INVENTORY

OF

CLIMATE SMART NATURAL RESOURCE MANAGEMENT & SUSTAINABLE BIO-ENERGY TECHNOLOGIES, INNOVATIONS & MANAGEMENT PRACTICES

Compiled by

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Kenya Agricultural and Livestock Research Organization

Under

KENYA CLIMATE SMART AGRICULTURE PROJECT (KCSAP)

July 2019

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1. INTRODUCTION

1.1 Background Information

The Kenya Climate Smart Agriculture Project (KCSAP) is a Government of Kenya/World Bank supported project under the State Department for Crops Development in the Ministry of Agriculture, Livestock, Fisheries and Irrigation (MoALF&I). The Project Development Objective (PDO) is "to increase agricultural productivity and build resilience to climate change risks in targeted smallholder farming and pastoral communities in Kenya, and in the event of an Eligible Crisis or Emergency, to provide immediate and effective response". This objective will be achieved through utilization of climate-smart agriculture (CSA) technologies, innovations and management practices (TIMPs). Natural Resource Management technologies, innovations and management practices are critical in achieving food security under a changing climate while delivering co-benefits for environmental sustainability, nutrition and livelihoods.

The KCSAP Project aims to inventorize all CSA TIMPs in the Natural Resource Management and Bio-energy. The overall goal is three pronged: (i) Improve efficiency in the use of natural resources for increased food production; (ii) Maintain the resilience of agricultural systems and the dependent communities, and (iii) reduce GHG emissions per unit of output.

1.2 Definition of Terms for Technologies, Innovations and Management Practices

1.2.1 Technology: Is an output of a research process which is beneficial to the target clientele (mainly farmers in our case). Technology can be commercialized and can be patented under Intellectual Property Rights (IPR) arrangements. **Examples** include research outputs such as fertilizer types.

1.2.2 Complementary Technology: Is any accompanying information on practice(s) that is (are) considered necessary for a technology to achieve its optimum output. **Examples** include integrated soil fertility management; fertilizer application rates.

NOTE: 'Complementary technology' is important information which is generated through research to accompany the parent technology before it is finally released to users and the technology would be incomplete without this information.

1.2.3 Innovation: Is a modification of existing technology for an entirely different use from the original intended use. It is also an application of new or existing knowledge/technology in a new way or context to do something better or different. **An example** is Rapid soil testing services using dry chemistry methods (i.e. scanners) for direct testing soils in farmers' fields.

1.2.4 Information/Knowledge: This is generated by adaptation trials which are site specific. Technology can be acquired by a KALRO from other sources e.g. external to the country, higher education centres/national research institutions or from CGIAR Centres and taken through adaptability trials to evaluate and fine-tune it to fit with the biophysical and socio-economic circumstances within the mandate areas of KALRO. **Examples** include growth performance of improved crop seed in different ecological zones. The resulting recommendations are classified as **knowledge** since they enlighten the target clientele in the area on a certain best practice(s).

1.2.5

Management practice: This is defined as recommendation(s) on practice(s) that is/are considered necessary for a technology to achieve its optimum output. These include, for instance, different agronomic and practices (seeding rates, fertilizer application rates, spatial arrangements, planting period, land preparation, watering regimes, etc.), protection methods, for crops; and feed rations, management systems, disease control methods, etc. for animal breeds. This is therefore important information which is generated through research to accompany the parent technology before it is finally released to users and the technology would be incomplete without this information.

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

The inventory process resulted in a total of 25 TIMPs including 14 technologies, 6 complementary technologies, 2 innovations and 3 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

Thematic area	Sub-Theme	Technologies	Complementary Technologies	Innovations	Management practice
Land, water & agroforestry (Natural Resource Management)	Soil fertility management	-	2	1	-
	Soil & water management	8		2	2
	Irrigation and drainage	1	-	1	-
	Agroforestry systems	-	3	-	2
Sustainable Bio-energy	Bio-energy systems	3	-	-	
Totals		**12**	**5**	**4**	**5**

1.4 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	-	2	1
	Soil & water management	7	3	2
	Irrigation and drainage	1	1	-
	Agro forestry systems	2	1	2
Sustainable bio-energy	Bio-energy systems	1	1	1
Totals		**11**	**8**	**6**

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

TIMPs Sub-Theme	TIMPs Title	TIMPs Category	Status
Soil fertility management	Integrated soil fertility management	Complementary technology	Requires validation
	Integrated manure management	Complementary technology	Further research
	Rapid soil testing services	Innovation	Requires validation
Soil and water management	Conservation agriculture	Management practice	Ready for up scaling
	Zai pits	Technology	Ready for up-scaling
	Contour bunds	Technology	Ready for up scaling
	Bench terraces	Technology	Ready for up scaling
	Fanya juu terraces	Technology	Ready for up scaling
	Gabions	Technology	Requires validation
	Grass strips	Innovation	Ready for up scaling
	Stone lines	Technology	Requires validation
	Tied ridges	Technology	Requires validation
	Mulching	Innovation	Further research
	Roof catchment	Technology	Ready for up scaling
	Intercropping	Complementary technology	Further research
Irrigation and drainage management	Drip irrigation	Technology	Ready for up scaling
	Solar for small scale irrigation	Innovation	Requires validation
Agroforestry systems	Agroforestry for soil fertility	Management practice	Requires validation
	Agroforestry for fodder	Complementary technology	Ready for up scaling
	Agroforestry for fruit trees	Complementary technology	Further research
	Windbreaks and live hedges	Management practice	Ready for up scaling
	Woodlots for energy	Management practice	Further research
Bio-energy systems	Biogas	Technology	Requires validation
	Briquettes	Technology	Ready for up scaling
	Improved Cooking Stoves	Technology	Further research

2. SOIL FERTILITY MANAGEMENT TIMPs

2.1 Integrated Soil Fertility Management (ISFM)

TIMP name	**Integrated Soil Fertility Management (ISFM)**
Category (i.e. technology, innovation or management practice)	Complementary technology
A: Description of the technology, innovation or management practice	
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 combined to adapt practices to local conditions. The ISFM places emphasis on the importance of using often scarce resources like 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 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. 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.
B: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers
Approaches to be used in dissemination	Training in workshops On-farm visits Farmer field schools (FFS) On-farm demonstrations (during FFS)
Critical/essential factors for successful promotion	- Availability of affordable and quality manure, fertilizers and clean planting materials - Take into account variability between farms, in terms of farming goals and objectives, size, labour availability, ownership of livestock, importance of off-farm income; and - Take into account amount of production resources (i.e. land, money, labour, crop residues) that different farming families are able to invest in.
Partners/stakeholders for scaling up and their roles	• County government extension services - Provide link with farmers. • Community farmer groups - play coordination role for ease in problem identification and dissemination.
C: Current situation and future scaling up	
Counties where already promoted if any	Machakos, Busia, Siaya, Kisumu, Kakamega, Tharaka Nithi, Isiolo, Nyeri, Uasin Gishu, Elgeyo Marakwet
Current extent of reach	Practiced in some value chains in the 10 counties above
Counties where TIMP will be promoted	Bomet, Kericho, West Pokot, Taita Taveta, Lamu, Nyandarua, Tana River, Baringo, Marsabit, Garissa, Kajiado, Laikipia
Challenges in dissemination	- Change of mindset in some regions/cultures that organic manures cannot be applied on crops - Misconceptions that chemical fertilizer damage the soils
Suggestions for addressing the challenges	- Awareness trainings on role of organic manures in crop cultivation - Training and awareness creation on the usefulness of fertilizer applications to clear the misconceptions about fertilizers
Lessons learned if any	For ISFM to succeed, good germplasm/seed/seedlings, etc is required since farmers tend to re-use previous planted materials.
Social, environmental, policy and market conditions necessary	- Practice is socially acceptable, - Environmentally friendly, - Increased productivity will provide supply to the markets, - Supporting frameworks/policies are available
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
Basic costs	This is a technically demanding technology and high cost in areas where application of ISFM is non-responsive
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,	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.

dissemination adoption and scaling up	Adoption and scaling up of ISFM technologies could be affected by the ownership of the farm that are mainly male owned where the man does not own the technology
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	VMGs are physically disadvantaged for a practice that seeks to incorporate manures, etc in the farm. They are also resource poor and may not have the resources to purchase seed and fertilizers as required for successful implementation of the practice.
VMG related opportunities	The technology if well-practiced can increase farm incomes of VMGs by up to 50%.
E: Case studies/profiles of success stories	
Success stories	ISFM successes have been reported in sorghum and millet value chains in Machakos where the productivities have been improved
Application guidelines for users	- Always use well-adapted, disease- and pest-resistant germplasm/seed to make efficient use of available nutrients. - Ensure that good agronomic practices are upheld - For sustainability, use of pure inorganic or organic materials should be avoided but should rather be used in recommended combination.
F: Status of TIMP readiness (1=Ready for upscaling: 2=Requires validation; 3=Requires further research	2
G: Contacts	
Contacts	Centre Director, KALRO Kabete P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: cd.narl@kalro.org
Lead organization and scientists	KALRO; E. Gikonyo, C. Kibunja, A. Muriuki, D. Kamau, A. Esilaba, J. Ndufa
Partner organizations	County governments KEFRI

Research Gaps

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

2.2 Integrated Manure Management (IMM)

Technology name	Integrated Manure Management
Category (i.e. technology, innovation or management practice)	• Complementary technology

A: Description of the technology, innovation or management practice	
Problem addressed	Declining soil fertility has resulted in low crop productivity. To address this challenge, farmers have resulted to use of manures, albeit poorly in terms of management and handling leading to increased 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 (and aquaculture).
Justification	The decline in soil fertility in smallholder system is a major factor inhibiting agricultural development on farms. It is estimated that soils are being 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 growing on land 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 to providethe limiting nutrients and improve the soil health.
B: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers
Approaches used in dissemination	Open and field days Exchange visits Demonstration farms
Critical/essential factors for successful promotion	• Training on feeding, management and use of manure • Dissemination approach used to reach target farmers • Model demonstration plots using cereal crops
Partners/stakeholders for scaling up and their roles	• County government extension services - Provide link with farmers. • Community farmer groups - play coordination role for ease in problem identification and dissemination • ILRI - technical backstopping • NGOs – micro financing services
C: Current situation and future scaling up	

Counties where already promoted if any	Tharaka Nithi, Kajiado, Uasin Gishu
Current extent of reach	Though small scale farmers in the counties apply manures and composts on their farms, they do not optimize on usage.
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	• Limited model demonstration farms • Cultural challenges -Lack of interest by pastoral communities • Lack of continuity in training of extension and farmers in the skill for manure management • Lack of proper mobilization mechanism for reaching many farmers
Suggestions for addressing the challenges	• Establishment of many demonstration plot by counties • Capacity building of pastoral communities on manure management and its benefit • Continuous capacity building of demonstration farmers and extension workers • Use of approaches to mobilize farmer to attend demonstration forums
Lessons learned if any	- Proper use of manures improves soil fertility - Use of manures enhances crop productivity - Skills in manure preparation, storage and application ensures efficiency and effectiveness
Social, environmental, policy and market conditions necessary	• Applying manure to soils saves on purchase of inorganic fertilizer, increases crop yield and saves water. • Propagation of invasive species when the seed is ingested by the animal and passed to crop field • Manure can harbour pathogens which can cause disease outbreaks to livestock • Contamination of water sources by leaching of nutrients • Organic manures when poorly handled increase GHG emissions. However, IMM provides practices that are able to minimize GHG emissions
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
Basic costs	Proper handling of manure needs labour for collecting the manure, storing and maintaining it and finally transporting and applying it in the field which takes a lot of effort and time. Manure costs

	are dependent on type, e.g. goat, sheep, cattle, poultry, etc. Using locally available manure often saves on purchase of inorganic fertilizer.
Estimated returns	Returns dependent on crop and crop varieties in the value chain where IMM is practiced
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
Gender related opportunities	Manure is locally available for farm households that keep livestock, hence opportunities available for both men and women.
VMG issues and concerns in development, dissemination, adoption and scaling up	It is labour intensive in terms of handling and application hence may disadvantage VMGs. The VMGs are also resource poor, hence may not have access to adequate manures, e.g. need many livestock
VMG related opportunities	Manure is locally available for those farm households with livestock and can build on what they already own
E: Case studies/profiles of success stories	
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	The guideline focus on the following areas:- • Animal feeds • Livestock housing and manure collection • Manure storage to preserve nutrient and avoid loses • Manure treatment for ease of transport and application in the field • Timing of application for maximum utilization by the crop • Anaerobic digestion for biogas production • Regular analysis of manure to ascertain the quality • Manure/Composts take a long time to cure, hence need good planning prior to use.

	• IMM is always site specific and users advised to only use information relevant to local circumstances
F: Status of TIMP readiness (1=Ready for upscaling: 2=Requires validation; 3=Requires further research	2
G: Contacts	
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. Esilaba
Partner organizations	County government, Private Public Partnerships

Research gaps

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

2.3 Rapid soil testing services

TIMP name	**Rapid soil testing services**
Category (i.e. technology, innovation or management practice)	Innovation
A: Description of the technology, innovation or management practice	
Problem addressed	• Conventional methods for soil testing are expensive for farmers, results take long and are not reproducible. • Further, conventional methods have not provided solutions for paired soil and leaf testing to determine health of soil and crop simultaneously. • Current methods do not provide a framework for large scale assessment of geo-referenced sampled points using standardized protocols. • Limited access to soil testing services (centralized soil testing laboratories and cost).
What is it? (TIMP description)	• This is a dry method for soil testing using simplicity of light—the interaction of electromagnetic radiation with matter to characterize biochemical composition of a soil and/or plant tissue. • Requires partners involved (ICRAF, iSDA and SoilCares) to work closely with KALRO and county agricultural officers to sensitize farmers to embrace the testing method. • This innovation will involve working closely with agronomists to generate specific fertilizer recommendation driven by soil and crop data obtained.

Justification	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. However, limited access to soil testing services is depriving the farmers' ability to make informed decisions with regard to soil management and fertilizer use.
B: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers, Extension officers
Approaches to be used in dissemination	• Farmer visits • Training in workshops • Publicity campaigns done at county levels.
Critical/essential factors for successful promotion.	• Availability of the necessary equipment for rapid on the spot soil testing. • Established rapport between farmers and the technical personnel involved in soil testing. • Adequate qualified staff to cover the large number of samples from the target 24 counties before the planting season begins. • 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 recommendation according to crop type suitability). • Farmers must understand, trust, and be willing to act upon the information provided
Partners/stakeholders for scaling up and their roles	• County government extension services; Providing the link to farmers. • Soilcares; Provides soil scanners technology and capacity building in collaboration with KALRO and ICRAF, • ICRAF and iSDA; Tests and validate the recommendations obtained in collaboration with SoilCares and KALRO. • Fertilizer companies; To provide fertilizer blends according to soil health status • Agro dealers to stock required fertilizers that is readily available to farmers
C: Current situation and future scaling up	
Counties where already promoted	Technology has not been promoted though testing has been ongoing in a few counties
Current extent of reach	Minimal reach in Nyeri County
Counties where TIMP will be up scaled	All the 24 KCSAP counties
Challenges in dissemination	• It requires continuous updating of methods to improve recommendations. • Lack of awareness on the importance of regular testing of soil quality
Suggestions for addressing the challenges	• Awareness creation, intensive farmer field training (capacity building)

	• Make the whole process cost efficient. Use of scanners (spectroscopy) and less wet chemistry analysis. • Automated pipelines for updating existing recommendation methods.
Lessons learned in up scaling 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 Sulphur.
Social, environmental, policy and market conditions necessary	• Socially acceptable-brings income, increases food production, nutrition security and family cohesion. • Environmentally friendly; -Recommendations provided ensures that farmers only apply the required amounts of fertilizers. No excess nutrients to contaminate ground and surface water. • Market will absorb the increased productivity • Supporting frameworks/policies are available.
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
Basic costs	• Soil testing equipment and consumables, sampling and packaging materials, personnel. The actual costs will be determined upon consultation. • Shipping selected soil and plant materials for further testing and results verification in a certified lab.
Estimated returns	At least 30% higher returns for all value chains utilising the service.
Gender issues and concerns in development, dissemination adoption and scaling up	By bringing services closer to the users saves farmers (men, women and youth) time and resources.
Gender related opportunities	Offers employment especially for the youth where soil sampling champions will be trained to help the local community in sampling. Retooling of personnel at national and county levels.
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.
E: Case studies/profiles of success stories	
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 sugarcane.
Application guidelines for users	• A handheld scanner to test soils and crops in the field • Community soil sampling champions are identified and trained on good soil sampling procedures. • Soil and crop is analysed and the results including fertilizer recommendation generated on site.
F: Status of TIMP readiness	2

(1=Ready for upscaling: 2=Requires validation; 3=Requires further research	
G: Contacts	
Contacts	Director, Environment & Natural Resource Systems KALRO Secretariat P.O. Box 57811-00200 +254 722 206986/8, Ext 2316
Lead organization and scientists	KALRO; C. Kibunja, E. Gikonyo, Christy van Beek, A. Sila, D. Kamau, A. Esilaba
Partner organizations	County governments in the 24 counties, SoilCares, ICRAF and iSDA

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.

2.4 Low Cost Composting technology

Technology name	**Low Cost Composting**
Category (i.e. technology, innovation or management practice)	• Complementary technology
A: Description of the technology, innovation or management practice	
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	The decline in soil fertility in smallholder system is a major factor inhibiting agricultural development on farms. It is estimated that soils are being depleted at annual rate of

	22kg/ha for nitrogen, 2.5kg/ha for phosphorus, and 15kg/ha for potassium. 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
B: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers
Approaches used in dissemination	Open and field days Exchange visits Demonstration farms Mass and social media
Critical/essential factors for successful promotion	• Training on different composting techniques and use • Dissemination approach used to reach target farmers • Model demonstration plots using cereal crops
Partners/stakeholders for scaling up and their roles	• County government extension services - Provide link with farmers. • Community farmer groups - play coordination role for ease in problem identification and dissemination • ILRI - technical backstopping • NGOs – micro financing services
C: Current situation and future scaling up	
Counties where already promoted if any	Tharaka Nithi, Kajiado, Nyeri, Bomet, Uasin Gishu, Kakamega, Busia, Machakos
Current extent of reach	Composts only used by few small scale farmers who understand its benefits though usage still not optimized.
Counties where TIMP will be promoted	All 24 KSAP counties
Challenges in dissemination	• Lack of model demonstration farms • Lack of continuity in training of extension and farmers in composting skill • Lack of proper mobilization mechanism for reaching many farmers
Suggestions for addressing the challenges	• Establishment of many demonstration plots by counties • Capacity building of smallholder farmers on composting management and its benefit • Continuous capacity building of demonstration farmers and extension workers • Use of approaches to mobilize farmer to attend demonstration forums

Lessons learned if any	• Proper use of composts to improve soil fertility • Use of composts to enhance crop productivity • Skills in composting methodologies and minimizing health risks associated with composts making
Social, environmental, policy and market conditions necessary	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. Generally, applying composts to soils saves on purchase of inorganic fertilizer, increases crop yield and saves water. Hence socially and environmentally acceptable
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
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 Using locally available composts saves on purchase of inorganic fertilizer.
Estimated returns	Returns dependent on crop and crop varieties in the value chain where composting is practiced
Gender issues and concerns in development, dissemination, adoption and scaling up	It is labour intensive in terms of preparation and application (often by broadcasting) hence may disadvantage women
Gender related opportunities	Composts sources are available in farms and households hence opportunities available for both men and women.
VMG issues and concerns in development, dissemination, adoption and scaling up	It is labour intensive in terms of preparation and application hence may disadvantage VMGs.
VMG related opportunities	Materials for compost making include household wastes and only require one to be trained on composting techniques to ensure compost quality.
E: Case studies/profiles of success stories	
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:- • Need to mix the compost with the soil to ensure adequate nutrition in the rooting zone. • Compost storage to preserve nutrient and avoid loses. • Timing of application for maximum utilization by the crop.

	• Regular analysis of compost to ascertain the quality including contaminants like heavy metals and pathogens. • Type of composts and quality that will determine the application rates. • 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. eucalypts and cassia spp. <u>Reference</u> Karanja NK, Kwach HO, Njenga M (2005). Low cost composting training manual. Techniques based on the UN Habitat urban harvest CIP community based waste management initiative.
F: Status of TIMP readiness (1=Ready for upscaling: 2=Requires validation; 3=Requires further research	2
G: Contacts	
Contacts	Director Environment & Natural Resources KALRO Secretariat
Lead organization and scientists	KALRO, B. Mugo, D. Kamau, E. Mutuma, M. Okoti
Partner organizations	County government, NGO's

Research gaps

3. Promote composting technology in counties that have not practiced it.
4. Conduct nutrient budget study on selected farms using composts in the 24 Counties.

3. SOIL AND WATER MANAGEMENT TIMPs

3.1 Contour Bunds

TIMP name	**Contour bunds**
Category (i.e. technology, innovation or management practice)	Technology
A: Description of the technology, innovation or management practice	
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 runoff. Making furrows parallel to the contours ensures that rainfall and runoff 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: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers
Approaches to be 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 and the county extension service providers.
Most effective approach	Model farm demonstration
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 contour bunds. • Land tenure systems that allows individual ownership
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
C: Current situation and future scaling up	
Counties where already promoted if any	Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru
Current extent of reach	Practiced extensively among households in Makueni and Machakos especially in the hilly regions
Counties where TIMP will be promoted	Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu.
Challenge(s) in development and dissemination	• Increased risk of soil erosion if contours are improperly laid out • Labour intensive and many farmers may find it difficult to implement at large scale • Land tenure systems – communal land ownership, or in places where individuals don't have land title deeds
Suggestions for addressing the challenges	• Farmers need to be supported with appropriate equipment for preparation of Contour for efficiency and increased output per man hour. • Training youthful farmers to be champions of Contour bunds construction at the Ward level/village level. • Training on site specific designs and construction of contour bunds • Fast track land registration

Lessons learned, if any	• Terracing is popular due largely to the rapid benefits it gives in terms of improved crop performance. • Existence of well-developed self-help groups can lead to successful soil and water conservation activities. • Conducting well publicised campaigns has been found to add to the success of adoption of soil and water conservation practices. • 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	• Socially acceptable technology but needs awareness creation on its importance • Current national policies on soil and water conservation need to be enforced at the County level • Require policies that support individual land tenure systems
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
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	• Ownership of or access to land may limit women in some regions • Making decisions on land use may limit women in some region where decision making is men dominated • Differing accessibility of the technology and information may disadvantage different gender • The technology is labour intensive hence may disadvantage women and members who cannot procure labour services • 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. • Ownership of or access to land and credit will affect adoption and scaling up.
Gender related opportunities	• Increased agricultural production will increase access to food and income among all gender. • Potential for employment creation - youthful male and women will provide labour during the implementation of the technology.
VMG issues and concerns in development, dissemination, adoption and scaling up	• Limited access to information may bias t the VMG from technology access and use • Limited attendance during awareness and sensitization campaigns due to physical body challenges or insecurity challenges limits use of technologies. • The technology is labour intensive and may be difficult for the VMG to implement in the field. • The labour cost of adopting this technology might be out of reach for the VMGs thus affecting adoption and scaling up. • The technology demands proper training and access to information to enable proper implementation. This might be lacking among the VMGs • Competing priorities and household decisions might hinder adoption and scaling up.

VMG related opportunities	• Application of contour ridge is expected to improve agriculture production thus, more food and income for the VGMs.
E: Case studies/profiles of success stories	
Success stories, if any	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.
F: Status of TIMP readiness 1. Ready for up scaling, 2=Requires validation; 3=Requires further research	1
G: Contacts	
Contacts	**Centre Director** KALRO Kabete. P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: cd.narl@kalro.org
Lead organization and scientists	KALRO, E. Mutuma; J. Wamuongo; M, Wairimu; P. Kitiem, J. Mwaura; D. Kamau.
Partner organizations	County Governments extension offices.

GAPS

1. Develop site specific designs for construction – 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 labor demands in contour construction and maintenance
4. Develop a suitable model that guides technology type and costings.

3.2 Zai Pits

TIMP name	**ZAI PITS**
Category (i.e. technology, innovation or management practice)	Technology
A: Description of the technology, innovation or management practice	
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 h*arvest 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 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 to be 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.
Most effective approach	Model farm demonstration
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
Current extent of reach	Limited adoption because of the costs involved
Counties where TIMP will be promoted	Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu.
Challenge(s) in development and 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	• Farmers need to be supported with appropriate equipment for preparation of Zai Pits for efficiency and increased output per man hour. • Training youthful farmers to be champions of Zai pits construction at the Ward level/village level.
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	• Enforce policies on soil and water conservation at the County level • Create awareness on the importance of soil and water conservation • Avail low cost technologies for soil and water conservation • Policies that support individual land tenure systems • Provide support in the establishment of the Zai pits
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	

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	• Ownership of or access to land, farming inputs and credit is an important gender issue in the adoption of ZAI pits. • Making decisions on land use, what to grow, expenditures and savings is an important gender consideration in Zai Pits. This may disadvantage women • 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 • Ownership of or access to land, farming inputs, information technologies (radios, cell phones) and credit will affect adoption and scaling up.
Gender related opportunities	• Increased agricultural produce will increase access to food and income among women, male and youth. • Youthful male and women will provide labour during the implementation of the technology.
VMG issues and concerns in development, dissemination, adoption and scaling up	• Limited of access to information due to factors like physical disability affects technology access • In attendance during awareness and sensitization campaigns due to physical body challenges or insecurity challenges. • The technology is labour intense and may be difficult for the VMG to implement in the field.
VMG issues and concerns in adoption and scaling up	• The labour cost of adopting this technology might be out of reach for the VMGs thus affecting adoption and scaling up. • The technology demands proper training and access to information to enable proper implementation. This might be lacking among the VMGs • Competing priorities and household decisions might hinder adoption and scaling up. • The technology involves carrying of heavy manure to the field during establishment which may be difficult for the physically weak VMGs.
VMG related opportunities	• Application of ZAI pits is expected to improve agriculture production thus, more food and income for the VGMs.
E: Case studies/profiles of success stories	
Success stories, if any	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. Farmers in Kathonzweni, Makueni County increased dug pits from 170 to 500 pits for crop production due to initial observed benefits. Communities in ASALs have also rehabilitated degraded lands and increased production by many folds.

Application guidelines for users	Zai pits are 5-15 cm deep, 15-50 cm wide and 80-100 cm apart (Figure 19). 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. Steps to follow in establishing ZAI pits for specific crops are:- *Sorghum and Millet.* The zai pits are dug during the dry season when labour constraints are minimal. Each 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. *Maize.* The Zai pits is made of circular or square holes 30 cm deep. A square hole measuring 75 x75 x 30 (cm) will accommodates 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.
F: Status of TIMP readiness 1. Ready for upscaling, 2=Requires validation; 3=Requires further research	1
G: Contacts	
Contacts	**Centre Director** KALRO Kabete, P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: cd.narl@kalro.org
Lead organization and scientists	KALRO, E. Mutuma; J. Wamuongo; M, Wairimu; P. Kitiem, J. Mwaura; D. Kamau.
Partner organizations	County Governments extension offices.

GAPS

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

3.3 Bench Terraces

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

What is it? (TIMP description)	Bench 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.
Justification	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: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers
Approaches to be 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 and the county extension service providers.
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 contour bunds. • Land tenure systems that allows individual ownership
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
C: Current situation and future scaling up	
Counties where already promoted if any	Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru
Current extent of reach	Practiced widely among households in Kakamega, Nyeri and Meru
Counties where TIMP will be promoted	Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu.
Challenge(s) in development and dissemination	• Increased risk of soil erosion if terraces are improperly laid out • Labour intensive during construction and maintenance and many farmers may find it difficult to implement at large scale • Land tenure systems – communal land ownership, or in places where individuals don't have land title deeds
Suggestions for addressing the challenges	• Farmers need to be supported with appropriate equipment for preparation of Bench terrace for efficiency and increased output per man hour. • Training youthful farmers to be champions of making bench terraces construction at the Ward level/village level. • Training on site specific designs and construction of bench terraces • Fast track land registration
Lessons learned, if any	• Terracing is popular due largely to the rapid benefits it gives in terms of improved crop performance. • Existence of well-developed self-help groups can lead to successful soil and water conservation activities.

	• Conducting well publicised campaigns has been found to add to the success of soil and water conservation. • 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	• Enforce policies on soil and water conservation at the County level • Create awareness on the importance of soil and water conservation • Avail low cost technologies for soil and water conservation • Policies that support individual land tenure systems
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
Basic costs	The main input cost is the labour for *Bench terrace* preparation. The cost will depend on the land size, labour costs 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	• Making decisions on land use may limit specific gender • Differing accessibility between men and women because of gender norms places access to new information and technologies in the hands of male heads of will affect adoption and scaling up. • Ownership of or access to land and credit will affect adoption and scaling up.
Gender related opportunities	• Increased agricultural production will increase access to food and income among all gender. • Both men and women will provide labour during the implementation of the technology.
VMG issues and concerns in development and dissemination	• The labour cost of adopting this technology might be out of reach for the VMGs thus affecting adoption and scaling up. • The technology demands proper training and access to information to enable proper implementation. This might be lacking among the VMGs • Lack of access to information will limit the VMG accessing and adopting the technology • Competing priorities and household decisions might hinder adoption and scaling up.
VMG related opportunities	• Application of bench terraces is expected to improve agriculture production thus, more food and income for the VGMs.
E: Case studies/profiles of success stories	
Success stories, if any	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	Terraces draining in one direction should be at least 100m or more. The length can be slightly increased in arid and semi-arid regions. 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. 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%.
F: Status of TIMP readiness 1. Ready for upscaling, 2=Requires validation; 3=Requires further research	1
G: Contacts	
Contacts	**Centre Director** KALRO Kabete P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: cd.narl@kalro.org
Lead organization and scientists	KALRO, E. Mutuma; J. Wamuongo; M, Wairimu; P. Kitiem, J. Mwaura; D. Kamau.
Partner organizations	County Governments extension offices.

3.4 Fanya Juu Terraces

TIMP name	**Fanya Juu Terrace**
Category (i.e. technology, innovation or management practice)	Technology
A: Description of the technology, innovation or management practice	
Problem addressed	The risk of soil erosion and increased run off; low soil water retention capacity in most soils
What is it? (TIMP description)	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: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers
Approaches to be 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 and the county extension service providers.
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 contour bunds. • Land tenure systems that allows individual ownership
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
C: Current situation and future scaling up	
Counties where already promoted if any	Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru
Current extent of reach	Practiced in many parts of Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru, especillay among households with steep sloppy land
Counties where TIMP will be promoted	Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu.
Challenge(s) in development and dissemination	• Increased risk of soil erosion if terraces are improperly laid out • Labour intensive and many farmers may find it difficult to implement at large scale • Land tenure systems – communal land ownership, or in places where individuals don't have land title deeds
Suggestions for addressing the challenges	• Farmers need to be supported with appropriate equipment for preparation of terraces for efficiency and increased output per man hour. • Training youthful farmers to be champions of fanya juu terraces construction at the Ward level/village level. • Training on site specific designs and construction of fanya juu terraces • Fast track land registration
Lessons learned, if any	• Fanya juu terracing is popular due largely to the rapid benefits it gives in terms of soil and water conservation. • Existence of well-developed self-help groups can lead to successful soil and water conservation activities. • Conducting well publicised campaigns has been found to add to the success of soil and water conservation. • 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	• Enforce policies on soil and water conservation at the County level • Create awareness on the importance of soil and water conservation • Avail low cost technologies for soil and water conservation • Policies that support individual land tenure systems
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
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	• Ownership of or access to land may limit women in implementing the technology • Limited decision making power on land use may limit women in accessing and adopting the technology

	• Differing accessibility of the technology and information may disadvantage women and in some instances men • Limited access to credit will affect adoption and scaling up among women.
Gender related opportunities	• Increased agricultural production will increase access to food and income among all gender. • Youthful male and women will provide labour during the implementation of the technology.
VMG issues and concerns in development and dissemination	• Limited access to information will limit access to information and adoption • Limited decision making power on land use may limit VMG in accessing and adopting the technology • May not be in attendance during awareness and sensitization campaigns due to physical body challenges or insecurity challenges. • The technology is labour intense and may be difficult for the VMG to implement in the field. • The labour cost of adopting this technology might be out of reach for the VMGs thus affecting adoption and scaling up. • The technology demands proper training and access to information to enable proper implementation. This might be lacking among the VMGs
VMG related opportunities	• Application of contour ridge is expected to improve agriculture production thus, more food and income for the VGMs.
E: Case studies/profiles of success stories	
Success stories, if any	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.
F: Status of TIMP readiness 1. Ready for upscaling, 2=Requires validation; 3=Requires further research	1
G: Contacts	
Contacts	**Centre Director** KALRO Kabete P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: cd.narl@kalro.org
Lead organization and scientists	KALRO, E. Mutuma; J. Wamuongo; M, Wairimu; P. Kitiem, J. Mwaura; D. Kamau.
Partner organizations	County Governments extension service.

3.5 Stone Lines

TIMP name	**Stone lines**
Category (i.e. technology, innovation or management practice)	Technology
A: Description of the technology, innovation or management practice	
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
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: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers
Approaches to be 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 and the county extension service providers.
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 stone lines. • Land tenure systems that allows individual ownership
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; provide collective labour. • External service providers – capacity building and access to technology
C: Current situation and future scaling up	
Counties where already promoted if any	Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru
Current extent of reach	Minimally practiced in hilly parts of Kakamega and Machakos
Counties where TIMP will be promoted	Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu.
Challenge(s) in development and dissemination	• Increased risk of soil erosion if stone lines are improperly laid out • Labour intensive and many farmers may find it difficult to implement at large scale • Land tenure systems – communal land ownership, or in places where individuals don’t have land title deeds
Suggestions for addressing the challenges	• Farmers need to be supported with appropriate tools for preparation and laying of stones lines for efficiency and increased output per man hour.

	• Training youthful farmers to be champions of laying stone lines and maintenance. • Training on site specific designs and laying of stone lines • Fast track land registration
Lessons learned, if any	• Existence of well-developed self-help groups can lead to successful construction of stone lines. • Conducting well publicised campaigns has been found to add to the success of soil and water conservation. • 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	• Enforce policies on soil and water conservation at the County level • Create awareness on the importance of soil and water conservation • Avail low cost technologies for soil and water conservation • Policies that support individual land tenure systems
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
Basic costs	For each hectare, transport and other project costs amount to around KES 25,000.
Estimated returns	The returns depends on the value chain being addressed
Gender issues and concerns in development, dissemination, adoption and scaling up	• Limited ownership of or access to land may limit women from technology implementation • Limited decision making powers s on land use may limit women in technology adoption • The technology is labour intensive and may limit implementation by women • 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. • Limited access to appropriate tools and credit may limit application of technology among specific gender e.g. women
Gender related opportunities	• Increased agricultural production will increase access to food and income among all gender. • Men and women will provide labour during the implementation of the technology.
VMG issues and concerns in development, dissemination, adoption and scaling up	• Limited access to information will limit access to information and adoption • Limited decision making power on land use may limit VMG in accessing and adopting the technology • May not be in attendance during awareness and sensitization campaigns due to physical body challenges or insecurity challenges. • The technology is labour intense and may be difficult for the VMG to implement in the field. • The labour cost of adopting this technology might be out of reach for the VMGs thus affecting adoption and scaling up. • The technology demands proper training and access to information to enable proper implementation. This might be lacking among the VMGs
VMG related opportunities	• Application of stone lines is expected to improve agriculture production thus, more food and income for the VMGs.
E: Case studies/profiles of success stories	

Success stories, if any	In Burkina faso farmers have reported doubled cereal production when stone lines are used in combination with greater use of compost as fertilizer. https://www.rural21.com/fileadmin/_migrated/content_uploads/Stone_lines_against_desertification_01.pdf
Application guidelines for users	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 stone lines slow the fast-flowing rainwater, thereby reducing erosion. This allows up to 200 more litres of water to penetrate the soil per square metre. The amount of work involved is considerable: to quarry the stone, load it onto lorries and line it on the fields.
F: Status of TIMP readiness 1. Ready for upscaling, 2=Requires validation; 3=Requires further research	1
G: Contacts	
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Lead organization and scientists	KALRO, E. Mutuma; J. Wamuongo; M, Wairimu; P. Kitiem, J. Mwaura; D. Kamau.
Partner organizations	County Governments' extension service.

3.6 Retention Ditches

TIMP name	Retention ditches
Category (i.e. technology, innovation or management practice)	Technology
A: Description of the technology, innovation or management practice	
Problem addressed	The risk of soil erosion and increased run off
What is it? (TIMP description)	These are retention Ditches are dug to about 30-60 cm depth and 0.5-1 m width across the direction of the slope. They are spaced at 10 – 20m intervals and may closed ends open ends to discharge excess water, depending on slope. Retention ditchesare designed to catch and retain incoming runoff and hold it until it infiltrates into the ground. They can be an alternative to waterways in high rainfall areas, but they are most often used in semi-arid areas to harvest water. The technology is suitable in semi-arid areas; permeable, deep and stable soils; and on flat or gentle sloping land.
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 retention ditches has led to better and more reliable crop yields.

B: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers
Approaches to be 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 and the county extension service providers.
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 stone lines. • Land tenure systems that allows individual ownership
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; provide collective labor. • External service providers – capacity building and access to technology
C: Current situation and future scaling up	
Counties where already promoted if any	Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru
Current extent of reach	Practiced minimally in TharaKa Nithi and Makueni
Counties where TIMP will be promoted	Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu.
Challenge(s) in development and dissemination	• Increased risk of soil erosion if retention ditches are improperly laid out • Labour intensive and many farmers may find it difficult to implement at large scale • Land tenure systems – communal land ownership, or in places where individuals don't have land title deeds
Suggestions for addressing the challenges	• Farmers need to be supported with appropriate tools for digging out retention ditches for efficiency and increased output per man hour. • Training youthful farmers to be champions of digging out retention ditches. • Training on site specific designs and layout • Fast-track land registration
Lessons learned, if any	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	• Enforce policies on soil and water conservation at the County level • Create awareness on the importance of soil and water conservation • Avail low cost technologies for soil and water conservation • Policies that support individual land tenure systems
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
Basic costs	The main input cost is the labour for digging retention ditches. 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	• Limited ownership of or access to land may limit women from technology implementation • Limited power in making decisions on land use may limit women in technology adoption • The technology is labour intensive and may limit implementation by women

	• 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. • Limited access to appropriate tools and credit may limit application of technology among specific gender e.g. women
Gender related opportunities	• Increased agricultural production will increase access to food and income among all gender. • Youthful male and women will provide labour during the implementation of the technology.
VMG issues and concerns in development and dissemination	• Limited access to information will limit access to information and adoption • Limited decision making power on land use may limit VMG in accessing and adopting the technology • May not be in attendance during awareness and sensitization campaigns due to physical body challenges or insecurity challenges. • The technology is labour intense and may be difficult for the VMG to implement in the field. • The labour cost of adopting this technology might be out of reach for the VMGs thus affecting adoption and scaling up. • The technology demands proper training and access to information to enable proper implementation. This might be lacking among the VMGs
VMG related opportunities	• Application of contour ridge is expected to improve agriculture production thus, more food and income for the VGMs.
E: Case studies/profiles of success stories	
Success stories, if any	Over 50,000 smallholder farmers in Eastern and Central Kenya are recording a more than doubling of yields and reduced soil erosion after embracing a soil conservation scheme that involves digging of retention trenches in hillside to trap runaway water and soil.
Application guidelines for users	The ditches are dug to about 30-60 cm depth and 0.5-1 m width across the direction of the slope. In very stable soils it is possible to make the sides nearly vertical, but in most cases the top width of the ditch needs to be wider than the bottom width. The soil is thrown on the lower side of the slope to prevent it falling back in, forming an embankment. On flat land, ditches are spaced at about 20m and have closed ends so that all rainwater is trapped. On sloping land ditches are spaced at 10 - 15 m intervals and may have open ends to discharge excess water.
F: Status of TIMP readiness 1. Ready for up scaling, 2=Requires validation; 3=Requires further research	1
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Lead organization and scientists	KALRO, E. Mutuma; J. Wamuongo; M, Wairimu; P. Kitiem, J. Mwaura; D. Kamau.

Partner organizations	County Governments extension service.

3.7 Grass Strips

TIMP name	**Grass strips**
Category (i.e. technology, innovation or management practice)	Innovation
A: Description of the technology, innovation or management practice	
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 panted 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.
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: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers
Approaches to be 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 and the county extension service providers.
Critical/essential factors for successful promotion	• Availability of labour • Availability of land, apart from cropland. • Farmers and extension service with skills to design and construct stone lines. • Land tenure systems that allows individual ownership
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; provide collective labour. • External service providers – capacity building and access to technology
C: Current situation and future scaling up	
Counties where already promoted if any	Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru
Current extent of reach	Practiced widely in many counties, especially where crop-livestock interactions is key
Counties where TIMP will be promoted	Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu.
Challenge(s) in development and dissemination	• Labour intensive for maintaining and controlling grass from becoming a weed • Reduced land area for crop production
Suggestions for addressing the challenges	• Farmers need to be supported with appropriate tools and suitable grass varieties. • Capacity building on the maintenance of grass strips.

	• Training on site specific designs and layout
Lessons learned, if any	• Establishment of grass strips induces a process of natural terracing on slopes as soil collects behind the grass barrier, even in the first year. • Grass strips can be very appropriate for farmers who cut and carry fodder for their animals. • Grasses are also used as mulch for crops by farmers.
Social, environmental, policy and market conditions necessary	• Enforce policies on soil and water conservation at the County level • Create awareness on the importance of soil and water conservation • Avail low cost technologies for soil and water conservation
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
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	• Limited ownership of or access to land may limit women from technology implementation • Limited power in making decisions on land use may limit women in technology adoption • The technology is labour intensive and may limit implementation by women • 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. • Limited access to appropriate tools and credit may limit application of technology among specific gender e.g. women
Gender related opportunities	• Increased agricultural production will increase access to food and income among all gender. • Youthful male and women will provide labour during the implementation of the technology.
VMG issues and concerns in development and dissemination	• Limited access to information will limit access to information and adoption • Limited decision making powers on land use may limit VMG in accessing and adopting the technology • May not be in attendance during awareness and sensitization campaigns due to physical body challenges or insecurity challenges. • The technology is labour intense and may be difficult for the VMG to implement in the field. • The labour cost of adopting this technology might be out of reach for the VMGs thus affecting adoption and scaling up. • The technology demands proper training and access to information to enable proper implementation. This might be lacking among the VMGs
VMG related opportunities	• Application of contour ridge is expected to improve agriculture production thus, more food and income for the VGMs.
E: Case studies/profiles of success stories	
Success stories, if any	

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.
F: Status of TIMP readiness 1. Ready for upscaling, 2=Requires validation; 3=Requires further research	1 Ready for up scaling
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Contacts	**Centre Director** KALRO Kabete, off Waiyaki way, P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: cd.narl@kalro.org
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Partner organizations	County Governments extension service.

3.8 Tied Ridges

TIMP name	**Tied ridges**
Category (i.e. technology, innovation or management practice)	Technology
A: Description of the technology, innovation or management practice	
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 upslope 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.
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.
Region promoted	Tana River, Garissa, and West Pokot counties
B: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers
Approaches used in dissemination	Demonstrations; Farmer field schools

Critical/essential factors for successful promotion	• Proximity to water sources - close to permanent water sources • Suitable topography of area (level land) • Technical capacity for maintenance
Partners/stakeholders for scaling up and their roles	• County government – capacity building • Private sector – access to credit, capacity building • NGOs (Kenya Red Cross (KRC), Action Aid, World Vision, and OXFAM) – capacity building, credit facilities, facilitate technology access • National Irrigation Board – technology access and capacity building • Water Resources Management Authority – Water resources use management
C: Current situation and future scaling up	
Counties where already promoted if any	Makueni, Machakos, Tharaka Nithi, Kakamega, Nyeri, Meru
Current extent of reach	Practiced in many regions with soil moisture deficit or low rainfall levels
Counties where TIMP will be promoted	Busia, Kisumu, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos, Taita Taveta, Isiolo, Lamu.
Challenges in dissemination	• Can be labour intensive during establishment phase • Poor management may lead to water use inefficiencies • Limited access to credit may limit uptake • Land tenure insecurity in some counties limits adoption and investments
Recommendations for addressing the challenges	• Enhancing farmers' capacity to see benefits • Enhance access to credit • Implement policy on land use and tenure
Lessons learned	• Use of tied ridges with furrow irrigation significantly increases yields • Poor management and designs may often result in flooding of low areas • Assessment of soil erosion and sediment is key to sustainability
Social, environmental, policy and market conditions necessary	• The economics of furrow irrigation needs to be well articulated • Enhanced land quality control to mitigate against soil salinity • Adequate policies and guidelines regarding water abstraction from the main water sources to minimize resource conflicts especially along river downstream. • Market for the crops produced under irrigation should be identified early enough to minimize losses and increase profitability from the system
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
Basic costs	Not known
Estimated returns	Not known

Gender issues and concerns in development, dissemination, adoption and scaling up	Being labour intensive, there is likelihood for male dominance hence development prototypes benefit specific gender
Gender issues and concerns in development, dissemination, adoption and scaling up	• Gender differences in access to credit will limit technology uptake and utilization • Construction is labor intensive, there is likely for male dominance • Gender differences in access to credit will limit technology access, development and uptake
Gender related opportunities	Opportunities for women and youth to increase income through application of technology in production of specific value chains that favor them
VMG issues and concerns in development and dissemination	• Adequate planning and apportioning of space in the irrigation system is necessary with special consideration for VMG to empower their opportunities • The cost can hinder the rapid adoption by the VMGs due to high poverty levels.
VMG related opportunities	VMGs can make business arising from the increased yields from furrow fields.
E: Case studies/profiles of success stories	
Success stories	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. A sound understanding of the roles and responsibilities of farmers and water user associations is a feature of successful system.
Application guidelines for users	• 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 • FAO CSA Manual • FAO Irrigation Water Management: Irrigation Manual • GoK MoALFI: Training Manual for Water Users Association and farmers
F: Status of TIMP readiness (1. Ready for upscaling; 2. Requires validation; 3. Requires further research)	1.
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Lead organization and scientists	KALRO; J. Mwaura, I. Sijali
Partner organizations	National Irrigation Board (NIB), Water Resources Management Authority

GAPS

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

3.9 Rain Water Harvesting Through Roof Catchment

TIMP name	Rain water harvesting systems (roof catchment)
Category (i.e. technology, innovation or management practice)	Management practice
A: Description of the technology, innovation or management practice	
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 runoff). 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.
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 runoff and increases yields with the additional water.
B: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers, pastoralists and agro-pastoralist
Approaches to be 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	• Avail resources (human, technical and financial) to support acquisition and establishment of water harvesting systems • Policy to support use of communal land to establish and manage the earth dams • Policies supporting Public-Private Partnerships in water harvesting • Sensitization of local communities to embrace the practice
Partners/stakeholders for scaling up and their roles	• Private sector – access to technology, access to credit, technology installation

	• County government – capacity building, policy support, credit facilities, • NGOs – access to technologies, capacity building, technology installation
C: Current situation and future scaling up	
Counties where already promoted	Most counties are investing on water harvesting technology at community level. More is required to increase uptake at household level.
Current extent of reach	Practiced widely in most counties
Counties where TIMP will be upscaled	ASAL counties; Tana River, Marsabit, West pokot and Mandera
Challenges in dissemination	• High costs related to technology access and management • Resource use conflicts where land is communally owned • Limited skills in technology installation and management • Limited community mobilisation policy for water related activities • Lack of suitable training programmes in rainwater harvesting • Lack of proper water usage and control measures • In the case of earth dams where there is a lot of siltation, regular de-siltation is required. • Threats to sustainability of established systems because of lack of community participation in systems monitoring and maintenance. • Vandalism • Some systems require high investment costs.
Suggestions for addressing the challenges	• Resource mobilization through partnerships with private sector • Engaging a participatory process during the planning and implementation of the project. • User specific training programs water harvesting technologies, maintenance and operation skills • Cost of buying water harvesting structures is very high for most households and needs to be reviewed. • Securing systems to prevent vandalism
Lessons learned in upscaling, if any	- Potential to caution community against water scarcity - Improved productivity where water harvesting has been implemented.
Social, environmental, policy and market conditions necessary	• Devise systems that are gender sensitive – target different gender needs • Carry out environment and social impact assessment of the technology in specific Counties and cultures • Support structures that help access to credit for technology access and maintenance • Enact Policy frameworks to support water harvesting • Enact policies on land tenure systems to support water harvesting

D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
Basic costs	• Not determined • Not affordable to most rural households.
Estimated returns	• Time saved fetching water from afar is channelled into other economic enhancing activities. • Money used to treat diseases related to poor water hygiene is used for other activities. • Healthy population will have energy to provide labour required in agricultural activities
Gender issues and concerns in development and dissemination	• The distance from household need to be considered as women are the custodian of households in terms of domestic water demands. • The design of the water pans should take care of the Occupation, Health and Safety of the communities • The technologies will reduce time needed to fetch for water which will impact positively the women
Gender related opportunities	Water harvesting facilities save the time spent to collect water from far off, usually by women. The saved time is channeled into other economic activities
VMG issues and concerns in development, dissemination, adoption and scaling up	• Limited access to credit or financial services may limit access to technology • The land tenure systems may inhibit adoption of technology
VMG related opportunities	• Develop SME opportunities around water harvesting. Also do small food gardens and tree nurseries around water pans • VMG maximize can engage in n availability of water to engage in small IGAs around water harvesting • Livestock too easily access water and their market value likely to appreciate • The technology will reduce the time used to search for water
E: Case studies/profiles of success stories	
Success stories	Agro-pastoralists who adopted water harvesting technology have had sustained source of income and improved livelihoods 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. 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.
Application guidelines for users	Agro-pastoralists and farmers in target counties need training and empowerment on the technology and attendant management practices. **References** 1. Handbook on Rainwater Harvesting and Storage Options 2. Manual for Rooftop Rainwater Harvesting Systems in the Republic of Yemen
F: Status of TIMP readiness (1=Ready for upscaling: 2=Requires validation; 3=Requires further research	1
G: Contacts	
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Partner organizations	County government, PPP

GAPS

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

3.10 Conservation Agriculture (CA)

TIMP name	**Conservation Agriculture**
Category (i.e. technology, innovation or management practice)	Management Practice
A: Description of the technology, innovation or management practice	
Problem to be 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 target to conserve the soil, soil moisture, and soil-nutrients, and stabilise land production while reducing production costs. Conservation agriculture principles are: 1. Minimal soil disturbance, 2. 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), 3. Crop rotation or sequences and associations of crops including trees, which could include nitrogen-fixing legumes Conservation agriculture can sustainably increased crop yields

Justification	Crop yields are declining due to decreasing Land productivity. Continuous tillage continues to emit more GHGs (Carbon) responsible for the climatic changes. Conservation agriculture (CA) has potential to: • enhance management of soil fertility and organic matter, and improvement of the efficiency of nutrient inputs, helping to produce more with proportionally less fertilizer. • of increasing 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 • 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 • shields the soil surface from heat, wind and rain, keeps the soil cooler and reduce moisture losses by evaporation through improved soil cover • reduce soil compaction and plough pans and regenerates degraded lands
B: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers, Extension Agents, Researchers
Approaches to be used in dissemination	Agricultural shows, Mass media, Exhibitions, Farmer field Schools (FFS), On-farm and on-station demonstrations, Field Days, Extension Officers
Critical/essential factors for successful promotion	• Training on principles and benefits of CA • Model demonstration using crops
Partners/stakeholders for scaling up, their roles and stage of involvement	• County Extension officers - Dissemination of information, capacity building • NGO's (African Conservation Network, One Acre Fund)- Capacity Building, Dissemination of information • CIAT, FAO – capacity building • County Governments - Funding CA activities, support capacity building, enabling environment and supportive policies
C: Current situation and future scaling up	
Counties where already promoted if any	Bungoma, Meru, Embu, Tharaka Nithi, Laikipia, Kakamega
Current extent of reach	Practiced in several counties but among very few households due to various constraints
Counties where TIMP will be upscaled	Bungoma, Meru, Embu, Tharaka Nithi, Laikipia, Kakamega, Machakos, Makueni
Challenges in dissemination	• Non-availability of crop residue in suitable quantities • Competition for crop residues with other uses like wood fuel and livestock

	• Land tenure (farmers reluctant to invest in CA where they do not have clear land rights) • Limited knowledge on the incremental benefits of CA • Limited access to CA implements
Suggestions for addressing the challenges	• Enhance Public Private Partnerships (PPP) to support increased production and market access • Improve KALRO and county government capacity to train and re-tool technical team so as to enhance dissemination of the technology • Allocation of more funds for continued research and dissemination of this technology would aid increased uptake of CA with agro forestry
Lessons learned in up scaling if any	• Uptake of CA technology increases with the realized incremental benefits over time • Continuous capacity building increases CA technology uptake
Social, environmental, policy and market conditions necessary for development and dissemination	• Reliable technology adoption and suitable price and market access for produce under CA • Continuous capacity building of the community on the benefits of CA technology • County policies that support households investing in CA with inputs like implements
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
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 of 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	• CA with trees is a management practice that that can be easily adopted by women • Reduces labour demands across all gender, hence good for all gender • Land ownership is mainly by men therefore reducing wider adoption • Women are usually left out of decision making thereby reducing uptake
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	• Limited decision making on land use may limit the adoption by VMGs • Limited access to CA inputs like planting implements may limit the VMGs adopting
VMG related opportunities	• Opportunity to run SMEs such as tree nurseries for increased resilience

E: Case studies/profiles of success stories	
Success stories from previous similar projects	Farmers and agro-pastoralists who adopt the technology have had sustainable source of income and increased resilience
Application guidelines for users	When implementing the 3 principles of CA, one needs to note the following • 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. • 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 • Inputs – Equipment, seeds, herbicides, manures/fertilizers – use the right inputs • Livestock - try to keep livestock out of the fields, even after harvesting the crop. References • Okoba, B. (2018), Climate-Smart Agriculture: Training Manual for Agricultural Extension Agents In Kenya. • Esilaba, E.O (2019), KCEP-CRAL CSA Extension Manual • SUSTAINET EA 2010. Technical Manual for farmers and Field Extension Service Providers: Conservation Agriculture. Sustainable Agriculture Information Initiative, Nairobi
F: Status of TIMP readiness (1. Ready for upscaling; 2. Requires validation; 3. Requires further research)	1
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Partner organizations	County government, Private Public Partnerships

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:

3.11 Intercropping

TIMP name	**Intercropping**
Category (i.e. technology, innovation or management practice)	Complementary technology
A: Description of the technology, innovation or management practice	
Problem addressed:	• Decreased yields, hence low farm returns • Declining soil fertility, due to soil degradation • Soil erosion problems - runoff are minimized • Weeds infestation – manage using increased soil cover crops • Vulnerability to crop pests - practice helps slow the proliferation of pests and protect yields
What is it? (TIMP description)	Intercropping is the growing of two or more crops 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 productions. 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 practice of enhancing climate change adaptation. It offers the potential to increase yield, enhance soil fertility/biodiversity and minimize the effects of climate change. The practice is known to build healthy soils, control pests and harness a variety of benefits to increase yields. Intercropping of compatible plants encourages biodiversity by providing a habitat for a variety of insects and soil organisms that would not be present in a single-crop environment. The practice has several advantages. First, an intercrop may use resources of light, water, and nutrients more efficiently than single crops planted in 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.
B: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers and wide range of users in the rural and urban areas
Approaches to be used in dissemination	Demonstrations, Agricultural shows and Extension services

Critical/essential factors for successful promotion	• Awareness creation on the benefits and contribution of the practice to all stakeholders. • Easy access of crop varieties that are compatible with associated crops planned for intercrop. • Technical packages describing appropriate schedules of planting intercrops. • Package on fertilizer rates and regimes under the practice.
Partners/stakeholders for scaling up and their roles	• County governments – to provide extension services, farmer mobilization and policy formulation • NGOs – to provide support on capacity building and micro-financing services
C: Current situation and future scaling up	
Counties where already promoted	Most Counties in the medium to high rainfall areas & Arid and semi-arid areas
Current extent of reach	Although farmers in these counties practice intercropping, most fall short of using the right seed and agronomic practices, hence do not benefit from the technology
Counties where TIMP will be up scaled	All the 24 KCSAP Counties
Challenges in dissemination	• Limited access and wide distribution of clean planting materials (intercrop varieties) • Inadequate access to technical materials on the establishment, operations and management of intercrop management practice by farmers • The increased effects of climate change hindering adoption. • Farmer high poverty levels coupled with illiteracy especially in deep rural areas of Kenya limits knowhow.
Suggestions for addressing the challenges	• Enhance access to clean planting materials across the counties. Work closely with certified seed merchants, research institutions • Train and sensitize farmers on the basic principles of intercropping, their benefits and types suitable to their contexts. Use farmer field schools and demonstrations • Develop a comprehensive manual on the practice to guide the farmers during the adoption
Lessons learned in up-scaling, if any	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 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.

Social, environmental, policy and market conditions necessary	• Socially accepted by both male and female gender. • The practice is environmentally friendly as it enhances biodiversity, controls erosion and minimizes use of pesticides
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
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	• The practice integrates participation of both male and female gender roles during field implementation • It is important to know the demands of the technology product end users for ease of acceptability • Gender disparities in access to information may impact on adoption decisions. Access to information is a pre-requisite for informed decisions on adoption.
Gender related opportunities	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
VMG issues and concerns in development, dissemination, adoption and scaling up	The technology can be practiced 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.
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.
E: Case studies/profiles of success stories	
Success stories	Farmers have reported improved soil conditions, reduced runoff 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	• 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 evaluations • Observe careful timing of field operations (sometimes necessitating special interventions) to keep competition between the intercropped species in balance • A crop mix that works well in one year may fail the next if weather favors one crop over another.

	• A mixture of crops with different growth forms or timing of development may make cultivation and use of mulches more difficult and less effective • Planting crops in alternate rows or strips greatly simplifies management and captures some of the benefits of intercropping for pest control • 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 • Intercropping requires extra care and effort in planning and maintaining a viable crop rotation.
F: Status of TIMP readiness (1=Ready for upscaling: 2=Requires validation; 3=Requires further research	3
G: Contacts	
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, E. Mutuma, M. Okoti, D. Kamau, E Mutuma, J. W. Wamuongo, M W. Gichuhi
Partner organizations	County governments, KCEP-CRAL project

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.

3.12 Mulching

TIMP name	**Mulching (organic)**
Category (i.e. technology, innovation or management practice)	Innovation
A: Description of the technology, innovation or management practice	
Problem addressed	Accelerated loss of soil moisture-water stress in the soil. Suppression of weeds, loss of organic matter, managing salinity in ASALS.

What is it? (TIMP description)	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. Benefits: retain moisture in the soil; suppress weeds; keep the soil cool; 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: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers
Approaches to be used in dissemination	- Farmer field schools - On-farm demonstrations during farmer field schools - Training in workshops
Critical/essential factors for successful promotion	- Availability of plant or crop residues. - Size of the land. - Competing uses of crop residues. - Type of the crops
Partners/stakeholders for scaling up and their roles	County government extension services; Provide link with farmers Community farmer groups; play coordination role for ease in problem identification and dissemination
C: Current situation and future scaling up	
Counties where already promoted	Baringo, Bomet, Kericho Tharaka Nithi, West Pokot, Nyeri, Machakos.
Current extent of reach	Available and practiced in different commodity value chains
Counties where TIMP will be promoted	All the other 17 counties
Challenges in dissemination	• Lack of enough plant and crop residues due to competing uses • Possibilities of insect build up categorized as pest or disease vectors
Suggestions for addressing the challenges	• Crop diversification to increase availability of residues. • Establish and follow a good integrated pest control management program for the particular crop. • Adapting alternative mulching materials like high absorbance polymers in fruit trees like mangoes and Bananas.
Lessons learned	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	• Practice is socially acceptable • Environmentally friendly • Increased productivity will provide supply to the markets • Supporting frameworks/policies are available.

D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
Basic costs	This is low cost but labour intensive during the initial application. Such costs are dependent on value chain and plant spacing.
Estimated returns	Dependent on value chain but generally >100% of the initial investments.
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 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.
E: Case studies/profiles of success stories	
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. Example of fruit tree crop** **1st step:** Shovel away all the old mulch, debris, and rocks so that you can see the tree trunk. A "mulch volcano" occurs when mulch is piled up year after year at the base of a tree. Mulch piled up at the base of a tree is detrimental and starves the roots of needed oxygen. **2nd step:** Cut up-growing roots with pruners. Up-growing roots can wrap around the base of the tree and kill it over time. If you notice any roots growing upward around the tree as you clear away old mulch, cut them away. Up-growing roots are a sign that the tree is starved for oxygen. **3rd step:** Remove grass and other weeds with a spade or gardening claw. Scrape the area around the base of the tree to get rid of any weeds or grass. **4th step:** Adding a proper mulch bed. Spread mulch in a 4–5 feet (1.2–1.5 m) diameter around the tree. Lay down a thin layer of mulch around the tree. The mulch should not touch the tree itself. Leave (2.5–5.1 cm) of space between the base of the tree and the mulch

	Mulch management **Pull or kill weeds that grow out of the mulch.** Mulch is meant to act as a barrier for weeds and grass. You should pull any weeds or grass that grow out of the mulch bed throughout the year to prevent future growth. You can also use an herbicide, which is a chemical weed killer, around your tree to prevent grass and weeds from growing in your mulch **Rake the mulch occasionally to prevent it from getting packed down.** Compacted mulch prevents oxygen from passing through and can starve your tree's roots. **Replenish the mulch once a year.** Make it a point to replenish the mulch around the tree once a year. This will prevent weeds, provide essential nutrients, and help with the tree's drainage.
F: Status of TIMP readiness (1=Ready for upscaling: 2=Requires validation; 3=Requires further research	3
G: Contacts	
Contacts	**Centre Director** KALRO Kabete, off Waiyaki way, P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: cd.narl@kalro.org
Lead organization and scientists	KALRO, E. Mutuma, P. Kitiem, J. Mwaura, A. Esilaba, D. Kamau
Partner organizations	County governments Public-Private-Partnerships

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

4. IRRIGATION AND DRAINAGE MANAGEMENT

4.1 Solar irrigation systems for smallholder farmers

TIMP name	Solar Irrigation for smallholder farmers
Category (i.e. technology, innovation or management practice)	Innovation
A: Description of the technology, innovation or management practice	
Problem addressed	High cost of pumping water for irrigation, using electricity of fossil fuel powered pumps
What is it? (TIMP description)	This is the sole use of 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 sustainablilty.
B: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers
Approaches to be used in dissemination	On-farm and on-station demonstrations Field days Training in workshops Stakeholders forums Technical releases
Critical/essential factors for successful promotion	• Documentation of available solar irrigation systems • Access to solar irrigation performance data. • Improving solar irrigation systems efficiencies in irrigation schemes • Creating local support for solar irrigation technologies
Partners/stakeholders for scaling up and their roles	County government extension services; Provide link with farmers. Community farmer groups; play coordination role for ease in problem identification and dissemination.
C: Current situation and future scaling up	
Counties where already promoted if any	Various counties including Marsabit, Garissa, Machakos, Nyeri, Kajiado, Siaya, Bomet, Kericho and Uasin Gishu
Current extent of reach	Practiced in individual farms as well as in few group farms for high value crops like tomatoes
Counties where TIMP will be promoted	All the 24 KSAP counties
Challenges in dissemination	• Farmers lack knowledge on the potential of solar as a power source for irrigation systems • High cost of innovation
Suggestions for addressing the challenges	• Awareness trainings on different solar irrigation systems • Awareness creation on advantages of solar irrigation systems pumps to governments, farmers and development agencies. • Capacity building of extension workers • Developing information packages • Creating solar irrigation systems network
Lessons learned if any	• Solar irrigation systems should be well designed in water delivery, storage and application to the field.
Social, environmental, policy and market conditions necessary	• Practice is socially acceptable, • Environmentally friendly, • Policies are friendly to the technology • Capable of increasing marketable products
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
Basic costs	Higher investment costs but low operation costs. Costs depend on the energy required and size of irrigated area.

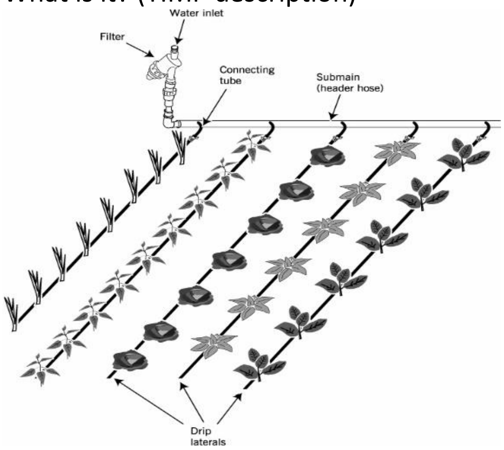
Estimated returns	Not yet done
Gender issues and concerns in development, dissemination adoption and scaling up	Solar irrigation is friendly to female gender compared to diesel or electric systems because they have low running and maintenance costs. It is modern technology that is attractive to the youth.
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
E: Case studies/profiles of success stories	
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 area • Use efficient water application method such as drip to avoid wastage since the water is relatively scarce.
F: Status of TIMP readiness (1=Ready for upscaling: 2=Requires validation; 3=Requires further research	2
G: Contacts	
Contacts	**Centre Director** KALRO Kabete, off Waiyaki way, P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: cd.narl@kalro.org
Lead organization and scientists	KALRO; IV Sijali, MPO Radiro, Francis Karanja, Fabian 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

TIMP name	Drip irrigation systems for small scale farmers
Category (i.e. technology, innovation or management practice)	Technology

A: Description of the technology, innovation or management practice	
Problem addressed	• Increased crop water stress caused by seasonal rainfall variability in rain fed production.
What is it? (TIMP description)  Layout of a drip irrigation system in vegetables	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
Justification	The impacts of climate change (seasonal rainfall variability and drought) to crop production is a real threat to food security. Mainstreaming drip irrigation systems into crop production provides the opportunity for farmers to enhance crop resilience, increase yields and incomes.
B: Assessment of dissemination and scaling up/out approaches	
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	• Correct field design (system installation) of the drip system to minimize water inefficiencies. Training of farmers and extension • Drip management skills
Partners/stakeholders for scaling up and their roles	• County governments; capacity building, supportive policies and frameworks • Private sector (AMIRAN); facilitate access to technology; technology demonstration; access to credit • NGOs (Kenya Red Cross- KRC, Action Aid, World Vision, and OXFAM); facilitate access to technology; technology demonstration
C: Current situation and future scaling up	
Counties where already promoted if any	Makueni, Bomet, Kajiado, Machakos
Current extent of reach	Limited to high value tomato and vegetable farmers in the above counties
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	• Relatively high cost of drip kits for majority of poor resource farmers in ASALs. • High temperatures experienced in ASALs cause water salinity challenges • Drip poly tubing also tend to collapse causing inadequate water conveyance along the tube • Limited knowledge on the drip irrigation technology and its management
Recommendations for addressing the challenges	• Model farmer demonstration would create awareness and willingness to invest on the system • Modification of drip system tubes in ASAL areas is required (use of PVC pipes) to manage clogging free flow of water • Regular maintenance of the system especially the drip filters is required to flush out accumulated salts that tend to clog emitters • Intensive farmer training is required on the management of drip irrigation system
Lessons learned	• Drip system increases yield, incomes and food security • Linking farmers with markets is critical for enhancing sustainability • 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 • It is also important to link farmers to Micro Finance Institutions for financial needs
Social, environmental, policy and market conditions necessary	• Capacity building for increased awareness • Policy support for increased investments in Drip irrigation systems • The water quality should be known to adjust the drip systems to avoid clogging
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
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	• Income from drip system rises by as much as 35% stemming from the management of crop water stresses. • Increased water saving means more water is available for other competing needs (domestic, livestock or industrial).
Gender issues and concerns in development, dissemination, adoption and scaling up	• Drip systems are easily installed and therefore suitable for both male and female gender • Drip system tends to reduce workload for all gender and provides significant positive impact on family food and nutritional intake.

	• Women are extensively involved in most horticultural farming enterprises (i.e. vegetable farming) under the drip-irrigation systems. This may increase their labor hours • Acceptable and easy to scale up by both male and female, including youth
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
E: Case studies/profiles of success stories	
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	• 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 • Use 1 or 2 emitters per plant depending on the size of the plant. Trees and large shrubs may need more. • In most situations install emitters at least 450mm (18") apart. 600mm (24") apart under 80% of the leaf canopy of the plant • Always have a backflow preventer to prevent water contamination by soil-borne disease. Use a 20mm (3/4") valve for most systems • Use 25mm (1 inch) PVC, PEX or polyethylene irrigation pipe for mainlines ("mains") and laterals • The total length of the mainline and the lateral together should not be more than 120 meters (400 feet). • The length of drip tube should not exceed 60 meters from the point the water enters the tube to the end of the tube • Never bury emitters underground unless they are made to be buried • Don't bury drip tube, moles or other rodents will chew it

	• Always install a flush valve or end cap at the end of each drip tube. Automatic flush valves are also available **References** 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. 2. FAO, 2014. Irrigation Techniques for Small-scale Farmers: Key Practices for DRR Implementers. Rome: Food and Agriculture Organization of the United Nations (FAO). http://www.fao.org/3/a-i3765e.pdf
F: Status of TIMP readiness (1. Ready for Up scaling; 2. Requires validation; 3. Requires further research)	1
G: Contacts	
Contacts	**Centre Director** KALRO Kabete, off Waiyaki way, P.O. Box 14733-00800, NAIROBI. Tel: +254-020-2464435 Ext. 300 E-mail: cd.narl@kalro.org
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)

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

TIMP name	HYDROPONICS TECHNOLOGY
Category (i.e. technology, innovation or management practice)	Complementary technology
A: Description of the technology, innovation or management practice	
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 pumis, cocopeat 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 search of white collar jobs by the youth who are more than 60% of the Kenyan population. Conventional land use is gradually becoming untenable due to escalating change of land use in high agricultural potential areas. 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. 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.
B: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Urban and peri-urban Farmers/youth
Approaches to be used in dissemination	Capacity building workshops On-farm visits and excursions On-farm demonstrations and adaptive research trials
Critical/essential factors for successful promotion	• Availability of affordable and quality local inert and clean planting media materials • Take into account the farming cluster dichotomy in and around urban and peri-urban areas are earmarked for the technology adoption. • Farms/ sites in terms of farming land size, labour and market availability.
Partners/stakeholders for scaling up and their roles	• County government extension services; Provide link with end consumer of the technology • Community leaders in case of an urban dwelling and village leaders play coordination role for ease in problem identification.
C: Current situation and future scaling up	
Counties where already promoted if any	Kiambu, Nairobi, Nakuru, Kakamega
Current extent of reach	Practiced in some value chains in the four counties above
Counties where TIMP will be promoted	Kajiado, Tharaka Nithi, Machakos, Kitui, Laikipia, Marsabit, Taita taveta
Challenges in dissemination	• Labour and expertise needed • Culture change of mind-set in some regions/cultures that the rich nutrient solution cannot support crops growth without soil.

	• Initial cost implications
Suggestions for addressing the challenges	• Awareness trainings on role of hydroponics in crop and fodder production. • Training and awareness crop and fodder intensification on small areas and short production span • Excursion training or exchange visits-- see and belief
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	• Practice is socially acceptable, • Environmentally friendly , since this is soilless farming • Increased productivity, maximising profits in small area. • In season and out season marketing
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
Basic costs	This is a technically labour friendly and low cost - 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 genderare 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-practiced can increase farm incomes of VMGs by more to 50%.
E: Case studies/profiles of success stories	
Success stories	Hydroponics technologies successes have been reported in fodder and vegetables production in Muguga, Limuru –Kiambu county.
Application guidelines for users	• Always use good quality, disease- and pest-resistant seed and planting media to ensure efficient use nutrients for vigorous growth and hence bumper production. • Ensure that best bet agronomic practices are upheld

	• For sustainability, proper structure maintenace and general management should be carried out as specified in the instructions manual
F: Status of TIMP readiness 1=Ready for upscaling: 2=Requires validation; 3=Requires further research	2
G: Contacts	
Contacts	Centre Director, KALRO Kabete
Lead organization and scientists	KALRO; E. Muriuki, F. Kaburu, David Kamau, IV 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.

5. AGROFORESTRY SYSTEMS TIMPs

5.1 Agroforestry - Fodder

Technology name	**Agrosilvipastoral practice**
Category (i.e. technology, innovation or management practice)	• Management practice
A: Description of the technology, innovation or management practice	
Problem addressed:	Shortages of high quality fodder result in low milk production and decreased ecosystem services and resilience.
What is it? (TIMP description)	It is a land use system where trees or shrubs are grown in the same space with crops and animals. In this instance it consists of the following systems of farming where fodder trees are deliberately planted for fodder production; • Tree/grass woodlots; a combination of trees and grasses planted in an enclosed area • Scattered trees on crop/pastureland; fodder trees planted on crop/grassland • Fodder banks – cut and carry system; a block of fodder trees in closed spacing, e.g. calliandra spp. spaced at 1 by $1m^2$ • Improved fallow systems; Leguminous trees planted in improved natural fallows

	• Hedgerow intercropping; Leguminous tree species planted in hedges • Evergreen agriculture; intensive farming that integrates trees into crop and livestock production systems at farm/landscape levels • Push and pull (t); strategy of controlling pests in farms by use of repellant 'push' and trap 'pull' plants
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: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers
Approaches used in dissemination	Open and field days Farmer field schools (FFS) On-farm demonstrations (during FFS) Mass and social media,
Critical/essential factors for successful promotion	• Training on principles and benefits of fodder trees and shrubs • 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 Network of Conservation Agriculture, technical backstopping CGIAR (CIAT & ICRAF); technical backstopping
C: Current situation and future scaling up	
Counties where already promoted	Machakos, Nyandarua, Nyeri, West Pokot, Siaya, Busia, Kisumu, Tharaka-Nithi, Kakamega, Uasin-Gishu
Current extent of reach	Practiced by few farmers who keep dairy animals located near towns/cities
Counties where the TIMP will be upscaled	All the 24 Counties
Challenges in dissemination	The key challenge constraining the uptake of fodder trees include:

	Limited species appropriate to different agro-ecological zones Shortage of seed 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
Recommendations for addressing the challenges	• Enhance Public Private Partnerships to support increased production and market access • Improve county government capacity to train and re-tool technical team so as to enhance uptake of the technology • Allocation of more funds for continued research and dissemination of this technology would aid increased uptake of fodder species
Lessons learned	1) Mind sets are negative about fodder trees 2) Inadequate skills in the technology and its management practices among the farmers and extensions agents
Social, environmental, policy and market conditions necessary	Reliable technology adoption and suitable price and market access for produce under fodder
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
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 practiced. In Embu, feeding trials have found that 1 kilogram of Calliandra increases milk production by 0.6–0.8 kilograms. With 500 Calliandra shrubs, a farmer's net income increases by About KES 10,000 to 12,000 per cow per year by using Calliandra 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 agro forestry 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
E: Case studies/profiles of success stories	
Success stories	Farmers in central Kenya have demonstrated that Calliandra 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
F: Status of TIMP readiness (1=Ready for up scaling: 2=Requires validation; 3=Requires further research	1
G: Contacts	
Contacts	Kenya Forestry Research Institute, P.O. Box 20412, Nairobi jkndufa@gmail.com +254 722 983238
Lead organization and scientists	KEFRI, KALRO, ICRAF, CIAT; J. Ndufa, E. Odoyo, B. Mugo, M. Okoti
Partner organizations	County governments, Private Public Partnerships

5.2 Agroforestry – Fruit trees

Technology name	**Fruit trees in agroforestry**
Category (i.e. technology, innovation or management practice)	Complementary technology
A: Description of the technology, innovation or management practice	
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	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. Continuous land degradation leads to continued emission of GHGs (Carbon) responsible for the climatic changes. Fruit trees in agroforestry system has the potential to: • Increase the productivity by improving soil structure and protects the soil against erosion and nutrient losses , thus Enhance food security and nutrition • Conserve soil water • Enhance biodiversity • Increased resilience
B: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers
Approaches used in dissemination	Open and field days Farmer Field Schools Exchange visits Mass and social media Demonstration plots
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
C: Current situation and future scaling up	
Counties where already promoted	Machakos, Nyandarua, Nyeri, West Pokot, Siaya, Busia, Kisumu, Tharaka-Nithi, Kakamega, Uasin-Gishu
Current extent of reach	Minimal in the counties where technology has been promoted
Counties where the TIMP will be upscaled	All 24 KCSAP counties
Challenges in dissemination	• Limited species appropriate to different agro-ecological zones • Shortage of seed/seedlings

	• Many farmers lack knowledge and skills needed to grow them • Failure to recognize agroforestry as an important investment option. • Land tenure (farmers reluctant to invest in agroforestry technologies where they do not have clear land rights • Lack of markets and processing techniques
Recommendations for addressing the challenges	• Enhance PPP to support increased production and market access • Capacity building of county government capacity to train and re-tool technical team so as to enhance uptake of the technology • Allocation of more funds for continued research and dissemination of this technology would aid increased uptake of indigenous fruit trees in agroforestry. • Developments in agroforestry policies are required to reform tree and land tenure to the benefit of small-scale farmers • Provision of planting material • Research should support tree domestication to improve yields and enhance the complementarity and stability of fruit trees in smallholder agroforestry systems.
Lessons learned	i) Mind sets negative about indigenous fruit trees ii) Inadequate skills in the technology and its management practices
Social, environmental, policy and market conditions necessary	Reliable technology adoption and suitable price and market access for grown fruits
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
Counties where already promoted	Machakos, Nyeri, Siaya, Tharaka-Nithi, Kisumu,
Current extent of reach	Minimal reach in counties that have ready markets for fruits
Counties where the TIMP will be up scaled	All the 24 Counties
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	The management practice can be easily carried out by Vulnerable and Marginalized Groups. Currently the uptake by VMG is minimal but has potential for wider adoption and up scaling
VMG related opportunities	SMEs such as fruit tree nurseries for increased resilience and income generation
E: Case studies/profiles of success stories	
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.
F: Status of TIMP readiness (1=Ready for upscaling: 2=Requires validation; 3=Requires further research	3
G: Contacts	
Contacts	Kenya Forestry Research Institute, P.O. Box 20412, Nairobi jkndufa@gmail.com +254 722 983238
Lead organization and scientists	KEFRI, KALRO and ICRAF, James Ndufa, E. Odoyo, M. Okoti
Partner organizations	County government, Private Public Partnerships NGOs

Research gaps

1. Validation of the technology in counties where the technology has not be 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 processing and linkages to markets including Carbon Credit.

5.3 Agroforestry – soil fertility

Technology name	**Agroforestry for soil fertility**
Category (i.e. technology, innovation or management practice)	• Complementary Technology
A: Description of the technology, innovation or management practice	

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 pastureland for the purpose of improving soil fertility and rehabilitation of degraded lands. These systems include: • Improved fallows; Leguminous trees planted in natural fallows • Hedgerow intercropping /alley cropping; Leguminous tree species planted in hedges • Green manure; Biomass from growing leguminous plants that are cut at a certain height and ploughed back to the soil as source of manure • 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. • Multi-strata; an agroforestry system whose components (crops, trees, shrubs, livestock) occupy distinct layers of the vertical structure of the community.
Justification	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. Moreover, continuous land operation continues to emit more GHGs (carbon) responsible for the climatic changes. Agroforestry with leguminous trees has potential to: • 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. • Conserve soil water. • Enhance biodiversity.
B: Assessment of dissemination and scaling up/out approaches	
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	• Training on principles and benefits of agroforestry legumes for green manure • Model demonstration plots using cereal 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
C: Current situation and future up scaling	
Counties where already promoted	Machakos, Siaya, Kisumu, Kakamega, Busia, Tharaka Nithi,
Current extent of reach	Few areas within the counties already promoted
Counties where the TIMP will be upscaled	All 24 KCSAP counties
Challenges in dissemination	• Limited species appropriate to different agro-ecological zones • Shortage of seed • Many farmers lack knowledge and skills needed to grow them • Change of mindset • Competing interests • land tenure (farmers reluctant to invest in agroforestry technologies where they do not have clear land rights
Recommendations for addressing the challenges	• Enhance Public Private Partnerships to support increased production and market access • Improve county government capacity to train and re-tool technical team so as to enhance uptake of the technology • Availing inputs and credit • Allocation of more funds for continued research and dissemination of this technology would aid increased uptake agroforestry for soil fertility
Lessons learned	• Mind sets of local farmers negative about agroforestry for soil fertility improvement. • Inadequate skills in the technology and its management practices
Social, environmental, policy and market conditions necessary	Reliable technology adoption and suitable price and market access for produce grown under the improved agroforestry system

D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
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 and dissemination	Agroforestry for soil fertility with trees is a complementary technology that can be easily adopted by men, women and the youth
Gender issues and concerns in adoption and scaling up	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.
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 and dissemination	The VMGs can easily get access to the products of the practice, e.g. source of fuelwood
VMG issues and concerns in adoption and scaling up	Taking care of the introduced agroforestry systems in their farms require labour.
VMG related opportunities	SMEs such as tree nurseries for increased resilience and income generation
E: Case studies/profiles of success stories	
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
F: Status of TIMP readiness (1=Ready for upscaling: 2=Requires validation; 3=Requires further research	2
G: Contacts	
Contacts	Kenya Forestry Research Institute, P.O. Box 20412, Nairobi jkndufa@gmail.com +254 722 983238
Lead organization and scientists	KEFRI and KALRO, J. Ndufa, M. Okoti; E. Odoyo, B. Mugo
Partner organizations	County government, Private Public Partnerships

Gaps

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

5.4 Woodlots for Energy

Technology name	**Woodlots**
Category (i.e. technology, innovation or management practice)	• Innovation
A: Description of the technology, innovation or management practice	
Problem addressed:	- Shortages of fuelwood and charcoal - Increased land degradation and low resiliencIncreased emission of GHGs (Carbon) responsible for the climatic changes. - These are as a result of overexploitation of aboveground vegetation biodiversity through fuelwood 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 woodfuel, sawlogs and pulpwood among others
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: Assessment of dissemination and scaling up/out approaches	
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	• Training on principles and benefits of short rotation tree woodlots for firewood and charcoal production

	• Model demonstration plots using cereal crops
Partners/stakeholders for scaling up and their roles	County government's extension services; Provide link with farmers. KEFRI, KALRO & KFS; Provide technical backstopping
C: Current situation and future scaling up	
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
Current extent of reach	Practiced minimally in these 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).
Recommendations for addressing the challenges	• Improve county government capacity to train and re-tool technical team so as to enhance uptake of the technology • Allocation of more funds for continued research and dissemination of this technology would aid increased uptake of woodlots for fuelwood • Provide training of seed collection and nursery management • Ensuring successful charcoal production and marketing through implementation of existing charcoal police that encourage investments in improved charcoal processing technologies. • 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 • 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 • Encouraging the use of dry wood during carbonisation and promoting appropriate technologies that are simple, affordable and easy to adopt • Promoting energy conservation through the use of improved cook stoves with higher efficiency levels • Streamlining the charcoal value chain through collaborative action among all players in the sector, including farmers

	• Enhancing implementation of land use regulations and guidelines, especially where changes in land use occur
Lessons learned	• Mind sets of local farmers are negative about short rotation woodlot for firewood and charcoal production. • Inadequate skills in the technology and its management practices
Social, environmental, policy and market conditions necessary	Reliable technology adoption will provide easy access to on-farm firewood and income from charcoal.
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
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	Trees woodlot is a technology that can easily be adopted by both men and women. However, land tenure issues will disadvantage the women and youth considering that land owned by men. Woodlots provide opportunities for SMEs e.g. tree nurseries. The technology therefore renders itself to easy adoption by women. Markets for charcoal produce can also be an issue upon scaling up. There is need to form charcoal producer and marketing association
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
E: Case studies/profiles of success stories	
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 Acacia polyacantha and A. xanthophloea 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
F: Status of TIMP readiness (1=Ready for upscaling: 2=Requires validation; 3=Requires further research	3
G: Contacts	
Contacts	Kenya Forestry Research Institute, P.O. Box 20412, Nairobi jkndufa@gmail.com +254 722 983238
Lead organization and scientists	KEFRI, KFS and KALRO; J. Ndufa, E. Odoyo, M. Okoti, D. Kamau
Partner organizations	County government, Private Public Partnerships

Research gap

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

5.5 Windbreaks and live hedges

Technology name	**Windbreaks and live hedges**
Category (i.e. technology, innovation or management practice)	• Management practices
A: Description of the technology, innovation or management practice	
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 changes

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
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 soil erosion, reduce mechanical damage to plants, increase crop yield, and improve cover and increase food supply for wildlife Windbreaks often are used to protect young trees in plantations and forest nurseries. Trees can 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: Assessment of dissemination and scaling up/out approaches	
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
C: Current situation and future scaling up	
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
Current extent of reach	Wide in target 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	Main challenges include: • Limited species appropriate to different agro-ecological zones • Shortage of seed • Tree and tenure issues when trees are planted along the common boundary • Lack of proper management plans as provided for under the Forests Act of 2005 can affect sustainable feedstock management. • 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. • Many farmers lack knowledge and skills needed to grow them • Competing interests
Suggestions for addressing the challenges	• Improve county government capacity to train and re-tool technical team so as to enhance uptake of the technology • Allocation of more funds for continued research and dissemination of this technology would aid increased uptake • Provide training of seed collection, nursery management and tree establishment and management • Promoted windbreak trees/shrubs which provide multiple e.g. medicine, fruits, timber, poles, fuelwood and fodder • Enhancing implementation of land use regulations and guidelines, especially where changes in land use occur
Lessons learned if any	• Mind sets change of local farmers about windbreak practices. • Inadequate skills in the technology and its management practices
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
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
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 spp used and value chain but no economic costs have been done
Gender issues and concerns in development, dissemination, and 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, and 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
E: Case studies/profiles of success stories	
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
F: Status of TIMP readiness (1=Ready for upscaling: 2=Requires validation; 3=Requires further research	2
G: Contacts	
Contacts	Kenya Forestry Research Institute, P.O. Box 20412, Nairobi jkndufa@gmail.com +254 722 983238
Lead organization and scientists	KEFRI, KFS and KALRO; J. Ndufa, M.Okoti, E. Odoyo
Partner organizations	County government, Private Public Partnerships

Gaps

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

6. BIO-ENERGY TIMPs

6.1 Improved Energy-Saving Cooking Stoves for Small Holder Famers

TIMP name	Improved energy cooking stoves
Category (i.e. technology, innovation or management practice)	Technology
A: Description of the technology, innovation or management practice	
Problem addressed:	1. Massive deforestation leading to environmental degradation 2. Increased cost of fuelwood 3. Increased indoor pollution affecting household members' health and increasing health related costs 4. Environmental degradation in search of firewood leading to increased GHGs 5. 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)
What is it? (TIMP description)	It is an improved cooking stove with a high energy efficiency. Cookstoves 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.
Justification	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. Fuelwood 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.
Counties where the TIMPs will be up scaled	ASAL counties: Baringo, West Pokot, Tana River, Kajiado, Elgeyo Marakwet, Busia, and Garissa

B: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers and wide range of users in the rural and urban areas
Approaches to be 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	• Linkages with private sector - to improve access to technology, capacity building and market support • Affordable energy-saving stoves • Linkages with carbon markets
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
C: Current situation and future scaling up	
Counties where already promoted	Diverse counties
Current extent of reach	Most counties have at least one ICS technology
Counties where TIMP will be up scaled	Baringo, West Pokot, Tana River, Kajiado, Elgeyo Marakwet, Busia, and Garissa
Challenges in dissemination	• Inadequate policies and strategies, regulatory and institutional framework for supporting promotion of ICS • Inadequate financing and affordable credit facilities to support improved stoves related initiatives • Inadequate awareness on socio-economic and environmental benefits of promoting improved cook stoves • Inadequate technical, business and marketing skills for many stove SMMEs • Underdeveloped institutional framework for improved stoves skills transfer to local levels • Poorly developed quality control and monitoring mechanisms for stoves delivered to the end users • Low capacity for County Government support in dissemination of ICS
Suggestions for addressing the challenges	• Link farmers to Micro Finance Institutions (MFIs) • Capacity building and awareness creation on improved cook stoves • Sensitize county government to support farmers • Strengthen the County government extension system • Work with Public-Private Partnerships • Intensive research to improve the technology
Lessons learned in up scaling, if any	• Capacity building on the environment benefits of improved cook stoves is important for increased uptake
Social, environmental, policy and market conditions necessary	• Enhanced outreach and partnerships • Develop policies and fund initiatives for increased cook stove uptake

	• Strengthen Public-Private Partnerships to foster uptake • Strategic engagement with NARs for continued market and policy research and information dissemination
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
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 distributers - 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	• The energy-saving devices are easily accessible and user-friendly so VMG can use. • The project will potentially be able to contribute to household energy conservation for the VMGs, which translates into saved incomes and time. • VMGs can establish energy-saving devices enterprises as source of income and livelihood
E: Case studies/profiles of success stories	
Success stories	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. KCSAP-PPP opportunity: BURN Manufacturing's 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.
Application guidelines for users	This depends on the specific technology or ICS References 1. Stephen Gitonga. Appropriate Mud Stoves In East Africa 2. Koffi Ekouevi 2013. Scaling Up Clean Cooking Solutions: The Context, Status, Barriers and Key Drivers. World Bank

	3. Mercy Corps 2010. Basic Guide To Fuel Efficient Stoves And Emission Testing 4. The Republic of Uganda 2008. Construction Manual For Household Rocket Stoves. Ministry Of Energy And Mineral Development 5. FAO 1993. Indian Improved Cookstoves: A Compendium 6. UNHCR 2002. Cooking Options In Refugee Situations A Handbook Of Experiences In Energy Conservation And Alternative Fuels 7. Lydia Muchiri and May Sengendo. Appropriate Household Energy Technology Development Training Manual
F: Status of TIMP readiness (1=Ready for upscaling: 2=Requires validation; 3=Requires further research	1 Ready for upscaling
G: Contacts	
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

GAPS

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

6.2 Biogas

TIMP name	Biogas
Category (i.e. technology, innovation or management practice)	Technology
A: Description of the technology, innovation or management practice	
Problem addressed:	• Increased cost of fuelwood • Increased scarcity of fuelwood • Massive deforestation • Increased indoor pollution • Environmental degradation in search of firewood leading to increased GHGs
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. This is counterproductive.

	Used of fuelwood releases a lot of stored carbon into the atmosphere, contributing to GHG emissions. The need for alternative energy technologies are aimed at reducing 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: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers and wide range of users in the rural and urban areas
Approaches to be 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	• Linkages with Private sector - to improve production capacity and empowerment • Linkages with credit facilities • Technical skills development for the users • Capacity building on the benefits of biogas
Partners/stakeholders for scaling up and their roles	• Private sector (KENDIP, KENFAP) – access to technology, access to credit, technology installation • County government – capacity building, policy support, credit facilities, • NGOs (Practical Action, SNV, GIZ, HIVOS, Biogas International Ltd, Flexi Biogas Systems, SCODE)– access to technologies, capacity building, technology installation
C: Current situation and future scaling up	
Counties where already promoted	Baringo, Kajiado, Elgeyo Marakwet, Busia, Narok, Kakamega, Garissa, Kiambu, Nyandarua, Nakuru
Current extent of reach	Most counties with investments in dairy sector have biogas technologies – this include counties in central Kenya, some parts of rift valley and western Kenya
Counties where TIMP will be up scaled	Baringo, West Pokot, Tana River, Kajiado, Elgeyo Marakwet, Busia, and Garissa
Challenges in dissemination	• Male control of land and credit for investment and role of men in decision-making may limit ability of interested women to install biogas • Different perception and prioritization of energy issues in the household may lead to low adoption of biogas even where women recognize its benefits • The cost of technology installation is still prohibitive to many potential users • Limited number of skilled artisans to construct and provide maintenance services

	• Limited feed stock in some households • Inadequate post installation support • Poor management and maintenance (because of household labour constraints) • Many potential users of the technology are not aware of the technology • Lack of quality control and standards
Suggestions for addressing the challenges	• Link households to Micro Finance Institutions (MFIs) • Sensitize county government to support households • Work with PPPs for technology access, technical skills development and management • Intensive research to improve the technology • Aggregation of feedstock to supply the households in a centralized place • Technical capacity development, as a package in biogas roll out • Awareness creation on the benefits from biogas adoption to women • Address household decision-making processes (and control of assets such as land or capital) that may prevent adoption even when women are interested • Improve targeting of access to information for women and men
Lessons learned in up scaling, if any	• Benefits of biogas systems are realized with time • Technical skills development is important for ease of management at the household level
Social, environmental, policy and market conditions necessary	• Enhanced outreach and partnerships • Strategic engagement with NARs for continued market and policy research and information dissemination • Implementation of policies on green energy • Financial incentives to spur technology access and expansion of market reach
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
Basic costs	Average installation costs Kshs. 75,000
Estimated returns	Not known
Gender issues and concerns in development, dissemination, adoption and scaling up	• Limited gender or end users' participation in the design of digesters and appliances in line with their needs and priorities • Limited skills in biogas development and installation • Limited skills in sales and marketing • 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. • Male household heads may not consider the benefits of biogas adoption, particularly the benefits for women, or may have different considerations and prioritization of concerns

	• Men often control the resources required for biogas adoption • Gender disparities in access to information may impact on adoption decisions. Access to information is a pre-requisite for informed decisions on adoption
Gender related opportunities	• Skills training for women in Biogas development • Encourage women to become biogas installers and service providers • Hire women for promotion and sales work • Credit support for women entrepreneurs • Link biogas programme with income generation for women users
VMG issues and concerns in development, dissemination, adoption and scaling up	• Limited skills in biogas development and installation • Limited skills in sales and marketing • Limited access to biogas feedstock at the household level • Limited access and control of resources required for biogas adoption
VMG related opportunities	• Skills training in Biogas development • Encourage VMGs to become biogas installers and service providers • Hire VMG for promotion and sales work • Link biogas programme with income generation for VMG users
E: Case studies/profiles of success stories	
Success stories	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. 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 repellant and has a lifespan of four years on the farm before reapplication.
Application guidelines for users	The specifications for construction need to be sought from a skilled artisan References 1. Karanja, G.M. and Kiruiro, E.M 2003. Biogas Production. KARI Technical Note No.10, January 2003 2. Al Seadi T, Rutz D, Prassl H, Köttner M, Finsterwalder T, Volk S and Janssen R 2008. Biogas handbook. University of Southern Denmark Esbjerg, Niels Bohrs

	Vej 9-10, DK-6700 Esbjerg, Denmark 3. Dana R 2010. Micro-Scale Biogas Production: A Beginners Guide. NCAT. www.attra.ncat.org/attra-pub/PDF/biogas.pdf 4. World Bio-energy Association 2013. Biogas – An Important Renewable Energy Source: WBA Fact Sheet 5. 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 6. UK AID 2013. The Potential of Small-Scale Biogas Digesters to Improve Livelihoods and Long Term Sustainability of Ecosystem Services in Sub-Saharan Africa.
F: Status of TIMP readiness (1=Ready for upscaling: 2=Requires validation; 3=Requires further research	1
G: Contacts	
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)

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

6.3 Briquettes from Bagasse

TIMP name	**Bagasse for briquettes**
Category (i.e. technology, innovation or management practice)	Technology
A: Description of the technology, innovation or management practice	
Problem addressed:	• Increased cost of fuelwood • Increased scarcity of fuelwood • Massive deforestation • Environmental degradation in search of firewood leading to increased GHGs

What is it? (TIMP description)	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. . Briquettes are mostly used in places where cooking fuels are not easily available.
Justification	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. 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. 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 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. 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.
B: Assessment of dissemination and scaling up/out approaches	
Users of TIMP	Farmers and wide range of users in the rural and urban areas
Approaches to be 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	• Linkages with Private sector - to improve production capacity and empowerment • Linkages with credit facilities • Technical skills development for the users

	• Awareness creation on the environment benefits of briquettes
Partners/stakeholders for scaling up and their roles	• Private sector (including individuals)– access to technology, access to credit, technology installation • County government – capacity building, policy support, credit facilities, • NGOs (Practical Action, SNV, GIZ, HIVOS, SCODE)– access to technologies, capacity building, technology installation
C: Current situation and future scaling up	
Counties where already promoted	All Counties
Current extent of reach	Most counties but mostly in the urban settings
Counties where TIMP will be up scaled	All Counties
Challenges in dissemination	• Briquettes and/or their benefits are unknown to many biomass fuel users, which makes tapping into the potential market challenging and costly. • 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 • Lack of product certification or standardization of briquettes, thus resulting in substandard briquettes being produced by many small- and medium-scale businesses • Briquettes and/or their benefits are unknown to many biomass fuel users, which makes tapping into the potential market challenging and costly. • 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 • Packaged weight inconsistent with market demand • Producer price is too high to make it competitive with charcoal and other cook stove fuels • Different perception and prioritization of energy issues in the household may lead to low adoption of briquettes even where women recognize its benefits • Many potential users of the technology are not aware of the technology
Suggestions for addressing the challenges	• Link businesses to Micro Finance Institutions (MFIs) • Sensitize county government to support households access the technology • Work with PPPs for technology access – especially briquetting machines, technical skills development and management

	• Intensive research to improve the technology • Aggregation of feedstock for steady supply in making briquettes • Diversify feedstock supply in order to reduce cost of supplies and increase volume, largely from locally available agricultural wastes. • Increased market awareness for increased uptake in retail markets • Policy on product standardization
Lessons learned in upscaling, if any	• 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. • Fuel briquette enterprise development requires workable partnerships for resource mobilization, technological support, establishment of linkages among stakeholders and enabling policy
Social, environmental, policy and market conditions necessary	• Enhanced outreach and partnerships • Strategic engagement with NARs for continued market and policy research and information dissemination • Implementation of policies on green energy • Financial incentives to spur technology access and expansion of market reach
D: Economic, gender, vulnerable and marginalized groups (VMGs) considerations	
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	• Depending on the technology used, some may not favor women because of the costs involved • Although women may be the main provisioner and user of energy, they are not necessarily the main decision maker in a household. • 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 • Gender disparities in access to information may impact on adoption decisions. Access to information is a pre-requisite for informed decisions on adoption
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	• Limited skills in briquette development and installation • Limited skills in sales and marketing • Limited access to briquette feedstock at the household level

	• Limited access and control of resources required for briquette adoption
VMG related opportunities	• Offers an opportunity for income generation for women through development of briquettes and sales
E: Case studies/profiles of success stories	
Success stories	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. 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. https://www.kenyacic.org/news/acacia-innovations-esfm-success-story
Application guidelines for users	• 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. • Drying - Crushed sugar cane bagasse should have moisture below 10%. Drying ensures high-quality charcoal is produced. • 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. • Carbonizing - Carbonization Furnace is a stove that changes biomass briquettes into the charcoal briquette. **References** 1. AMAHAWE Uganda. AWU Briquette Manual: Fuel from The Fields - Making Fuel Briquettes 2. BTG Biomass Technology Group 2013. Sustainable Charcoal Production From Alternative Feedstocks
F: Status of TIMP readiness (1=Ready for upscaling: 2=Requires validation; 3=Requires further research	1
G: Contacts	
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)

GAPS

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