### 3.12 Green Manure Cover Crops (GMCCs)

TIMP name	Green Manure Cover Crops
Category (i.e. technology, innovation or management practice)	Technology
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	In general, cover crops reduce nutrient leaching, suppress weeds, have positive effects on soil structure, soil erosion and feed the soil microbiome. They can increase plant nutrient supply in the soil especially nitrogen through biological nitrogen fixation and thus improve crop yields.
What is it? (TIMP description)	Green manure is a crop that is grown and then intentionally ploughed under to improve the underlying soil while green or just after flowering. They also protect the soil and act as a soil amendment. They are fast growing, hence accumulates high biomass within a short period of time.
Justification	<p>The impact of climate change has become tangible. Weather has become quite unpredictable; rains come late, and then too little or too much at once. Protecting soils from erosion, assuring that rainwater infiltrates rather than runs off, and that soils maintain the capacity to store water are becoming crucial things for farmers to consider if they are to cope with climate change. GMCCs provide such a service.</p> <p>Cover crops have multiple uses, providing several opportunities for inclusion in crop rotation. Cover crops may be used as green manures, living mulches, residue mulches, catch crops and forages source of organic matter ('green manure') when incorporated into the soil</p> <p>They are deep rooting and thus lead to improved soil structure and recycling of nutrients, farm productivity, minimizes soil erosion through reduction of raindrop impact and run off and improves soil physical properties</p> <p>They minimize weed problems and indirectly promote biological activity</p>

<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers
Approaches used in dissemination	Demonstrations on technology use; Farmer Field Schools; Technical training and awareness creation through various platforms like local FM stations
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Awareness creation on the benefits and contribution of the technology to all stakeholders.</li> <li>• Easy access of varieties that are compatible with associated systems.</li> <li>• Technical packages describing appropriate schedules of planting GMMCs.</li> <li>• Linkages with Private sector - to improve production capacity and empowerment</li> <li>• Linkages with credit facilities</li> <li>• Technical skills development for the users</li> <li>• Capacity building on the benefits of GMCCs</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• County governments – to provide extension services, farmer mobilization and policy formulation</li> <li>• NGOs – to provide support on capacity building and micro- financing services</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Most Counties in the medium to high rainfall areas & Arid and semi-arid areas
Counties where TIMP will be promoted	All the 24 KCSAP Counties
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Unavailability of quality seeds</li> <li>• Lack of good knowledge can have some unpleasant consequences</li> <li>• Inadequate access to technical materials on the establishment, operations and management of GMCCs by farmers</li> <li>• The increased effects of climate change hindering adoption.</li> <li>• Farmer high poverty levels coupled with illiteracy especially in deep rural areas of Kenya limits know how</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Enhance access to clean planting materials across the counties. Work closely with certified seed merchants, research institutions</li> <li>• Train and sensitize farmers on the basic principles of intercropping, their benefits and types suitable to their contexts. Use farmer field schools and demonstrations</li> <li>• Develop a comprehensive manual on the practice to guide the farmers during the adoption</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• The technology is very important in soil fertility management. Farmers can use GMCCs to improve soil fertility, feed livestock as well as</li> </ul>

	<p>food. Therefore, farmers can easily adopt this to significantly cut down on input costs</p> <ul style="list-style-type: none"> <li>• The number of ecological benefits provided by this practice can also accelerate up scaling.</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Socially accepted by both male and female gender.</li> <li>• The practice is environmentally friendly as it enhances biodiversity, controls erosion and minimizes use of chemical inputs</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	This is a low cost management practice though technically demanding especially where the objective is to improve soil fertility. The price of quality seeds is also high
Estimated returns	Dependent on the type of GMCCs adopted
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• The practice integrates participation of both male and female gender roles during field implementation</li> <li>• It is important to know the demands of the technology product end users for ease of acceptability</li> <li>• Gender disparities in access to information may impact on adoption decisions. Access to information is a pre-requisite for informed decisions on adoption.</li> </ul>
Gender related opportunities	GMCCs offer good opportunities to both men and women to grow diverse crops for economic gains and at the same time offers enhanced biodiversity benefits
VMG issues and concerns in development, dissemination, adoption and scaling up	The technology can be practised using a variety of types and hence enhances adoption by the vulnerable and marginalized farmers/users. However, for optimized benefits, the availability of the required inputs like clean planting materials can be a challenge to this vulnerable group of people
VMG related opportunities	GMCCs places emphasis on the importance of using available land space to grow diverse of food, feed, increase biodiversity, thus the practice is economically viable. The practice is available to the advantage of VMG
<b>E: Case studies/profiles of success stories</b>	
Success stories	Farmers have reported improved soil conditions, reduced run off and nutrient loss, soil moisture retention in the soil and generally an increased crop production following application of this widely used and readily available practice

Application guidelines for users	<p>When planted solely for soil conservation, cover crops should provide a high percentage of ground cover as quickly as possible. Sowing a mix of grassy and leguminous types will increase ground coverage, act as insurance if one crop does not establish as well as provide more benefits than planting a single cover crop. Crop selection depends upon the niche, or need to be met and establishment guidelines will vary by crop.</p> <p>In selecting a cover crop, first identify your objective, problem or need. Determine what would be the ideal species that would fit your needs, then match this with the best available cover/green manure crop.</p> <p>To control soil erosion, plant crops that establish quickly to provide soil coverage such as hairy vetch.</p> <p>To increase organic matter, plant non-legumes or mixture of grasses and legumes. Small grains can provide significant amounts of biomass vegetation.</p> <p>To supply nitrogen to subsequent crops, select a legume such as alfalfa, clovers and hairy vetch</p>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up scaling
<b>G: Contacts</b>	
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Lead organization and scientists	KALRO, G. Ayaga, S. Kimani, C. Kundu
Partner organizations	County government, PPPs

### Research gaps

1. Major information gaps on GMCCs performances in specific areas of Kenya.
2. Little information on the interactions of various crop intercrops especially in the arid and semi- arid areas (ASALs).
3. Limited knowledge on resource-use efficiency particularly in regions with impoverished soils (ASALs) and economies where measured benefits are greatest

### 3.13 Participatory Range Land Management (PRM)

<b>TIMP name</b>	<b>Participatory Range Land Management</b>
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Degraded range lands

What is it? (TIMP description)	<p>Participatory Range land Management (PRM) is a systematic process that involves a series of activities including inventory of existing range resources, identification of the grazing unit, and implementation of range land management plan.</p> <p>The approach considers the indigenous knowledge of local resources and integrate it with the conventional range land restoration techniques</p>
Justification	<p>The climatic resilience and sustainability of range lands for many decades has been realized due to the management by pastoral groups who apply their rich indigenous knowledge and enforce local governance systems. However, the local customary institutions for managing grazing lands are being weakened by less their less involvement in conventional restoration approaches as well as by the formation of new government administration and structures whose needs and aspiration are sometimes not in tandem with those of the local resource users. Consequently, important approaches for controlling range land degradation including the opportunistically herd mobility for across landscapes as well as the resting of degraded range lands, are becoming less applicable, resulting in rampant range land degradation and vulnerability of local range land users in the context of climate change.</p> <p>PRM has been found successful in restoration of degraded range lands since it exploits synergies in the integration of indigenous and conventional knowledge systems. The involvement of local resource users also make the approach sustainable and effective</p>
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Pastoralist and agro-pastoralist communities
Approaches used in dissemination	<ul style="list-style-type: none"> <li>● Use of traditional institutions for grazing control</li> <li>● Capacity building/strengthening of local grazing management institutions</li> </ul>
Critical/essential factors for successful promotion	Enough implementation time frame for successful restoration
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>● County governments in ASALs</li> <li>● Community Initiative Facilitation Assistance</li> <li>● Center for Research and Development in Drylands</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	<p>Low and high variable rainfall that limits quick restoration</p> <p>Sololo, Kalacha, and Ngurunit areas of Marsabit County</p>
Counties where TIMP will be promoted	ASAL Counties

Challenges in dissemination	Low and high variable rainfall that limits quick restoration
Suggestions for addressing the challenges	Targeting of seasons/years of good/above average rains
Lessons learned if any	Enhanced community resilience against climatic shocks.
Social, environmental, policy and market conditions necessary	Local grazing institutions do not only help in managing grazing resource uses, but also useful in conflict resolutions and self- organization of pastoral societies at the time of difficulties
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Not done
Estimated returns	Not determined
Gender issues and concerns in development, dissemination, adoption and scaling up	Circumvent the cultural norm of excluding women in the grazing management decisions by advocating for their participation.
Gender related opportunities	Regeneration of community enclosures and other areas used by home-based herds have potential to increase nutritional and income for women and children who are usually left at home when other herds migrate to distant grazing areas.
VMG issues and concerns in development, dissemination, adoption and scaling up	Inclusion of women and youth is important in up-scaling and adoption of participatory range land management All strata community including VMG are involved in up-scaling and adoption.
VMG related opportunities	VMGs are involved in the decision making and enjoy the benefits
<b>E: Case studies/profiles of success stories</b>	
Success stories	To be determined
Application guidelines for users	<ul style="list-style-type: none"> <li>• Identify range land resources, users and range land management institutions</li> <li>• Define range land management units and prepare range land resource assessment</li> <li>• Develop range land management plan and agreement</li> <li>• Arrest and reverse declining range land productivity</li> <li>• Participatory monitoring and evaluation</li> </ul> <p><b>Reference</b> Flintan, F., Cullis, A., 2010. Introductory guidelines to participatory rangeland management in pastoral areas. Addis Ababa: Save the Children/US</p>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up scaling

<b>G: Contacts</b>	
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Partner organizations	County government, PPPs

## 4.0 IRRIGATION AND DRAINAGE MANAGEMENT

### 4.1 Solar irrigation systems for smallholder farmers

<b>TIMP name</b>	<b>Solar Irrigation Systems for smallholder farmers</b>
Category (i.e. technology, innovation or management practice)	Innovation
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	High cost of pumping water for irrigation, using electricity or fossil fuel powered pumps; reduction of greenhouse gas emissions.
What is it? (TIMP description)	This is a technology that uses solar power in the pumping of irrigation water and running of the irrigation systems.
Justification	There has been general increase in prices of diesel and electricity making pumping of irrigation water to be a costly operation. Though Solar panels have been used successfully to light houses and in small businesses in the rural areas, they have hardly been used in the irrigation systems despite their potential. Solar power would be a good source of power for addressing climate smart agriculture focusing on renewable and green energy. It also has the advantage of low cost and sustainability.
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers
Approaches used in dissemination	<ul style="list-style-type: none"> <li>• On-farm and on-station demonstrations</li> <li>• Field days</li> <li>• Training in workshops</li> <li>• Stakeholders forums</li> <li>• Technical releases</li> </ul>
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Documentation of available solar irrigation systems</li> <li>• Access to solar irrigation performance data.</li> <li>• Improving solar irrigation systems efficiencies in irrigation schemes</li> <li>• Creating local support for solar irrigation technologies</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• County government extension services; Provide link with farmers.</li> </ul>

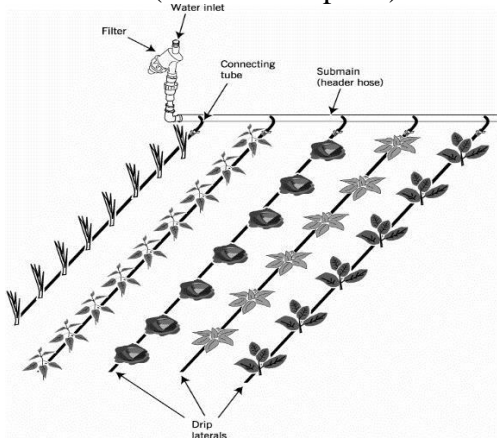
	<ul style="list-style-type: none"> <li>Community farmer groups; play coordination role for ease in problem identification and dissemination.</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Various Counties including Marsabit, Garissa, Machakos, Nyeri, Kajiado, Siaya, Bomet, Kericho and Uasin Gishu
Counties where TIMP will be promoted	All the 24 KCSAP Counties
Challenges in dissemination	<ul style="list-style-type: none"> <li>Farmers lack knowledge on the potential of solar as a power source for irrigation systems</li> <li>High cost innovation</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>Awareness trainings on different solar irrigation systems</li> <li>Awareness creation on advantages of solar irrigation systems pumps to governments, farmers and development agencies.</li> <li>Capacity building of extension workers</li> <li>Developing information packages</li> <li>Creating solar irrigation systems network</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>Solar irrigation systems should be well designed in water delivery, storage and application to the field.</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>Practice is socially acceptable,</li> <li>Environmentally friendly,</li> <li>Policies are friendly to the technology</li> <li>Capable of increasing marketable products</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Higher investment costs but low operation costs. Costs depend on the energy required and size of irrigated area.
Estimated returns	<ul style="list-style-type: none"> <li>Not yet done</li> </ul>
Gender issues and concerns in development, dissemination, adoption and scaling up	Solar irrigation is friendly to female gender compared to diesel or electric systems because they have low running and maintenance costs. It is modern technology that is attractive to the youth
Gender related opportunities	The systems are adaptable to different irrigation scenarios thus fitting to all genders.
VMG issues and concerns in development, dissemination, adoption and scaling up	VMGs may not afford the investment costs but will afford the operational and maintenance costs if assisted
VMG related opportunities	The technology can increase farm incomes of VMGs by more than 70% because of the very operation and low maintenance costs
<b>E: Case studies/profiles of success stories</b>	
Success stories	Solar irrigation systems success stories have been reported in Counties such as Kajiado on high value crops

Application guidelines for users	Choose a solar irrigation system that suits the farm area to irrigate Use efficient water application method such as drip to avoid wastage since the water is relatively scarce.
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	2 =Requires validation
<b>G: Contacts</b>	
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Lead organization and scientists	KALRO; I. V. Sijali, M. P. O. Radiro, F. Karanja, F. Kaburu
Partner organizations	Solar irrigation systems suppliers County governments National Irrigation Acceleration Programme (NIAP)

### Research Gaps

1. Validation of the solar irrigation systems in the different counties.
2. Up scaling of the technology to smallholder community schemes
3. Solar irrigation systems that maximize crop water productivity

### 4.2 Drip Irrigation Systems

<b>TIMP name</b>	<b>Drip Irrigation Systems for smallholder farmers</b>
Category (i.e. technology, innovation or management practice)	Technology
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Increased crop water stress caused by seasonal rainfall variability in rain fed production.
What is it? (TIMP description)	This is a technology that supplies water to plants grown in solid substrates in small controlled drops. It allows the optimal usage of the limited water resource by dripping water slowly into the crop roots at low pressure through a number of emission points (drippers). Drip system saves water by minimizing evaporation losses and delivering water at the root zone where it is required. It also provides the opportunity for farmers to increase crop yields. It's easy to design and operated. The layout can either be above surface or buried below the surface. System provides efficient fertilizer usage (fertigation) with irrigation water
Layout of a drip irrigation system in vegetables	

Justification	The impacts of climate change (seasonal rainfall variability and drought) to crop production is a real threat to food security. Main streaming drip irrigation systems into crop production provides the opportunity for farmers to enhance crop resilience, increase yields and incomes.
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Model Farmers
Approaches used in dissemination	Field Demonstrations, farmer field schools, ASK trade and exhibition fairs
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Correct field design (system installation) of the drip system to minimize water inefficiencies. Training of farmers and extension</li> <li>• Drip management skills</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• County governments; capacity building, supportive policies and frameworks</li> <li>• Private sector (AMIRAN); facilitate access to technology; technology demonstration; access to credit</li> <li>• NGOs (Kenya Red Cross- KRC, Action Aid, World Vision, and OXFAM); facilitate access to technology; technology demonstration</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Makueni, Bomet, Kajiado, Machakos
Counties where TIMP will be promoted	High value crop production (e.g. tomatoes, vegetables, bananas) in Elgeyo Marakwet, Bomet, Kericho, Kajiado, Mandera, Siaya, Tharaka Nithi, Nyandarua, Nyeri, Kisumu, Busia, Taita Taveta, Machakos, Isiolo, Laikipia, Marsabit, Baringo and Garissa counties
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Relatively high cost of drip kits for majority of poor resource farmers in ASALs.</li> <li>• High temperatures experienced in ASALs cause water salinity challenges</li> <li>• Drip poly tubing also tend to collapse causing inadequate water conveyance along the tube</li> <li>• Limited knowledge on the drip irrigation technology and its management</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Model farmer demonstration would create awareness and willingness to invest on the system</li> <li>• Modification of drip system tubes in ASAL areas is required (use of PVC pipes) to manage clogging free flow of water</li> <li>• Regular maintenance of the system especially the drip filters is required to flush out accumulated salts that tend to clog emitters</li> </ul>

	<ul style="list-style-type: none"> <li>• Intensive farmer training is required on the management of drip irrigation system</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Drip system increases yield, incomes and food security</li> <li>• Linking farmers with markets is critical for enhancing sustainability</li> <li>• Covering the soil with organic matter (crop residue or green manures) in a drip system have also helped preserve moisture and additional nutrients to the soil</li> <li>• It is also important to link farmers to Micro Finance Institutions for financial needs</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Capacity building for increased awareness</li> <li>• Policy support for increased investments in Drip irrigation systems</li> <li>• The water quality should be known to adjust the drip systems to avoid clogging</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Inputs materials include water source, drip lines, drippers, pumping unit, filtering and fertilizing systems. ¼ acre costs between KES 50, 000 to KES 100,000
Estimated returns	<ul style="list-style-type: none"> <li>• Income from drip system rises by as much as 35% stemming from the management of crop water stresses.</li> <li>• Increased water saving means more water is available for other competing needs (domestic, livestock or industrial).</li> </ul>
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Drip systems are easily installed and therefore suitable for both male and female gender</li> <li>• Drip system tends to reduce workload for all gender and provides significant positive impact on family food and nutritional intake.</li> <li>• Women are extensively involved in most horticultural farming enterprises (i.e. vegetable farming) under the drip-irrigation systems. This may increase their labor hours</li> <li>• Acceptable and easy to scale up by both male and female, including youth</li> </ul>
Gender related opportunities	Opportunities available for women and men to generate sustainable income
VMG issues and concerns in development, dissemination, adoption and scaling up	The technology fits well with the VMGs and easily installed and manageable, thus improving nutrition for the VMG
VMG related opportunities	Drip technology reduces the workload to the VMGs and provides an opportunity to make

	business because they are mostly done on high value crops such as tomatoes and vegetables
<b>E: Case studies/profiles of success stories</b>	
Success stories	There are many successful farmer drip irrigation models across the country implemented by government and other development partners. It is noted that linking markets to crops under drip is crucial for sustainability
Application guidelines for users	<ul style="list-style-type: none"> <li>• Use appropriate emitters during design and installation i.e. sites with elevation difference of over 1.5 meters (5 feet), use pressure compensating emitters and turbulent flow emitters more level areas. Gravity flow systems normally use short-path emitters</li> <li>• Use 1 or 2 emitters per plant depending on the size of the plant. Trees and large shrubs may need more.</li> <li>• In most situations install emitters at least 450mm (18") apart. 600mm (24") apart under 80% of the leaf canopy of the plant</li> <li>• Always have a backflow preventer to prevent water contamination by soil-borne disease. Use a 20mm (3/4") valve for most systems</li> <li>• Use 25mm (1 inch) PVC, PEX or polyethylene irrigation pipe for mainlines ("mains") and laterals</li> <li>• The total length of the mainline and the lateral together should not be more than 120 meters (400 feet).</li> <li>• The length of drip tube should not exceed 60 meters from the point the water enters the tube to the end of the tube</li> <li>• Never bury emitters underground unless they are made to be buried</li> <li>• Don't bury drip tube, moles or other rodents will chew it</li> <li>• Always install a flush valve or end cap at the end of each drip tube. Automatic flush valves are also available</li> </ul> <p><b>References</b></p> <ol style="list-style-type: none"> <li>1. Isaya V. Sijali, 2001. Drip Irrigation: Options for smallholder farmers in eastern and southern Africa. Technical Handbook No. 24. Published by SIDA's Regional Land Management Unit, Nairobi.</li> <li>2. FAO, 2014. Irrigation Techniques for Small-scale Farmers: Key Practices for DRR Implementers. Rome: Food and Agriculture</li> </ol>

	Organization of the United Nations (FAO). <a href="http://www.fao.org/3/a-i3765e.pdf">http://www.fao.org/3/a-i3765e.pdf</a>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up scaling
<b>G: Contacts</b>	
Contacts	Centre Director KALRO Kabete, off Waiyaki way, P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: <a href="mailto:cd.narl@kalro.org">cd.narl@kalro.org</a>
Lead organization and scientists	KALRO, Isaya Sijali,
Partner organizations	AMIRAN Kenya, HortiPro, Agro-Irrigation, Aqua- Valley Services Ltd, Davis & Shirtliff, and many Micro finance institutions (MFIs)

#### Research gaps

1. The impact of drip irrigation on economics of agriculture in the regions of adoption under study
2. Limited irrigation packages suited to small farmers - improved irrigation, agronomy, credit, technical support and assistance with marketing – to spur adoption

#### 4.3 Hydroponics Systems

<b>TIMP name</b>	<b>Hydroponics Systems</b>
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Declining farming land area, irrigation water scarcity, environmental pollution and low food crop and fodder productivity
What is it? (TIMP description)	Hydroponic farming is soilless farming system that utilizes inert media as an anchor to the crop and a rich nutrient solution applied for the growth of the plant. There are various systems used but the most famous is the vertical hydroponic system. This utilises a small area and accommodates higher crop population than the conventional method of farming. Use of locally available soilless media such as pumices, coco peat contributes into the reduction of the cost of production such as weeding, water usage, soil analysis and more
Justification	An upward swing in Increased food demand by an ever expanding population inhabiting dwindling and fragmented land sizes is the current scenario in Kenya and poised to linger on for some while. Agricultural land has been converted into real estates, commercial and industrial parks thus posing a threat to sustainable food production. Implementation of alternative and intensive farming methods becomes inevitable due to increased rural urban migration in

	<p>search of white collar jobs by the youth who are more than 60% of the Kenyan population.</p> <p>Conventional land use is gradually becoming untenable due to escalating change of land use in high agricultural potential areas.</p> <p>It is estimated that by the year 2050, over 80% of the Kenya's population will be residing in urban areas. Food security will become unsustainable therefore, implementation of alternative farming method that could increase output and reduce environment impacts such as soil pollution caused by high use of chemicals for crop protection is the way to go.</p> <p>Vertical hydroponic farming is a suitable technology in urban areas where people live in apartments and with micro-plots for farming space. Likewise, in areas that are not endowed with natural resources such as arid and semi -arid lands. Hydroponics farming system does not require herbicides and pesticides which remain in the soil causing ill-health to humans, livestock and environment. To redress these challenges, adoption of hydroponics as an alternative farming methods will greatly boost food security.</p>
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Urban and peri-urban Farmers/youth
Approaches used in dissemination	Capacity building workshops On-farm visits and excursions On-farm demonstrations and adaptive research trials
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Availability of affordable and quality local inert and clean planting media materials</li> <li>• Take into account the farming cluster dichotomy in and around urban and peri-urban areas are earmarked for the technology adoption.</li> <li>• Farms/ sites in terms of farming land size, labour and market availability</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• County government extension services; Provide link with end consumer of the technology</li> <li>• Community leaders in case of an urban dwelling and village leaders play coordination role for ease in problem identification</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Kiambu, Nairobi, Nakuru, Kakamega
Counties where TIMP will be promoted	Kajiado, Tharaka Nithi, Machakos, Kitui, Laikipia, Marsabit, Taita Taveta
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Labour and expertise needed</li> <li>• Culture change of mind-set in some regions/cultures that the rich nutrient solution cannot support crops growth without soil.</li> <li>• Initial cost implications</li> </ul>

Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Awareness trainings on role of hydroponics in crop and fodder production.</li> <li>• Training and awareness crop and fodder intensification on small areas and short production span</li> <li>• Excursion training or exchange visits</li> </ul>
Lessons learned if any	For hydroponics to succeed mind-set has to change, planting materials and media has to be of high quality and the hydroponic support structurally sound
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Practice is socially acceptable,</li> <li>• Environmentally friendly , since this is soilless farming</li> <li>• Increased productivity, maximising profits in small area.</li> <li>• In season and out season marketing</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	This is a technically labour friendly and low cost for all gender, vulnerable and marginalized groups
Estimated returns	Farmers who have adopted Hydroponics technologies have realised high returns due to reduction of production and high yield in a short production cycle. But the economic costs have not been calculated
Gender issues and concerns in development, dissemination, adoption and scaling up	The practice integrates participation of male and female gender roles during field activities. Female gender are disadvantaged when setting up of the hydroponics structures. Adoption and scaling up of hydroponics technologies could be affected by the ownership of the premises that are mainly male owned where the man does not support the technology
Gender related opportunities	Apart from the hydroponics structures and good seed, the practice adopts other locally available materials like planting media that saves on cost which is beneficial to all gender in the farm household.
VMG issues and concerns in development, dissemination, adoption and scaling up	VMGs are physically disadvantaged for a practice that seeks cultural acceptability. VMGs are usually resource poor and may not have sufficient resources to purchase seeds and fertigation nutrient solutions that are required for successful implementation of the practice
VMG related opportunities	The technology if well practised can increase farm incomes of VMGs by more to 50%
<b>E: Case studies/profiles of success stories</b>	
Success stories	Hydroponics technologies successes have been reported in fodder and vegetables production in Muguga, Limuru Kiambu County
Application guidelines for users	<ul style="list-style-type: none"> <li>• Always use good quality, disease- and pest-resistant seed and planting media to ensure efficient use nutrients for vigorous growth and hence bumper production.</li> </ul>

	<ul style="list-style-type: none"> <li>• Ensure that best bet agronomic practices are upheld</li> <li>• For sustainability, proper structure maintenance and general management should be carried out as specified in the instructions manual</li> </ul>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	2 =Requires validation
<b>G: Contacts</b>	
Contacts	Centre Director KALRO Kabete, off Waiyaki way, P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: <a href="mailto:cd.narl@kalro.org">cd.narl@kalro.org</a>
Lead organization and scientists	KALRO; E. Muriuki, F. Kaburu, D. Kamau, I. V. Sijali.
Partner organizations	County governments Ministry of Agriculture, Livestock, Fisheries & Irrigation World Vision

### Research Gaps

1. Validation of the hydroponics technology in Counties where technology has not been tested.
2. Testing with different value chains, feed and food.

### 4.4 Sensor-Based Drip Irrigation

<b>TIMP name</b>	<b>Sensor-Based Drip Irrigation</b>
Category (i.e. technology, innovation or management practice)	Technology
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Low irrigation water use efficiency due to manual operations of drip irrigation
What is it? (TIMP description)	The sensor based irrigation system comprises of four modules namely; the solar power supply module, the programmed micro-controller module, soil moisture probes module and the motorized ball balls module. The modules are linked together and packaged as a unit in a wheel barrow to facilitate easy mobility of the system to different section of the land under cultivation. Figure 1 gives a block diagram of the system followed by a description of each module.
Justification	The sensor based irrigation system uses sensors to automate irrigation thereby increasing the irrigation water use significantly
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmer groups practicing irrigation for high value vegetable crops in ASALs

Approaches used in dissemination	Field demonstrations, Joint evaluation with farmers, ASK trade and exhibition shows
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Correct installation of soil probes</li> <li>• Correct operation of the sensor</li> <li>• Training of extension staff and farmers for handling and management of system</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• County Governments: capacity building, supportive policies and frameworks</li> <li>• Private sector: Fabrication of the sensor systems</li> <li>• Non-State Actors: Development based NGO's such as CARITAS : Mobilization of farmers and facilitation of the adoption process</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Tharaka Nithi
Counties where TIMP will be promoted	All 24 KCSAP Counties
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Low levels of smartphone use in rural areas</li> <li>• Low levels of training in IT for farm enterprises</li> <li>• Lack of knowledge to install the digital kits</li> <li>• Unavailability of sensor-based irrigation kits</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Promote use of smartphones in rural areas</li> <li>• Train agricultural extension workers on the TIMP</li> <li>• Train Lead farmers who will train farmer groups about the TIMP</li> <li>• Promote the sensor-based kits to agrodealers</li> </ul>
Lessons learned if any	There's need to create awareness on using IT in farming This TIMP is a good business opportunity particularly for the youth
Social, environmental, policy and market conditions necessary	This will require capacity building for increased awareness and a conducive policy framework for water saving irrigation technologies
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	The estimates will be given after the validation
Estimated returns	This will be quantified after the validation process
Gender issues and concerns in development, dissemination, adoption and scaling up	<p>Sensor Based Drip Irrigation system are easily installed and therefore suitable for both male and female gender. The system reduces workload for all gender and have the potential to significantly enhance household incomes, family food and nutritional intake. The system is suitable for high value vegetable crops, which are attractive to women.</p> <p>Sensor Based Drip Irrigation has attractive ICT features that can interest the youth and potentially youth participation in agriculture for sustainability.</p>

Gender related opportunities	Opportunities available for women and men to generate sustainable income
VMG issues and concerns in development, dissemination, adoption and scaling up	Sensor Based drip irrigation technology fits well with the VMGs. It can be easily installed and managed. It cuts down time spend on manual operation of drip irrigation, reduces amount of irrigation water. The VMGs can thus have time and water for other farm activities leading to more income and improved livelihood
VMG related opportunities	Drip technology reduces the workload to the VMGs and provides an opportunity to make business because they are mostly done on high value crops such as tomatoes and vegetables
<b>E: Case studies/profiles of success stories</b>	
Success stories	Use of sensor based drip irrigation is being validated on farmers' fields for the first time in Tharaka Nithi County. The data obtained indicates significant increase in irrigation water use efficiency.
Application guidelines for users	Appropriate guidelines will be developed after the validation stage
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	2 =Requires validation
<b>G: Contacts</b>	
Contacts	Meru University of Science and Technology, P.O Box 972-60200, Meru dmaitethia@must.ac.ke
Lead organization and scientists	Meru University of Science and Technology, P. Masinde, D. Maitethia, F. Kaburu, S. Kimani M. Okoti, C. Kundu and D. Kamau
Partner organizations	KALRO

### Research Gaps

1. The impact of sensor based drip irrigation on socio-economics aspects of vegetable production in ASALs need to be studied
2. Challenges that face drip irrigation and its adoptions in ASALs will be largely impacting on sensor-based drip irrigation

## 5.0 AGROFORESTRY SYSTEMS TIMPs

### 5.1 Agroforestry for Fodder

<b>TIMP name</b>	<b>Agroforestry for Fodder (Agrosilvopastoral practice)</b>
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	

Problem addressed	Shortages of high quality fodder result in low milk production and decreased ecosystem services and resilience. Agroforestry fodder will contribute towards carbon sequestration and reduction of greenhouse gas emissions
What is it? (TIMP description)	<p>Agroforestry for Fodder is a land use system where trees or shrubs are grown in the same space with crops and animals. In this system, trees are deliberately planted for fodder production. Combinations include;</p> <ul style="list-style-type: none"> <li>• Tree/grass woodlots; a combination of trees and grasses planted in an enclosed area</li> <li>• Scattered trees on crop/pastureland; fodder trees planted on crop/grassland</li> <li>• Fodder banks – cut and carry system; a block of fodder trees in closed spacing, e.g. Calliandra spp. spaced at 1 by 1m<sup>2</sup></li> <li>• Improved fallow systems; Leguminous trees planted in improved natural fallows</li> <li>• Hedgerow intercropping; Leguminous tree species planted in hedges</li> <li>• Evergreen agriculture; intensive farming that integrates trees into crop and livestock production systems at farm/landscape levels</li> <li>• Push and pull (t); strategy of controlling pests in farms by use of repellent ‘push’ and trap ‘pull’ plants</li> </ul>
Justification	Land degradation itself is a driver of climate change and exacerbates its impact. Different forms of agroforestry systems provide a solution to address the fodder problem in addition to improved soil health. Fodder trees are important feed source of livestock in a wide range of agroforestry system. Farmers have used fodder trees since ancient times and they are common in traditional feeding systems. Overexploitation and low land productivity and loss of biodiversity of fodder trees and shrubs has been a major challenge. Proper agro forestry practices can significantly contribute to availability of quality fodder and ecosystem rehabilitation
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers
Approaches used in dissemination	<p>Open and field days  Farmer field schools (FFS)  On-farm demonstrations (during FFS)  Mass and social media</p>
Critical/essential factors for successful promotion	<p>Training on principles and benefits of fodder trees and shrubs  Model demonstration using crops</p>

Partners/stakeholders for scaling up and their roles	County governments extension services; Community mobilization and support, Supporting frameworks/policies at the local level KALRO/KEFRI; Implementing institutions Network of Conservation Agriculture, technical backstopping CGIAR (CIAT & ICRAF); technical backstopping
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Machakos, Nyandarua, Nyeri, West Pokot, Siaya, Busia, Kisumu, Tharaka-Nithi, Kakamega, Uasin-Gishu
Counties where TIMP will be promoted	All the 24 Counties
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Limited species appropriate to different agro-ecological zones</li> <li>• Shortage of seed</li> <li>• Many farmers lack knowledge and skills needed to grow them due to; (i) Negative mindset (ii) land tenure (farmers reluctant to invest in agroforestry technologies where they do not have clear land rights, (iii) lack of awareness</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Enhance Public Private Partnerships to support increased production and market access</li> <li>• Improve county government capacity to train and re- tool technical team so as to enhance uptake of the technology</li> <li>• Allocation of more funds for continued research and dissemination of this technology would aid increased uptake of fodder species</li> </ul>
Lessons learned if any	<ol style="list-style-type: none"> <li>1. Mind sets are negative about fodder trees</li> <li>2. Inadequate skills in the technology and its management practices among the farmers and extensions agents</li> </ol>
Social, environmental, policy and market conditions necessary	Reliable technology adoption and suitable price and market access for produce under fodder
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Fodder trees easy to establish and grow, require only small pieces of land, low labour requirements and have numerous by-products. They often supply feeds throughout the year.
Estimated returns	Increased milk productivity in the dairy sector has been reported in areas where technology is practised. In Embu, feeding trials have found that 1 kilogram of <i>Calliandra</i> increases milk production by 0.6–0.8 kilograms. With 500 <i>Calliandra</i> shrubs, a farmer’s net income increases by About KES 10,000 to 12,000 per cow per year by using <i>Calliandra</i> as a substitute for dairy meal (World Agroforestry Centre 2009)
Gender issues and concerns in development, dissemination, adoption and scaling up	Planting of fodder trees is a practice that can be easily adopted by both men and women.

	Fodder provides opportunities for SMEs e.g. tree nurseries. The technology therefore renders itself to easy adoption by women and youth groups. However, there will be conflicts in places where the man who owns the land is not supportive of the practice
Gender related opportunities	SMEs e.g. tree nurseries for agroforestry can easily be adopted by men and women
VMG issues and concerns in development, dissemination, adoption and scaling up	Can easily be carried out by vulnerable and marginalized groups. Currently the uptake by VMGs is minimal but can be up scaled
VMG related opportunities	Can create tree nurseries for increased resilience and income generation by the VMGs
<b>E: Case studies/profiles of success stories</b>	
Success stories	Farmers in central Kenya have demonstrated that <i>Calliandra</i> can replace or supplement dairy meal. Both options increase profitability and provided good and sustainable source of income and provide other ecological services like erosion control, provide firewood, and increased resilience in farms
Application guidelines for users	Adopters of fodder will need training in establishment, feeding amounts and ratios. Information will be packaged in training manuals
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up scaling
<b>G: Contacts</b>	
Contacts	Kenya Forestry Research Institute, P.O. Box 20412, Nairobi <a href="mailto:jkndufa@gmail.com">jkndufa@gmail.com</a> +254 722 983238
Lead organization and scientists	KEFRI, KALRO, ICRAF, CIAT; J. Ndufa, E. Odoyo, B. Mugo, M. Okoti, D. Kamau and S. Kimani
Partner organizations	County government, Private Public Partnerships

## 4.2 Agroforestry for Fruit Trees

<b>4.2. TIMP name</b>	<b>Agroforestry for Fruit Trees</b>
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Land degradation characterized by declining soil fertility, low yields, increased soil moisture stress, increased soil erosion and loss of biodiversity. Lack of food and nutritional security, Anthropogenic climate change

What is it? (TIMP description)	Incorporation of fruit trees in agroforestry systems for food and nutritional security
Justification	<p>Fruit trees in agroforestry systems can support food and nutritional security through the direct provision of food, by raising farmers' incomes, providing fuel for cooking, providing fodder for livestock, improving soil fertility and soil health. It can also provide other ecosystem services. Agroforestry is an important climate-smart agriculture approach. However most of the indigenous fruit trees in agroforestry systems have been over-exploited for various products and led to loss of biodiversity. Solving the problem of food and nutritional security in smallholder farms requires replanting and incorporation of fruit trees into the farms.</p> <p>Continuous land degradation leads to continued emission of GHGs (Carbon) responsible for the climatic changes. Fruit trees in agroforestry system has the potential to:</p> <ul style="list-style-type: none"> <li>• Increase the productivity by improving soil structure and protects the soil against erosion and nutrient losses , thus Enhance food security and nutrition</li> <li>• Conserve soil water</li> <li>• Enhance biodiversity</li> <li>• Increased resilience</li> </ul>
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers
Approaches used in dissemination	<ul style="list-style-type: none"> <li>• Open and field days Farmer Field Schools Exchange visits</li> <li>• Mass and social media</li> <li>• Demonstration plots</li> </ul>
Critical/essential factors for successful promotion	Training on principles and benefits of fruit trees Model demonstration using crops
Partners/stakeholders for scaling up and their roles	County governments extension services; Community mobilization and support, Supporting frameworks/policies at the local level KALRO, KEFRI; Implementing institutions ICRAF; Technical backstopping
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Machakos, Nyandarua, Nyeri, West Pokot, Siaya, Busia, Kisumu, Tharaka-Nithi, Kakamega, Uasin-Gishu
Counties where TIMP will be promoted	All 24 KCSAP Counties

Challenges in dissemination	<ul style="list-style-type: none"> <li>• Limited species appropriate to different agro-ecological zones</li> <li>• Shortage of seed/seedlings</li> <li>• Many farmers lack knowledge and skills needed to grow them</li> <li>• Failure to recognize agroforestry as an important investment option.</li> <li>• Land tenure (farmers reluctant to invest in agroforestry technologies where they do not have clear land rights)</li> <li>• Lack of markets and processing techniques</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Enhance PPP to support increased production and market access</li> <li>• Capacity building of county government capacity to train and re-tool technical team so as to enhance uptake of the technology</li> <li>• Allocation of more funds for continued research and dissemination of this technology would aid increased uptake of indigenous fruit trees in agroforestry.</li> <li>• Developments in agroforestry policies are required to reform tree and land tenure to the benefit of small-scale farmers</li> <li>• Provision of planting material</li> <li>• Research should support tree domestication to improve yields and enhance the complementarity and stability of fruit trees in smallholder agroforestry systems.</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Mind sets negative about indigenous fruit trees</li> <li>• Inadequate skills in the technology and its management practices</li> </ul>
Social, environmental, policy and market conditions necessary	Reliable technology adoption and suitable price and market access for grown fruits
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	For a farmer who owns the land, only the cost of purchase of germplasm and nursery operation are required, hence fairly low
Estimated returns	Dependent on fruit tree species planted
Gender issues and concerns in development, dissemination, adoption and scaling up	Technology can be easily adopted by both gender, e.g. women and men. Fruit trees provide opportunities for SMEs e.g. tree nurseries. The technology therefore renders itself to easy adoption by women and youth groups
Gender related opportunities	Opportunities available to all gender e.g. fruit tree nurseries
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• The management practice can be easily carried out by Vulnerable and Marginalized Groups.</li> <li>• Currently the uptake by VMG is minimal but has potential for wider adoption and up scaling</li> </ul>

VMG related opportunities	SMEs such as fruit tree nurseries for increased resilience and income generation
<b>E: Case studies/profiles of success stories</b>	
Success stories	Farmers and agro-pastoralists who adopt the technology have had high and sustainable source of income and increased resilience where markets are available
Application guidelines for users	Adopters of fruit trees will need training in potential fruit tree species, nursery establishment and management, linkages to markets and processors. The systems can access Carbon Credit markets at the same time
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	3 =Requires further research
<b>G: Contacts</b>	
Contacts	Kenya Forestry Research Institute, P.O. Box 20412, Nairobi <a href="mailto:jkndufa@gmail.com">jkndufa@gmail.com</a> +254 722 983238
Lead organization and scientists	KEFRI, KALRO and ICRAF, James Ndufa, E. Odoyo, M. Okoti, S. Kimani, C. Kundu and D. Kamau
Partner organizations	County government, Private Public Partnerships NGOs

### Research gaps

1. Validation of the technology in Counties where the technology has not been tested
2. Research should support tree domestication to improve yields and enhance the complementarity and stability of food production in smallholder agroforestry
3. More research on processing and linkages to markets including carbon credits

## 5.2 Agroforestry – Soil Fertility

<b>TIMP name</b>	<b>Agroforestry for Soil Fertility</b>
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Land degradation characterized by the declining soil fertility, low yields, increased soil moisture stress, increased soil erosion and loss of biodiversity
What is it? (TIMP description)	It is a land use management system in which trees or shrubs grown in or among crops or pasture land for the purpose of improving soil fertility and rehabilitation of degraded lands. These systems include: <ul style="list-style-type: none"> <li>• Improved fallows; Leguminous trees planted in natural fallows</li> </ul>

	<ul style="list-style-type: none"> <li>• Hedgerow intercropping/alley cropping; Leguminous tree species planted in hedges</li> <li>• Green manure; Biomass from growing leguminous plants that are cut at a certain height and ploughed back to the soil as source of manure</li> <li>• Mixed cropping; system of sowing two or three crops (that includes a legume) together on the same land, where one is the main crop and others are considered subsidiaries.</li> <li>• Multi-strata; an agroforestry system whose components (crops, trees, shrubs, livestock) occupy distinct layers of the vertical structure of the community.</li> </ul>
Justification	<p>Given the acute poverty and limited access to mineral fertilizers in most rural farmers in Kenya, the promising approach is one that integrates organic and inorganic fertilizers. Organic fertilizers include the use of improved fallows of leguminous trees, shrubs, herbaceous legumes and biomass transfer.</p> <p>Moreover, continuous land operation continues to emit more GHGs (carbon) responsible for the climatic changes. Agroforestry with leguminous trees has potential to:</p> <ul style="list-style-type: none"> <li>• Increase the productivity improving soil structure and protect the soil against erosion and nutrient losses by maintaining a permanent soil cover and minimizing soil disturbance.</li> <li>• Conserve soil water.</li> <li>• Enhance biodiversity</li> </ul>
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers
Approaches used in dissemination	Open and field days Agricultural shows, Farmer Field Schools Mass and social media, Exchange visits, Demonstration plots
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Training on principles and benefits of agroforestry legumes for green manure</li> <li>• Model demonstration plots using cereal crops</li> </ul>
Partners/stakeholders for scaling up and their roles	County governments extension services; Community mobilization and support, Supporting frameworks/policies at the local level KALRO & KEFRI; Implementing institutions
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Machakos, Siaya, Kisumu, Kakamega, Busia, Tharaka Nithi
Counties where TIMP will be promoted	All 24 KCSAP Counties
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Limited species appropriate to different agro-ecological zones</li> <li>• Shortage of seed</li> </ul>


	<ul style="list-style-type: none"> <li>• Many farmers lack knowledge and skills needed to grow them</li> <li>• Change of mindset</li> <li>• Competing interests</li> <li>• land tenure (farmers reluctant to invest in agroforestry technologies where they do not have clear land rights)</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Enhance Public Private Partnerships to support increased production and market access</li> <li>• Improve county government capacity to train and re-tool technical team so as to enhance uptake of the technology</li> <li>• Availing inputs and credit</li> <li>• Allocation of more funds for continued research and dissemination of this technology would aid increased uptake agroforestry for soil fertility</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Mind sets of local farmers negative about agroforestry for soil fertility improvement.</li> <li>• Inadequate skills in the technology and its management practices</li> </ul>
Social, environmental, policy and market conditions necessary	Reliable technology adoption and suitable price and market access for produce grown under the improved agroforestry system
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Dependent on the technology being promoted, though minimal focusing on labour costs
Estimated returns	Returns dependent on the technology and value chain
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Agroforestry for soil fertility with trees is a management practice that can be easily adopted by men, women and the youth</li> <li>• Agroforestry provides opportunities for SMEs e.g. tree nurseries. The technology therefore renders itself to easy adoption by both men and women. Providing ready markets of the produce can also be an issue upon scaling up</li> </ul>
Gender related opportunities	There are opportunities for the rural women and unemployed youths in seed and seedlings sales e.g. tree nurseries
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• The VMGs can easily get access to the products of the practice, e.g. source of fuel wood</li> <li>• Taking care of the introduced agroforestry systems in their farms require labour.</li> </ul>
VMG related opportunities	SMEs such as tree nurseries for increased resilience and income generation
<b>E: Case studies/profiles of success stories</b>	
Success stories	Farmers who adopt the technology have reported increased and sustainable source of income

Application guidelines for users	Adopters of agroforestry for soil fertility will need training for informed decisions on appropriate tree species to plant
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	2 =Requires validation
<b>G: Contacts</b>	
Contacts	Kenya Forestry Research Institute, P.O. Box 20412, Nairobi <a href="mailto:jkndufa@gmail.com">jkndufa@gmail.com</a> +254 722 983238
Lead organization and scientists	KEFRI and KALRO, J. Ndufa, M. Okoti; E. Odoyo, B. Mugo, S. Kimani, C. Kundu and D. Kamau
Partner organizations	County government, Private Public Partnerships

### Research gaps

1. Validation of existing technologies in different agro-ecological zones/Counties

### 5.3 Woodlots for Energy

TIMP name	Woodlots for Energy
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Shortages of fuel wood and charcoal, increased land degradation and low resilience and increased emission of GHGs (Carbon) responsible for the climatic changes. Poor land that cannot be used for anything but trees is primarily recommended for woodlots These are as a result of overexploitation of aboveground vegetation biodiversity through fuel wood harvesting and charcoal burning which led to the loss of biological and economic productivity of the land.
What is it? (TIMP description)	Tree woodlots is a parcel of land planted with trees for the purpose of harvesting them for wood fuel, saw logs and pulpwood among other uses. Vegetables or crops are often intercropped in the woodlot in the early stages of establishment, but with time, wood production is the most important use.
	

<i>Grevillea</i> woodlot in Western Kenya (C. Kundu)	
Justification	Fuelwood consumption by rural household and charcoal production for urban energy consumption is a main driver of land degradation and loss of biological and economic productivity in most of landscapes. In Kenya it is estimated that 90% of rural households use fuel wood or charcoal, with fuel wood meeting the energy needs of over 93% of rural households, and charcoal being the dominant fuel in urban households. Charcoal production depends predominantly on natural woody biomass hence the rising demand for charcoal as a household fuel is associated with increasing levels of deforestation, loss of land productivity and biodiversity and emission of GHGs that are responsible for climate change. To address this challenge, on-farm cultivation of fast maturing tree and shrub species which can produce high quality charcoal and adapt to a wide range of climatic conditions is crucial.
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers
Approaches used in dissemination	Open and field days Agricultural shows, Farmer Field Schools, Mass and social media, Exchange visits, Demonstration plots.
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• In woodlots the most fast-growing trees, e.g. Eucalyptus, can be used since the land is used entirely for trees and there is little need to worry about competition with crops.</li> <li>• Training on principles and benefits of short rotation tree woodlots for firewood and charcoal production</li> <li>• Model demonstration plots using cereal crops</li> </ul>
Partners/stakeholders for scaling up and their roles	County government's extension services; Provide link with farmers. KEFRI, KALRO & KFS; Provide technical backstopping
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Promoted in Kericho, Busia, Bomet, Nyandarua, Kakamega, Siaya, Nyeri, Tharaka Nithi, Kisumu, Machakos, Isiolo, Marsabit, Tana River, Garissa and Baringo Counties
Counties where TIMP will be promoted	Marsabit, Isiolo, Tana River, Garissa, Wajir, and Mandera (Arid areas): West Pokot, Baringo, Laikipia, Machakos, Nyeri, Tharaka Nithi, Lamu, Taita Taveta and Kajiado (Semi-Arid areas): Busia, Siaya, Nyandarua, Bomet, Kericho, Kakamega,

	Uasin Gishu, Elgeyo Marakwet and Kisumu (Medium to high rainfall areas)
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Limited species appropriate to different agro-ecological zones</li> <li>• Shortage of seed</li> <li>• Many farmers lack knowledge and skills needed to grow them</li> <li>• Change of mindset</li> <li>• Competing interests</li> <li>• Land tenure (farmers reluctant to invest in agroforestry technologies where they do not have clear land rights)</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Improve county government capacity to train and re-tool technical team so as to enhance uptake of the technology</li> <li>• Allocation of more funds for continued research and dissemination of this technology would aid increased uptake of woodlots for fuelwood</li> <li>• Provide training of seed collection and nursery management</li> <li>• Ensuring successful charcoal production and marketing through implementation of existing charcoal police that encourage investments in improved charcoal processing technologies.</li> <li>• Encouraging establishment of woodlots of high density trees, promoting species of low density that are appropriate for briquetting, such as bamboo, and encouraging utilization of agricultural residues and industrial residues such as sawdust and bagasse for fuel</li> <li>• Promoting the use of improved charcoal kilns (with efficiency of more than 25%); currently majority of charcoal producers use the traditional earth kilns with 10-20% efficiency</li> <li>• Encouraging the use of dry wood during carbonisation and promoting appropriate technologies that are simple, affordable and easy to adopt</li> <li>• Promoting energy conservation through the use of improved cook stoves with higher efficiency levels</li> <li>• Streamlining the charcoal value chain through collaborative action among all players in the sector, including farmers</li> <li>• Enhancing implementation of land use regulations and guidelines, especially where changes in land use occur</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Mind sets of local farmers are negative about short rotation woodlot for firewood and charcoal production.</li> </ul>


	<ul style="list-style-type: none"> <li>• Inadequate skills in the technology and its management practices</li> </ul>
Social, environmental, policy and market conditions necessary	Reliable technology adoption will provide easy access to on-farm firewood and income from charcoal.
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Initial cost of establishment is high but have good returns if well managed. Farmers will also save on time spent on firewood collection
Estimated returns	Returns dependent on the technology and value chain. Overall charcoal production cost amount to an average of KES 100/bag. With the sales price of KES 250-350, the producers net income amounts to KES 150-350/bag
Gender issues and concerns in development, dissemination, adoption and scaling up	A high level of wood production for domestic or cash-income purposes can be achieved. Trees in woodlots can also be a good way of making some savings. The negative aspect is that land, which is normally scarce, is taken out of agricultural production
Gender related opportunities	There are opportunities for the rural women in seed and seedlings sales e.g. tree nurseries and generating income from firewood and charcoal. The time saved from firewood collection by women can be used for other economic activities
VMG issues and concerns in development, dissemination, adoption and scaling up	The VMGs can be easily adopt woodlot technology considering the low cost. Also, VMGs will easily get access to the products of the practice, e.g. source of fuelwood. VMGs are also disadvantaged by the land tenure system in place
VMG related opportunities	SMEs such as tree nurseries for increased resilience and income generation from firewood and charcoal Opportunity to utilize the woodlots at initial stages to grow other crops of economic value
<b>E: Case studies/profiles of success stories</b>	
Success stories	Farmers who adopt the technology have reported increased and sustainable source of income and increased resilience and have sufficient fuelwood for home consumption. Siaya County (Kenya) communities have raised <i>Acacia polyacantha</i> and <i>A. xanthophloea</i> trees through an initiative that started in 2002. The group of 545 farmers have set aside 240 hectares and planted woodlots for charcoal production on land pieces ranging from 0.5 – 3 acres (0.21 - 1.25 hectares) with a 6-year harvesting cycle.
Application guidelines for users	Farmers who adopt tree woodlots practice will be provided with information on appropriate tree species, spacing and husbandry practices suitable in their counties

<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up scaling
<b>G: Contacts</b>	
Contacts	Kenya Forestry Research Institute, P.O. Box 20412, Nairobi <a href="mailto:jkndufa@gmail.com">jkndufa@gmail.com</a> +254 722 983238
Lead organization and scientists	KEFRI, KFS and KALRO; J. Ndufa, E. Odoyo, M. Okoti, S. Kimani and D. Kamau
Partner organizations	County government, Private Public Partnerships

### Research gap

1. Research on streamlining the charcoal value chain through collaborative action among all players in the sector, including farmers.
2. Validation of existing woodlot species in different agro-ecological zones/Counties
3. Further research on species selection for different agro-ecological zones/Counties

### 5.4 Windbreaks and live hedges

<b>TIMP name</b>	<b>Windbreaks and Live hedges</b>
Category (i.e. technology, innovation or management practice)	Management practice
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Increased land degradation and loss of biological and economic productivity caused by overexploitation of the vegetation is the major cause of wind and water erosion in most of landscapes. This is characterised by declining soil fertility, low yields, increased soil moisture stress, increased soil erosion from water and wind and loss of biodiversity; shortages of poles, timber, fuelwood and charcoal; shortages of medicine, fruit and fodder; increased emission of GHGs (Carbon) responsible for the climatic change
What is it? (TIMP description)	Windbreak/shelterbelts/live hedges is the planting of one or two rows of trees or shrubs along the edge of the farm, boundary and around the homestead in such manner as to provide shelter from the wind by reducing wind velocity and to protect soil from soil erosion and to provide other tree products
 <p><i>Source: S, Kimani</i></p>	

Justification	A windbreak (also called a hedge, hedgerow, shelter belt, vegetative barrier, or wind barrier) is a row planted with trees that prevents or reduces the speed of the strong wind coming through it. The use of trees for windbreaks serves multiple purposes. Belts of trees as windbreaks can be of considerable practical value because they decrease <a href="#">soil erosion</a> , reduce mechanical damage to plants, <a href="#">increase crop yield</a> , and improve cover and increase food supply for wildlife. Windbreaks often are used to protect young trees in <a href="#">plantations</a> and <a href="#">forest nurseries</a> . Trees can be planted around the homestead and the edge of the farms can also provide medicine, fruits, timber, poles, fuelwood and fodder. Trees and shrubs planted along boundaries of fields can also provide demarcation for boundaries and provide other ecosystem service
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers
Approaches used in dissemination	Open and field days Agricultural shows, Farmer Field Schools Mass and social media, Chief's Baraza, exchange visits, demonstration plots
Critical/essential factors for successful promotion	Training on principles and benefits of windbreak/shelterbelts/live hedges for wind and water erosion control and provision of other tree products and ecosystem services
Partners/stakeholders for scaling up and their roles	County governments - Provide extension services, farmer mobilization and policy formulation KEFRI and KFS – capacity building, provide tree; policy implementation NGOs – capacity building
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Machakos, Laikipia, Nyeri, Tana river, Isiolo, Wajir, Garissa, Taita Taveta, Tharaka Nithi, Kericho, Bomet, Busia, Kakamega, Uasin Gishu, Elgeyo Marakwet, Nyandarua, Siaya, Kisumu, Siaya, Lamu, Baringo
Counties where TIMP will be promoted	Marsabit, Isiolo, Tana River, Garissa, Wajir and Mandera (Arid areas): West Pokot, Baringo, Laikipia, Machakos, Nyeri, Tharaka Nithi, Lamu, Taita Taveta and Kajiado (Semi-Arid areas): Busia, Siaya, Nyandarua, Bomet, Kericho, Kakamega, Uasin Gishu, Elgeyo Marakwet and Kisumu (Medium to high rainfall areas).
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Limited species appropriate to different agro-ecological zones</li> <li>• Shortage of seed</li> <li>• Tree and tenure issues when trees are planted along the common boundary</li> </ul>

	<ul style="list-style-type: none"> <li>• Lack of proper management plans as provided for under the Forests Act of 2005 can affect sustainable feedstock management.</li> <li>• The arid and semi-arid areas of Kenya where windbreaks have potential of adoption are water deficient environments that experience challenges in vegetation growth and tree regeneration. This highlights the need for proper agronomic planning.</li> <li>• Many farmers lack knowledge and skills needed to grow them</li> <li>• Competing interests</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Improve county government capacity to train and re-tool technical team so as to enhance uptake of the technology</li> <li>• Allocation of more funds for continued research and dissemination of this technology would aid increased uptake</li> <li>• Provide training of seed collection, nursery management and tree establishment and management</li> <li>• Promoted windbreak trees/shrubs which provide multiple e.g. medicine, fruits, timber, poles, fuelwood and fodder</li> <li>• Enhancing implementation of land use regulations and guidelines, especially where changes in land use occur</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Mindset change of local farmers about windbreak practices.</li> <li>• Inadequate skills in the technology and its management practices</li> </ul>
Social, environmental, policy and market conditions necessary	Reliable technology adoption will provide easy access to multiple tree products and income , and mitigation of climate of change
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Initial cost of establishment is high but there is the benefit of good returns if well managed. Farmers will also save on time spent on firewood collection
Estimated returns	Returns dependent on type of tree species used and value chain but no economic costs have been done
Gender issues and concerns in development, dissemination, adoption and scaling up	Windbreak is a technology that can be easily adopted by all gender including the youth although tree tenure issues need to be sorted out. Also provides opportunities for SMEs e.g. tree nurseries.
Gender related opportunities	There are opportunities for the unemployed youths and rural women in seed and seedlings sales e.g. tree nurseries and generating income from firewood and charcoal. The time saved from firewood collection can be used for other economic activities. The major

	advantage is that it is easy to look after trees planted as windbreaks and live hedges
VMG issues and concerns in development, dissemination, adoption and scaling up	The VMGs can easily get access to the products of the practice, e.g. source of fuelwood, etc Land and tree tenure issues need to be addressed for proper management of the planted trees
VMG related opportunities	SMEs such as tree nurseries for increased resilience and income generation from trees
<b>E: Case studies/profiles of success stories</b>	
Success stories	Farmers who adopt the technology have reported increased and sustainable source of income and increased resilience and have sufficient fuelwood for home consumption
Application guidelines for users	Adopters of windbreaks will need training to decide appropriate tree species
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	2 =Requires validation
<b>G: Contacts</b>	
Contacts	Kenya Forestry Research Institute, P.O. Box 20412, Nairobi <a href="mailto:jkndufa@gmail.com">jkndufa@gmail.com</a> +254 722 983238
Lead organization and scientists	KEFRI, KALRO and ICRAF, James Ndufa, E. Odoyo, D. Kamau and S. Kimani
Partner organizations	County government, Private Public Partnerships


### Research gaps

1. Validation of existing windbreak and live hedges species in different agro-ecological zones/counties
2. Further species selection for different agro-ecological zones/counties

## 6.0 BIO-ENERGY TIMPs

### 6.1 Improved Energy-Saving Cooking Stoves for Small Holder Farmers

<b>TIMP name</b>	<b>Improved Energy saving Cooking Stoves</b>
Category (i.e. technology, innovation or management practice)	Technology
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Massive deforestation leading to environmental degradation, increased cost of fuelwood, increased indoor pollution affecting household members' health and increasing health related costs, Environmental degradation in search of firewood leading to increased

	GHGs. Seasonal variation in availability or affordability of fuels (e.g. biomass as back-up if fossil fuels or electricity is not available, increasing prices or money shortages at the end of the month)
<p>What is it? (TIMP description)</p>  <p>Source: C. Kundu</p>	<p>It is an improved cooking stove with a high energy efficiency. Cook stoves are commonly called “improved” if they are more efficient, emit less gasses or are safer than the traditional cook stoves or three-stone-fires. The term usually refers to stoves which burn firewood, charcoal, agriculture residues or dung. The improved stove has high energy efficiency. Energy efficiency describes the heat transferred into the pot in relation to the overall energy generated by the stove within a defined task e.g. water boiling. A higher efficiency can be achieved by: better combustion of the fuel by providing an insulated combustion chamber around and above the fire, which leads to a better mixing of gases, flame and air; maximum transfer of heat of combustion from the flame and the hot gases to the cooking pot; minimum loss of heat to the surroundings</p>
Justification	<p>Seventy-five percent of households in Kenya rely on solid biomass energy (mainly firewood and charcoal) as the primary source of fuel for cooking and heating, while only a smaller proportion relies on gas (12%), kerosene (11%) and electricity (0.4%). The use of biomass is predominant in rural areas, with about 95% of the households relying on it.</p> <p>Fuel-wood consumption remains one of the major factors for degradation of Kenya’s forest resources, with the UNFCCC estimating that 92% of biomass consumption in the country is non-renewable (leading to net GHG emissions). Deforestation and degradation is increasing at alarming rates in search of firewood – more stored carbon released. The need for alternative energy technologies are aimed at reducing GHGs emission</p>
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers and wide range of users in the rural and urban areas
Approaches used in dissemination	Demonstrations; Agricultural shows; local FM stations; Mass media & print media; social media; Stakeholder meetings; farmer field schools as well as extension services
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Linkages with private sector - to improve access to technology, capacity building and market support</li> <li>• Affordable energy-saving stoves</li> <li>• Linkages with carbon markets</li> </ul>

Partners/stakeholders for scaling up and their roles	Private sector – access to credit, access to technology County government – capacity building NGOs – Practical Action, SNV, GIZ, Practical Action, One Acre Fund – capacity building, access to technology, credit facilities
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	ASAL counties: Baringo, West Pokot, Tana River, Kajiado, Elgeyo Marakwet, Busia, and Garissa
Counties where TIMP will be promoted	Diverse counties
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Inadequate policies and strategies, regulatory and institutional framework for supporting promotion of ICS</li> <li>• Inadequate financing and affordable credit facilities to support improved stoves related initiatives</li> <li>• Inadequate awareness on socio-economic and environmental benefits of promoting improved cook stoves</li> <li>• Inadequate technical, business and marketing skills for many stove SMMEs</li> <li>• Underdeveloped institutional framework for improved stoves skills transfer to local levels</li> <li>• Poorly developed quality control and monitoring mechanisms for stoves delivered to the end users</li> <li>• Low capacity for County Government support in dissemination of ICS</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Link farmers to Micro Finance Institutions (MFIs)</li> <li>• Capacity building and awareness creation on improved cook stoves</li> <li>• Sensitize county government to support farmers</li> <li>• Strengthen the County government extension system</li> <li>• Work with Public-Private Partnerships</li> <li>• Intensive research to improve the technology</li> </ul>
Lessons learned if any	Capacity building on the environment benefits of improved cook stoves is important for increased uptake
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Enhanced outreach and partnerships</li> <li>• Develop policies and fund initiatives for increased cook stove uptake</li> <li>• Strengthen Public-Private Partnerships to foster uptake</li> <li>• Strategic engagement with NARs for continued market and policy research and information dissemination</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	KES 1150 per unit

Estimated returns	Not known – varied depending on the ICS type
Gender issues and concerns in development, dissemination, adoption and scaling up	The technology is affordable and easy to use; reducing the amount of time women spend looking for firewood and allowing more trees the opportunity to grow.
Gender related opportunities	Opportunity for income generation by establishing green energy enterprises – manufacturers and distributors - source of income and livelihood
VMG issues and concerns in development, dissemination, adoption and scaling up	May be limited in accessing the technology due to the costs involved
VMG related opportunities	<ul style="list-style-type: none"> <li>• The energy-saving devices are easily accessible and user-friendly so VMG can use.</li> <li>• The project will potentially be able to contribute to household energy conservation for the VMGs, which translates into saved incomes and time.</li> <li>• VMGs can establish energy-saving devices enterprises as source of income and livelihood</li> </ul>
<b>E: Case studies/profiles of success stories</b>	
Success stories	<p>The use of improved fuel-efficient stoves can reduce the production of smoke and harmful gasses within households, reduce the use of biomass by up to 60 percent (wood, crop waste, dung etc), reduce cooking cycle times, and create significant household safety and labour benefits.</p> <p>KCSAP-PPP opportunity: BURN Manufacturing Jikokoa cook stove halves fuel use compared to the commonly used jiko stoves allowing women to save 50 Kenyan Shillings a day or up to 18,000 Kenyan Shillings (roughly \$200 USD) per year. As well as providing economic savings, the Jikokoa produces 64 percent less smoke than a standard charcoal jiko and is a vast improvement of air quality, explained Chris McKinney, the Research and Development Engineer at the company.</p>
Application guidelines for users	<p>This depends on the specific technology or ICS</p> <p><b>References</b></p> <ol style="list-style-type: none"> <li>1. Stephen Gitonga. Appropriate Mud Stoves In East Africa</li> <li>2. Koffi Ekouevi 2013. Scaling Up Clean Cooking Solutions: The Context, Status, Barriers and Key Drivers. World Bank</li> <li>3. Mercy Corps 2010. Basic Guide To Fuel Efficient Stoves And Emission Testing</li> <li>4. The Republic of Uganda 2008. Construction Manual For Household Rocket Stoves. Ministry Of Energy And Mineral Development</li> <li>5. FAO 1993. Indian Improved Cookstoves: A Compendium</li> </ol>

	<p>6. UNHCR 2002. Cooking Options In Refugee Situations A Handbook Of Experiences In Energy Conservation And Alternative Fuels</p> <p>7. Lydia Muchiri and May Sengendo. Appropriate Household Energy Technology Development Training Manual</p>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up scaling
<b>G: Contacts</b>	
Contacts	Director, Environment & Natural Resource Systems KALRO Secretariat P.O. Box 57811-00200 +254 722 206986/8, Ext 2316
Lead organization and scientists	KALRO, P. Ketiem, M. Okoti, T. Nandokha
Partner organizations	County government, PPP with MASH Biotech ApS, BURN (Jikokoa), SNV, GIZ

### Research gaps

1. Assessment of effectiveness of different business models, and their potential for scale up

## 6.2 Biogas

<b>TIMP name</b>	<b>Biogas</b>
Category (i.e. technology, innovation or management practice)	Technology
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Greenhouse gas emissions, increased cost and scarcity of fuelwood, massive deforestation, increased indoor pollution and declining soil fertility coupled with overall environmental degradation
What is it? (TIMP description)	Biogas is the mixture of gases produced by the breakdown of organic matter in the absence of oxygen. This can be produced from raw materials such as agricultural waste and manure, among others
Justification	Deforestation and degradation is increasing at alarming rates in search of firewood. Decreased availability of fuelwood, makes women spend a lot of time looking for firewood. Animal manure is not well managed and a lot of methane is lost which could be used as gas for domestic purposes. In turn the slurry produced as waste during biogigestion can be used as quality fertilizer for crop growth, enhancing productivity and food security. Used of fuelwood releases a considerable amount of carbon dioxide into the atmosphere, contributing to GHG emissions. Using biogas technology reduces GHGs emission.

	Biogas provides energy to cook; reduces workload for women for collecting firewood; saves time that can be used for other activities; improves health – through reduction of indoor air pollution; improves agricultural productivity by encouraging zero grazing; improves environment protection and sanitation through reduced water pollution. The technology has potential for income generation through business, with the main direct beneficiaries being women and VMGs
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers and wide range of users in the rural and urban areas
Approaches used in dissemination	Demonstrations, Agricultural shows, local FM stations, Mass media & print media, social media, chiefs Baraza, farmer field schools as well as extension services
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Linkages with Private sector - to improve production capacity and empowerment</li> <li>• Linkages with credit facilities</li> <li>• Technical skills development for the users</li> <li>• Capacity building on the benefits of biogas</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• Private sector (KENDIP, KENFAP) – access to technology, access to credit, technology installation</li> <li>• County government – capacity building, policy support, credit facilities,</li> <li>• NGOs (Practical Action, SNV, GIZ, HIVOS, Kenya Biogas Programme, Afrisol, Biogas International Ltd, Flexi Biogas Systems, SCODE)– access to technologies, capacity building, technology installation</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	Baringo, Kajiado, Elgeyo Marakwet, Busia, Narok, Kakamega, Garissa, Kiambu, Nyandarua, Nakuru
Counties where TIMP will be promoted	Baringo, West Pokot, Tana River, Kajiado, Elgeyo Marakwet, Busia, and Garissa
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Male control of land and credit for investment and role of men in decision-making may limit ability of interested women to install biogas</li> <li>• Different perception and prioritization of energy issues in the household may lead to low adoption of biogas even where women recognize its benefits</li> <li>• The cost of technology installation is still prohibitive to many potential users</li> <li>• Limited number of skilled artisans to construct and provide maintenance services</li> <li>• Limited feed stock in some households</li> </ul>

	<ul style="list-style-type: none"> <li>• Inadequate post installation support</li> <li>• Poor management and maintenance (because of household labour constraints)</li> <li>• Many potential users of the technology are not aware of the technology</li> <li>• Lack of quality control and standards</li> </ul>
Suggestions for addressing the challenges	<ul style="list-style-type: none"> <li>• Link households to Micro Finance Institutions (MFIs)</li> <li>• Sensitize county government to support households</li> <li>• Work with PPPs for technology access, technical skills development and management</li> <li>• Intensive research to improve the technology</li> <li>• Aggregation of feedstock to supply the households in a centralized place</li> <li>• Technical capacity development, as a package in biogas roll out</li> <li>• Awareness creation on the benefits from biogas adoption to women</li> <li>• Address household decision-making processes (and control of assets such as land or capital) that may prevent adoption even when women are interested</li> <li>• Improve targeting of access to information for women and men</li> </ul>
Lessons learned if any	<ul style="list-style-type: none"> <li>• Benefits of biogas systems are realized with time</li> <li>• Technical skills development is important for ease of management at the household level</li> </ul>
Social, environmental, policy and market conditions necessary	<ul style="list-style-type: none"> <li>• Enhanced outreach and partnerships</li> <li>• Strategic engagement with NARs for continued market and policy research and information dissemination</li> <li>• Implementation of policies on green energy</li> <li>• Financial incentives to spur technology access and expansion of market reach</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	Average installation costs Kshs. 75,000
Estimated returns	Payback period of two years
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Limited gender or end users' participation in the design of digesters and appliances in line with their needs and priorities</li> <li>• Limited skills in biogas development and installation</li> <li>• Limited skills in sales and marketing</li> <li>• Competing uses of agricultural waste e.g. cow dung for biogas feedstock or manure. Although women may be the main provisioner and user of energy, they are not necessarily the main decision maker in a household.</li> </ul>

	<ul style="list-style-type: none"> <li>• Male household heads may not consider the benefits of biogas adoption, particularly the benefits for women, or may have different considerations and</li> <li>• prioritization of concerns</li> <li>• Men often control the resources required for biogas adoption</li> <li>• Gender disparities in access to information may impact on adoption decisions. Access to information is a pre-requisite for informed decisions on adoption</li> </ul>
Gender related opportunities	<ul style="list-style-type: none"> <li>• Skills training for women in Biogas development</li> <li>• Encourage women to become biogas installers and service providers</li> <li>• Hire women for promotion and sales work</li> <li>• Credit support for women entrepreneurs</li> <li>• Link biogas programme with income generation for women users</li> </ul>
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>• Limited skills in biogas development and installation</li> <li>• Limited skills in sales and marketing</li> <li>• Limited access to biogas feedstock at the household level</li> <li>• Limited access and control of resources required for biogas adoption</li> </ul>
VMG related opportunities	<ul style="list-style-type: none"> <li>• Skills training in Biogas development</li> <li>• Encourage VMGs to become biogas installers and service providers</li> <li>• Hire VMG for promotion and sales work</li> <li>• Link biogas programme with income generation for VMG users</li> </ul>
<b>E: Case studies/profiles of success stories</b>	
Success stories	<p>About 22,000 biogas plants have been installed in the country of which 20,000 rely on livestock manure and the rest from crop waste.</p> <p>Mr. Muraguri installed in Biogas in August 2015 from SIMGAS. Having three cows on his farm provided the best opportunity to generate biogas. Since the installation, he has not looked back. “My wife’s cooking experience has transformed. She no longer has to go looking for firewood or struggle in a smoky kitchen.” Apart from the biogas, he has been using the slurry as a fertilizer for his farm. This has improved the yields from his farm. He does not use any other chemical fertilizer or pesticides. “The smell of the slurry has also helped wade off moles which were a nuisance,” he noted. The bio slurry is a good pest repellent and has a lifespan of four years on the farm before reapplication.</p>


Application guidelines for users	<p>The specifications for construction need to be sought from a skilled artisan</p> <p><b>References</b></p> <ol style="list-style-type: none"> <li>1. Karanja, G.M. and Kiruiro, E.M 2003. Biogas Production. KARI Technical Note No.10, January 2003</li> <li>2. Al Seadi T, Rutz D, Prassl H, Köttner M, Finsterwalder T, Volk S and Janssen R 2008. Biogas handbook.</li> <li>3. University of Southern Denmark Esbjerg, Niels Bohrs Vej 9-10, DK-6700 Esbjerg, Denmark</li> <li>4. Dana R 2010. Micro-Scale Biogas Production: A Beginners Guide. NCAT. <a href="http://www.attra.ncat.org/attra-pub/PDF/biogas.pdf">www.attra.ncat.org/attra-pub/PDF/biogas.pdf</a></li> <li>5. World Bio-energy Association 2013. Biogas – An Important Renewable Energy Source: WBA Fact Sheet</li> <li>6. Biogas Solutions Uganda Ltd and SNV. Operation and Maintenance of Biogas Plants, Bio-Slurry Management and Use: A Practical Handbook for the Trainer of Trainers of Biogas Construction Enterprises</li> <li>7. UK AID 2013. The Potential of Small-Scale Biogas Digesters to Improve Livelihoods and Long Term Sustainability of Ecosystem Services in Sub-Saharan</li> <li>8. Africa.</li> </ol>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	<p>1 =Ready for up scaling</p> <p>The use of slurry as a soil fertility amendment- direct application and compost making requires further research and validation.</p>
<b>G: Contacts</b>	
Contacts	<p>Director, Environment &amp; Natural Resource Systems KALRO Secretariat P.O. Box 57811-00200 +254 722 206986/8, Ext 2316</p>
Lead organization and scientists	<p>KALRO, P. Ketiem, M. Okoti, T. Nandokha, P. Njeru, S. Kimani and D. Kamau</p>
Partner organizations	<p>County government, PPP with MASH Biotech ApS, BURN (Jikokoa)</p>

## Research gaps

1. A re-examination of the efficiency of the technologies. The low cost plastic tubular digester appears promising, but fieldwork indicates that there are several technical issues that need to be resolved;
2. Ways of storing/using excess gas produced
3. Exploring the possible ways of packaging biogas sludge as a fertiliser

4. Research into the relative merits of sludge from the digesters on different crops for sustainable land management
5. Ways of reducing the fabrication costs;
6. Effective communications for promotion of the technology and emerging socio-economic (including gender) dynamics with the introduction of the technology
7. Utilization of slurry for soil improvement as raw or compost

### 6.3 Briquettes from Bagasse

TIMP name	Briquettes from Bagasse
Category (i.e. technology, innovation or management practice)	Technology
<b>A: Description of the technology, innovation or management practice</b>	
Problem addressed	Increased cost of fuelwood, increased scarcity of fuelwood, massive deforestation and environmental degradation in search of firewood leading to increased GHGs
What is it? (TIMP description) 	<p>It is the manufacture of a compressed block of combustible biomass material out of Bagasse (the dry pulpy fibrous residue that remains after sugarcane or sorghum stalks are crushed to extract their juice). It is used as a biofuel for the production of heat, energy, and electricity.</p> <p>Briquettes are mostly used in places where cooking fuels are not easily available</p>
Justification	<p>Due to intensive deforestation, the government started to issue official bans on the production and transportation of charcoal which led to adoption of environmental sound fuels as early as 1980's. The implementation of the Energy Act of 2006 has led to a reduction of dependency on charcoal, together with wider programme of awareness creation and dissemination of energy efficient equipment.</p> <p>Briquettes are believed to offer an alternative fuel which is clean and environmentally friendly. A number of biomass are used to produce them for examples sugarcane waste, maize cobs, charcoal dust, macadamia shell, sawdust, coconut waste and rice husks amongst others.</p> <p>Briquettes have numerous advantages over other form of fuels which include lower cost of production since they use waste materials; there is easy availability of materials for production; eco-friendly – utilizes waste hence helps in recycling and reduces pressure placed on natural</p>

Source: C. Kundu, Kakamega

	<p>resources; and it's a source of income - provide additional income to the farmers who can sell their agro waste to briquette manufacturing companies thus offering a very good substitute for wood fuel, charcoal coal and lignite.</p> <p>Sugar cane bagasse briquettes are renewable sources of energy; they are also cheaper than coal. They lack sulfur meaning they don't pollute the environment. Besides, sugarcane bagasse briquettes have high thermal value and low ash content. They have high energy value compared to other sources of energy like wood.</p>
<b>B: Assessment of dissemination and scaling up/out approaches</b>	
Users of TIMP	Farmers and wide range of users in the rural and urban areas
Approaches used in dissemination	Demonstrations, Agricultural shows, local FM stations, Mass media & print media, social media, chiefs Baraza, extension services
Critical/essential factors for successful promotion	<ul style="list-style-type: none"> <li>• Linkages with Private sector - to improve production capacity and empowerment</li> <li>• Linkages with credit facilities</li> <li>• Technical skills development for the users</li> <li>• Awareness creation on the environment benefits of briquettes</li> </ul>
Partners/stakeholders for scaling up and their roles	<ul style="list-style-type: none"> <li>• Private sector (including individuals)- access to technology, access to credit, technology installation</li> <li>• County government – capacity building, policy support, credit facilities,</li> <li>• NGOs (Practical Action, SNV, GIZ, HIVOS, SCODE)- access to technologies, capacity building, technology installation</li> </ul>
<b>C: Current situation and future scaling up</b>	
Counties where already promoted if any	All Counties
Counties where TIMP will be promoted	All Counties
Challenges in dissemination	<ul style="list-style-type: none"> <li>• Briquettes and/or their benefits are unknown to many biomass fuel users, which makes tapping into the potential market challenging and costly.</li> <li>• Access to finance is a major bottleneck for the advancement of the briquette sector and is part of the reason why there are a limited number of briquette businesses operating purely on a commercial basis</li> <li>• Lack of product certification or standardization of briquettes, thus resulting in substandard</li> </ul>

	<p>briquettes being produced by many small- and medium-scale businesses</p> <ul style="list-style-type: none"> <li>• Briquettes and/or their benefits are unknown to many biomass fuel users, which makes tapping into the potential market challenging and costly.</li> <li>• Medium- and large-scale briquette operations face input-related risks which increase the cost of production – e.g. procuring a consistent supply of raw materials in appropriate quantities and desired quality is a bottleneck</li> <li>• Packaged weight inconsistent with market demand</li> <li>• Producer price is too high to make it competitive with charcoal and other cook stove fuels</li> <li>• Different perception and prioritization of energy issues in the household may lead to low adoption of briquettes even where women recognize its benefits</li> <li>• Many potential users of the technology are not aware of the technology</li> </ul>
<p>Suggestions for addressing the challenges</p>	<ul style="list-style-type: none"> <li>• Link businesses to Micro Finance Institutions (MFIs)</li> <li>• Sensitize county government to support households access the technology</li> <li>• Work with PPPs for technology access – especially briquetting machines, technical skills development and management</li> <li>• Intensive research to improve the technology</li> <li>• Aggregation of feedstock for steady supply in making briquettes</li> <li>• Diversify feedstock supply in order to reduce cost of supplies and increase volume, largely from locally available agricultural wastes.</li> <li>• Increased market awareness for increased uptake in retail markets</li> <li>• Policy on product standardization</li> </ul>
<p>Lessons learned if any</p>	<p>Drying the briquettes well and applying an adequate amount of pressure and binder improves the bulk density and durability of the briquettes. These are important parameters, especially if the briquettes are to be transported long distances.</p> <p>Fuel briquette enterprise development requires workable partnerships for resource mobilization, technological support, establishment of linkages among stakeholders and enabling policy</p>
<p>Social, environmental, policy and market conditions necessary</p>	<ul style="list-style-type: none"> <li>• Enhanced outreach and partnerships</li> <li>• Strategic engagement with NARs for continued market and policy research and information dissemination</li> <li>• Implementation of policies on green energy</li> </ul>

	<ul style="list-style-type: none"> <li>Financial incentives to spur technology access and expansion of market reach</li> </ul>
<b>D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations</b>	
Basic costs	This depends on the material used in producing the briquettes but they can be as low as 50 shillings per one kilogram of briquette. The cost of briquetting machines vary but the minimum cost is Kshs. 20,000
Estimated returns	Not known
Gender issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>Depending on the technology used, some may not favor women because of the costs involved</li> <li>Although women may be the main provisioner and user of energy, they are not necessarily the main decision maker in a household.</li> <li>Male household heads may not consider the benefits of briquette adoption, particularly the benefits for women, or may have different considerations and prioritization of concerns</li> <li>Gender disparities in access to information may impact on adoption decisions. Access to information is a pre-requisite for informed decisions on adoption</li> </ul>
Gender related opportunities	Offers an opportunity for income generation for women through development of briquettes and sales
VMG issues and concerns in development, dissemination, adoption and scaling up	<ul style="list-style-type: none"> <li>Limited skills in briquette development and installation</li> <li>Limited skills in sales and marketing</li> <li>Limited access to briquette feedstock at the household level</li> <li>Limited access and control of resources required for briquette adoption</li> </ul>
VMG related opportunities	Offers an opportunity for income generation for women through development of briquettes and sales
<b>E: Case studies/profiles of success stories</b>	
Success stories	<p>Acacia Innovations is a company that makes briquettes from sugar cane bagasse. So far, they have employed 70 people, most of whom would traditionally have difficulties finding employment. Additionally, sugarcane briquettes have numerous environmental and health advantages.</p> <p>The use of traditional firewood for cooking leads to deforestation; every ton of sugarcane briquettes saves 25 trees. Furthermore, the product has almost no smoke. In the short term, this means that cooks do not suffer as much from coughing, watery eyes, etc.; in the long run, they are less at risk for respiratory illnesses. <a href="https://www.kenyacic.org/news/acacia-innovations-esfm-success-story">https://www.kenyacic.org/news/acacia-innovations-esfm-success-story</a></p> <p>By 2010 some of the most successful community groups in Kibera, Kahawa Soweto, and similar low-</p>

	<p>income neighbourhoods in Nairobi were making up to \$2000 monthly from the sale of charcoal briquettes, and women were slashing their cooking-fuel costs to a tenth or less</p> <p>Milka, a 30-year-old mother of two and a member of the self-help group ‘Kahawa Soweto Youth in Action’, makes her living by selling charcoal briquettes made by her group in Nairobi to residents of a village called ‘Engineer’ about 80 km west of Nairobi, and in Limuru and Kirinyaga. ‘Engineer’ village abuts the Aberdare forest, one of Kenya’s most important water catchment areas and game reserves</p>
Application guidelines for users	<ul style="list-style-type: none"> <li>• Crushing system - Sugarcane waste is crushed into 2- 5mm diameter pieces by the crusher hammer mill. Raw material needs to be cut into high quality and uniform thickness.</li> <li>• Drying - Crushed sugar cane bagasse should have moisture below 10%. Drying ensures high-quality charcoal is produced.</li> <li>• Briquetting - After drying the raw material is taken to the briquette making machine. Compressing under high pressure produces high density, small size, and better combustion sugarcane bagasse briquettes.</li> <li>• Carbonizing - Carbonization Furnace is a stove that changes biomass briquettes into the charcoal briquette.</li> </ul> <p><b>References</b></p> <ol style="list-style-type: none"> <li>1. AMAHAWWE Uganda. AWU Briquette Manual: Fuel from The Fields - Making Fuel Briquettes</li> <li>2. BTG Biomass Technology Group 2013. Sustainable Charcoal Production From Alternative Feedstocks</li> </ol>
<b>F: Status of TIMP readiness</b> (1=Ready for up scaling; 2=Requires validation; 3=Requires further research)	1 =Ready for up scaling
<b>G: Contacts</b>	
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Partner organizations	County government, PPP with MASH Biotech ApS, BURN (Jikokoa)

**Research gaps**

1. The Energy and GHG values of different briquette materials
2. The economics of briquetting from Bagasse



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