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From buffet to best-fits: co-identifying and prioritizing best-bet CSA practices for targeting and scaling

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Report on CSA technology co-identification and selection for implementation in climate-smart landscapes of Ethiopia

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Abstract

Recent evidences and developments highlight that climate-smart agriculture (CSA) is best placed to support the growing global populations under the world of land degradation and climate change while sustaining the environment and reducing emissions. It is considered progress and sustainable approach designed to link agricultural production and food security to climate change adaptation and mitigation, in order to guide the management of agriculture and food systems at multiple scales. Implementation and scaling of CSA practices/technologies/options are however resource and knowledge intensive exercises. CSA is also site-specific whereby what can be defined as 'climate-smart' in one location may not be smart in other context. It thus requires identifying practices and technologies that fit the landscape conditions under consideration and are profitable to and acceptable by the respective local communities. Climate-smart interventions need also consider local social differences, particularly gender and economic inequalities, to ensure equal benefits for men, women, and marginalized groups and to avoid exacerbating existing discriminations as well as be effective and sustainable. Careful selection among suit of options that satisfy the needs and requirements of nature and society is thus crucial to get meaningful contribution from CSA and promote its adoption. Linkages with key actors and exploring institutional options for targeting and scaling are also of paramount importance to achieve implementation of CSA at landscape scale and maintain sustainability. In this roprt we highlighted major steps and processes that have been followed to identify basket of CSA technologies and identified short-list of best bets that fit the situations of the two CSVs: Godoberet and Doyogena landscapes in two contrasting farming systems of the highlands of Ethiopia. The approach employed a combination of tools such as participatory methods, expert consultations, literature review, and survey data to identify and prioritize key CSA practices that are location- and context-specific. Among a copendum of CSA options, the key five technologies short-listed for the two sites are soil bunds (combined with and Phalaris grass (Phalaris acquatica and tree Lucerne (Chamaecytisus palmensis)), gully stabilization (with on-site and off-site interventions), exclosure, in-situ water harvesting, and agroforestry are the most important ones. Soil bunds of different types integrated with biological options such as grasses and trees (depending on site characteristics) are the most widely used and studied. This is because of the multiple benefits these options can offer: increase income (mainly from grasses and trees), reduce erosion, enhance soil moisture, restore soil health, sequester more carbon in the soil and with trees above ground and serve as livestock feed among others. It is however important to note that the 'prioritized CSA practices' highlighted in this report should be considered with caution as multiple and complementary options are 'profitable' compared to single ones. In addition, coupling CSA options with other agroadvisories will be more relevant to address complex problems.

Keywords: Land degradation, landscape restoration, coupling, budling, smartness indicators

Acronyms

CIAT	International Center for Tropial Agricultures
CSA	Climate Smart Agriculture
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CGIAR	Consultative Group on International Agricultural Research
GHG	Greenhouse Gas
ICARDA	International Center for Agricultural Research in the Dry Areas
ILRI	International Livestock Research Institute
MoA	Ministry of Agriculture
USAID	United States Agency for International Development

Background

Population growth, rapid urbanization, and dietary changes are placing tremendous pressure on food systems. The world's population is predicted to increase by 50% over the next few years, possibly reaching 9.8 billion by 2050 (UNDESA, 2017). To feed this population, crop production should increase by 50–70% through the closing of a yield gap of about 7,400 trillion calories, or by gaining 56% more crop calories than were produced in 2010 (WRI, 2018; Lundqvist et al., 2021). This has to be achieved in an environment where there will be a global agricultural land deficit by 2050 of about 593 million hectares (Mha) compared with that available by 2020 (WRI, 2018). The gap is expected to widen even more due to the impacts of climate change and land degradation, which are expected to lead to a global average crop yield reduction of about 10% by 2050 (IPBES, 2018). Satisfying the food and nutrition needs of the global population by 2050 will thus be more daunting.

A similar trend prevails in developing regions such as sub-Saharan Africa. For example, the ca. 110 million population of Ethiopia will reach more than 180 million by 2050 (Bekele and Lakew, 2014; UNDESA, 2017). This requires an increase in billions of tons of cereal and 200 million tons of annual meat production in order to meet the nutritional and food security needs of the increasing demand (FAO, 2017). This situation is worsened by the fact that over 60% of the farming households in the country operate on small plots averaging less than 1 ha (e.g., Rahmato, 2011; CSA, 2015) and scattered across space with significant operational challenges (e.g., Zewdie and Tamene, 2020). Because the possibility of significantly expanding cultivable land is unlikely, the efficiency of agricultural production should increase substantially to feed the growing population. This should be achieved without compromising ecological integrity and environmental sustainability. Achieving these targets under the challenges of climate change (mainly rainfall variability) and continued land degradation can be challenging in a dominantly rainfed system of the country.

The above scenarios clearly reflect that resources should be targeted in a rational way to the production systems that have the highest potential to achieve the triple wins of poverty reduction, environmental protection, and food security. Increasing agricultural productivity in a sustainable manner while at the same time adapting to a changing climate and reducing GHG emissions are three interlinked challenges that the agricultural sectors need to overcome in the next decades. This means that the agricultural production and food systems need to undergo a profound transformation in order to achieve the above triple objectives. Recent evidences and developments highlight that climate-smart agriculture (CSA) is best placed to achieve the above targets: feeding the increasing population while sustaining the environment and reducing emissions (FAO, 2010; Rosenstock et al., 2016). CSA is an approach designed to link agricultural production and food security to climate change adaptation and mitigation, in order to guide the management of agriculture and food systems at multiple scales.

CSA is however a resource and knowledge intensive exercise. It is also site-specific whereby what can be defined as 'climate-smart' in one location may not be smart in other context. It thus requires identifying practices and technologies that fit the landscape conditions under consideration and are acceptable by the respective local communities. Climate-smart interventions need also consider local social differences, particularly gender and economic inequalities, to ensure equal benefits for men, women, and marginalized groups and to avoid exacerbating existing discriminations as well as be effective and sustainable (Nelson and Huyer, 2016). Careful selection among suit of options that satisfy the needs and requirements of nature and society is thus crucial to get meaningful contribution from CSA and promote its adoption (Thornton et al., 2018). Linkages with key actors and exploring institutional options for targeting and scaling are also of paramount importance to achieve implementation of CSA at landscape scale and maintain sustainability.

Participatory approaches, literature review and modelling techniques can be used to identify and prioritize key CSA options/practices/technologies that are location- and context-specific (Thornton et al., 2018). Under a collaborative project that involve key partners such as USAID, EU-IFAD, and World Bank, the Alliance of Bioversity and CIAT in collaboration with Inter Aide, ILRI, WLE, CCAFS, Woreda Bureaus of Agriculture and local communities has been implementing integrated land and water management practices aimed to restore degraded areas and enhance resilience of communities and landscapes in the highlands of Ethiopia. Started piloting in two catchments under the Africa RISING project, it was possible to scale methods, frameworks, and technologies across various sites. This report highlights the key steps and processes followed to select and prioritize key CSA practices in two contrasting sites of Ethiopia and that can be scaled to other locations.

Co-identifying and piloting candidate CSA options

Some of the major drivers that motivate the implementations of integrated land and water management and CSA practices in Ethiopia is land degradation and poor soil fertility. Communities in the majority of the rural areas of Ethiopia are faced with severe erosion, poor soil fertility and unreliable rainfall events that trigger overall production decline and food insecurity. Concerted efforts have been made to tackle these problems for the last decide with different levels of success (Abera et al., 2020). The effort of the government and local communities to restore degraded areas through integrated soil and water conservation (SWC) and sustainable land management (SLM) practices is commendable. There is no other country in the world where national campaigns are organized every year to bring communities together to contribute free labour for 40-60 days and implement extensive SWC and SLM technologies (Adimassu et al., 2018). Recent efforts by the government and other development and non-governmental organizations focus on coupling SWC and SLM practices with water harvesting techniques to support smallholder livelihoods.

Figure 1. Participatory approaches employed to define the major constraints in the Gudoberet and Doyogena sites. The problem identification exercise included participatory mapping of the major hotspots where CSA practices interventions show be prioritized.

Sequential and step-wise processes are followed to locate priority areas of intervention, identify suitable, location- and context-specific technologies, implement the technologies and generate evidences. In the Gudoberet site, located in the North Shewa Zone of Basona District, participatory mapping using GIS-system as a background was one of the key techniques used to identify hotspots and corresponding SLM/CSA technologies (Fig. 1). In all cases, participatory approach is crucial to make sure that the demand of communities is taken into consideration to promote adoption. In addition, collaboration between and among actors as well as involvement of interdisciplinary teams are essential. In this section we document and outline the steps followed to identify CSA options and implement those in two sites: Gudoberet (Amhara region) and Doyogena (South Nations, Nationalities and Peoples region). In both sites, key stakeholders operating in the study sites of interest were identified and discussion held to bring forces together and co-implement activities. Participatory approaches were followed whereby relevant stakeholders and local communities co-identified technologies that are suitable for the respective environments and at the same time that can bring multiple benefits. This is an essential step to make sure that CSA recommendations are not prescriptive.

In the case of the Gudoberet site, focus group discussion was held to co-list potential CSA technologies that can be used to tackle the problems observed in the site under consideration. Communities first identified and listed the major problems in their areas (Fig. 1). Soil erosion (including gullies), poor soil fertility, feed shortage, small parcel size, shortage of fuel for cooking, and unreliable rainfall were listed as the major factors that undermine their agricultural productivity and livelihood options (Lewoyehu et al., 2020). The communities also 'identified and mapped' the hotspots where the above major problems prevail and thus should be prioritized for management intervention. Once the causes of their livelihood problems were defined and their geographical location defined, the next step was about what to do in order to tackle those problems. This led to the identification of potential CSA options that are fit for the intended purpose and can suit the existing environment. Accordingly, various CSA practices/technologies were identified and implemented following complementarity and matching to the landscape continuum (Fig. 2). The key CSA options that have been piloted in the Gudoberet area include soil bunds, bunds with grass-trips, terraces, terraces with biological measures, trenches, enclosures, percolation pits, check dam, and gully rehabilitation technologies. Approximately, about 1000 ha of land is covered with these practices. About 500 households benefited from the interventions. In addition, maintenance was conducted in areas where there was a need by involving local communities. An example is the effort made to maintain restored gully of over 50 meters in the Gudoberet site. The gully has been restored and now farmers managed to re-claim lost cultivated area. It is important to note that the technology identification and implementation was conducted by the North Shewa Zone and Basona Werena Woreda Bureau of Agriculture, the Gudoberet and Adisge Kebeles watershed management team and the local communities. The Alliance of Bioversity and CIAT provided technical support and capacity building at various stages of the exercises. In this site, "multi stakeholder platforms" were established through the Africa RISING project to support and coordinate project implementation. Brief information about the major CSA practices implemented, tested and evaluated in the two CSVs can be found here

(CSA practices at Doyogena.pptx CSA, practices at Basona.pptx).

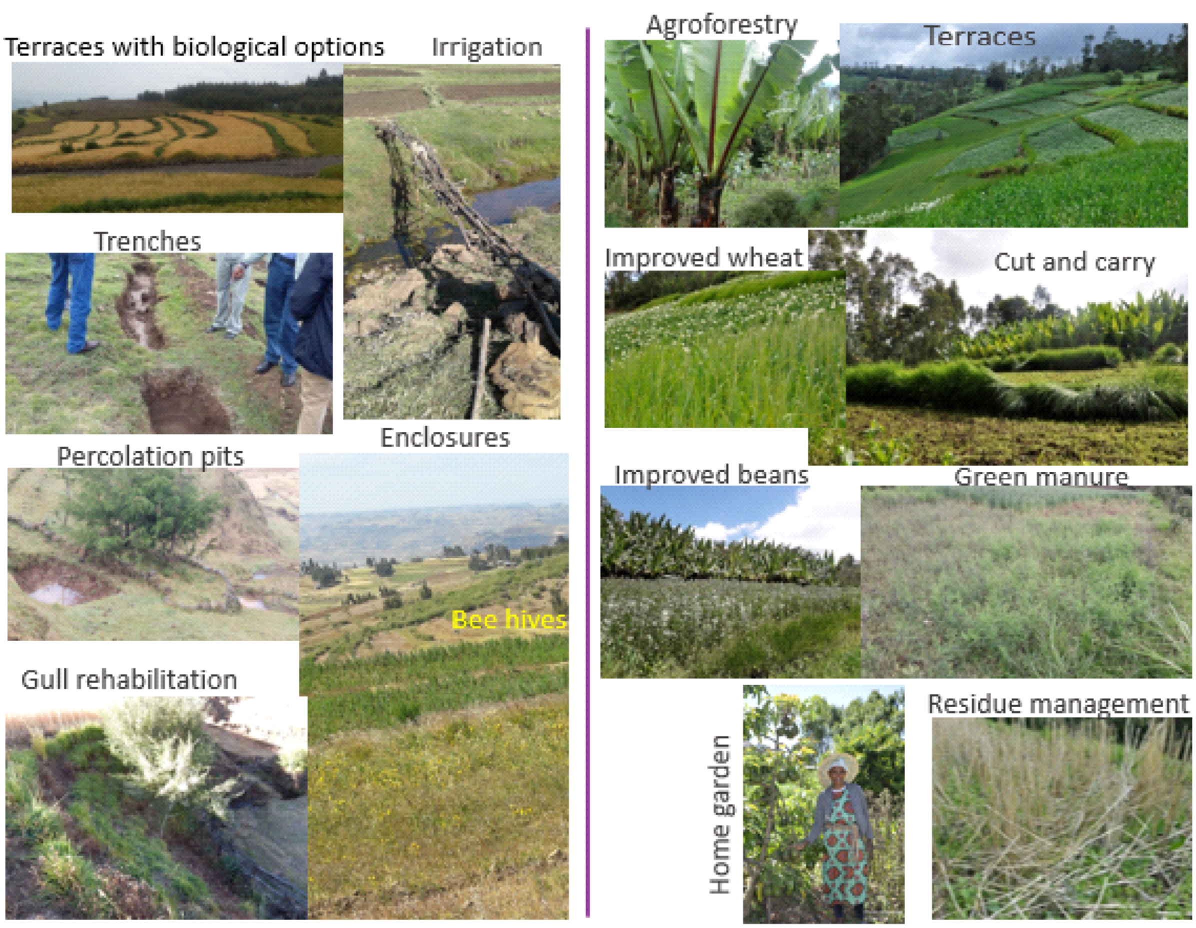

Figure 2. Glossary/compendium of major CSA technologies implemented in the (a) Godoberet and (b) Doyogena sites.

With regards to the Doyogena site in the Doyogena District of Kembata Tembaro zone, similar participatory engagements were followed to plan CSA interventions. The local NGO called Inter Aide played prominent role to mobilize resources and coordinate technology selection and implementation of CSA practices in the Doyogena site. The first step followed participatory and local knowledge approach to identify the dominant problems to tackle. The major constrains in the area are poor soil fertility associated with population pressure, water shortage for both livestock and people, lack of feed and forage for livestock, soil erosion, unreliable rainfall and small parcel size. Despite relatively suitable 'ecological zone' compared to the Gudoberet site, the Doyogena area experiences one of the highest land degradation problem due to high population pressure. Because of this migration of the youth towards urban areas and abroad is very common. However, the area has high potential to implement diverse integrated land and water management practices. Accordingly, several CSA practices such as terrace with forages, controlled grazing, improved verities (wheat, bean, and potato), crop rotation, crop residue, green manure, agroforestry, and cut and carry system were implemented (Fig 2). An approximate area of 2000 ha is covered with these practices. Around 1500 households benefited from the CSA practices. As stated above, different partners contributed to the various CSA interventions in the area. The key ones include Africa RISING, Woreda Bureau of Agriculture, CCAFS, and WLE. Inter Aide and local communities capitalize on the traditional institution called "Idir" to implement and enforce bylaws associated with the management of the CSA practices.

From buffets to best-bets: select best-fit CSA options for targeting and scaling

Though promising CSA practices exist and much has been learnt in recent years that can support decision-making, many decision-makers still struggle in identifying the best-bet CSA interventions in their own context. Generally, compendium of potential CSA options are available that can be implemented at different scales. However, it may not be necessary and/or possible to apply those larger number of options due to different reasons. In some cases, the identified options can be expensive in terms of time, resources, labour to fit the specific local conditions. In other cases, the availability and accessibility of the options can be limited to be used in a sustainable manner. There is thus a need to develop 'short list' of best-bets/fits that can be prioritized for specific areas. This requires detailed assessment of the 'menu of options' to compare among available ones and determine those that can be applied in the short-term and identify those that can be used in the future.

Figure 3. Approaches used to generate evidences about the performances of CSA technologies in the two CSVs of Ethiopia

Prioritization of best-bet CSA options can be achieved following different approaches such as focus group discussions, interviews and based on results from field experimentation of CSA practices (Fig. 3). Participatory and expert rankings are the most commonly used methods. In addition, modelling techniques can be employed to prioritize CSA practices. Literature review to conduct meta-data analysis (about the performances of CSA practices across space and time) is also widely used in many instances. A recent study related to experience capitalization that assess relevance of land and water management technologies at household and community level was also used to gain an idea of which CSA options performed well in their respective areas of implementation (see this link for summary result). In this exercise we used a combination of techniques to short-list CSA techniques for targeting and scaling in similar areas. Examples of the process followed are given below.

Fig. 4 shows the major steps and example indicators used to identify best-best CSA technologies from potentially large number of options in the two CSVs in the highlands of Ethiopia. The designation given in Fig. 4 may not have clear cut boundary but can be used as key criterion to short-list CSA options among a compendium of list available. Broadly, the criteria can be classified into biophysical and socio-economic with sustainability parameter. The ability to offer multiple benefits and those which consider gender and youth responsiveness are also among the useful papermakers that should be considered when 'prioritizing' CSA technologies.

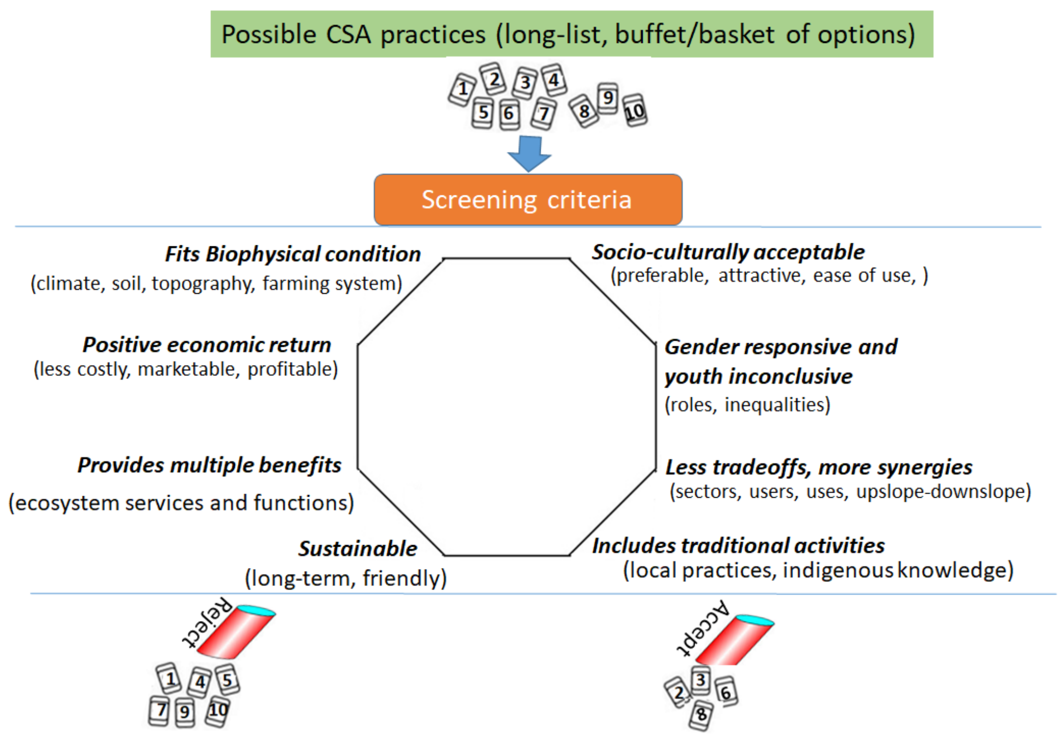

Figure 4. Major indicators commonly used to select CSA options for targeting and scaling

One of the key criteria commonly used to short-list from a basket of CSA technologies is its *fitness* to the area under consideration considering climate, soil, terrain, and associated farming systems. With regards to the existing two CSVs, we matched CSA options to biophysical conditions using overall suitability assessment of given farming systems for specific technologies. For targeting and scaling, recommendation domain is being developed (Tamene et al., under review). In addition, farmers' experiences and local knowledge were used to select options that can fit for the two sites.

The other parameter used to short-list CSA best-bets is their *acceptability* by local communities. In this exercise, preference analysis was conducted focusing on the two sites (Getachew et al., 2021). Using the Evaluating Land Management Options (ELMO) tool, it was possible to identify the major constraints and challenges of farmers' in utilizing specific CSA technologies. The assessment also included evaluating the potentials, opportunities and benefits (as perceived by farmers) of the different CSA options. In both cases, terraces integrated with biological options followed by in-situ water harvesting are preferred.

The *economic benefits* and profitability of the various CSA options are other options that can be used to facilitate technology choice. Various approaches such as field data, socio-economic survey and focus group discussions are commonly used to achieve this task (Mutoko, 2014). In this study, various studies associated with the two CSVs and at national scale were used to assess the role of different CSA practices (e.g., Abonesh et al., 2021).

The multiple benefits that a given CSA practice can offer are among the essential parameters used to prioritize those practices. Meta-data analysis and assessment using field observations were used to achieve this goal. Evidence generated for the Gudoberet site showed that use of SWC practices on cultivated lands increased total Nitrogen, available phosphorus, exchangeable K and organic carbon by 70%, 79%, 23% and 33%, respectively (Tefere et al., 2020b). It is also shown that water discharge increased from 0.235Ls^{-1} to 1.619 Ls^{-1} due to landscape restoration activities. Other meta-analysis in Ethiopia showed that use of soil/stone bunds combined with grasses the triple wins of CSA through increasing crop yield and income from grasses (productivity), reduce soil erosion and nutrient depletion (adaptation) and increase soil organic carbon accumulation (enhance mitigation) (Meaza et al., 2021). Meta-data studies were also conducted to identify options that performed well considering different parameters in various parts of Ethiopia (Abera et al., 2020; Desta et al., 2021; Meaza et al, 2021). These studies show the effectiveness of the technologies vary with the dominant problems that need to be addressed. For instance, when erosion is the primary problem that need to be addressed by the local community, mechanical controls such as terraces and bunds are proven to be prioritized technologies (Desta et al., 2021). On the other hand, integrated mechanical and biological interventions are proved to be effective to address the multiple benefits such as erosion reduction, enhance productivity and sequester more carbon in the soil, and others (Abera et al., 2020). In terms of biodiversity, a study shows that 39 plant species were recorded in exclosure areas as compared to 13 plant species in the adjacent degraded land (Terefe et al., 2020a). This shows that exclosure in Gudoberet site improved the biodiversity of landscapes. In addition to these, it is generally essential to consider local practices and knowledge as these have better chance of adoption by the local community. An important consideration in this regard is analysis of tradeoffs. For instance, a meta-data analysis shows that soil/stone bund has an impact of decreasing erosion with a potential to decreasing crop yield (Admassu et al., 2014; Abera et al., 2020).

The gender responsiveness of the various CSA technologies is another important factor that needs to be considered when prioritizing CSA technologies. The Geofarmer tool (Bonilla-Findji et al., 2020) was used to assess whether the technologies implemented in the two CSVs are gender responsive. Nigussie et al. (2021) assessed the impact of CSA practices on productivity, resilience and gender dimension. Preliminary results show that CSA practices that requires low labor and knowledge respond to gender priorities and can be considered gender responsive (Nigussie et al., 2021).

Based on the above assessments, soil bunds combined with and Phalaris grass (*Phalaris acquatica, Phalaris arundinacea*) and tree Lucerne (*Chamaecytisus palmensis*), gully stabilization, exclosure, in-situ water harvesting, are the most important CSA practices in the Gudoberet area (Fig. 5). The development of trees and grasses around soil and stone bunds created opportunities in improving the availability of animal-feed in the system in Gudoberet. Phalaris grass in the Gudoberet site is the most important animal feed grown on soil/stone bunds and exclosure (Fig. 6). Similarly, development of tree lucerne on soil/stone bunds increased the availability of animal feed in Gudoberet site (Fig. 6). The successful work in the Gudoberet site that rehabilitated a huge gully is among the key technologies preferred in the area (Fig. 6). This was achieved using multiple interventions such as reshaping, construction of check dams (730 m^3 wooden check dam and 71 m^3 gabion check dams) and percolation pits, and planting of biological measures (Terefe et al., 2020a).

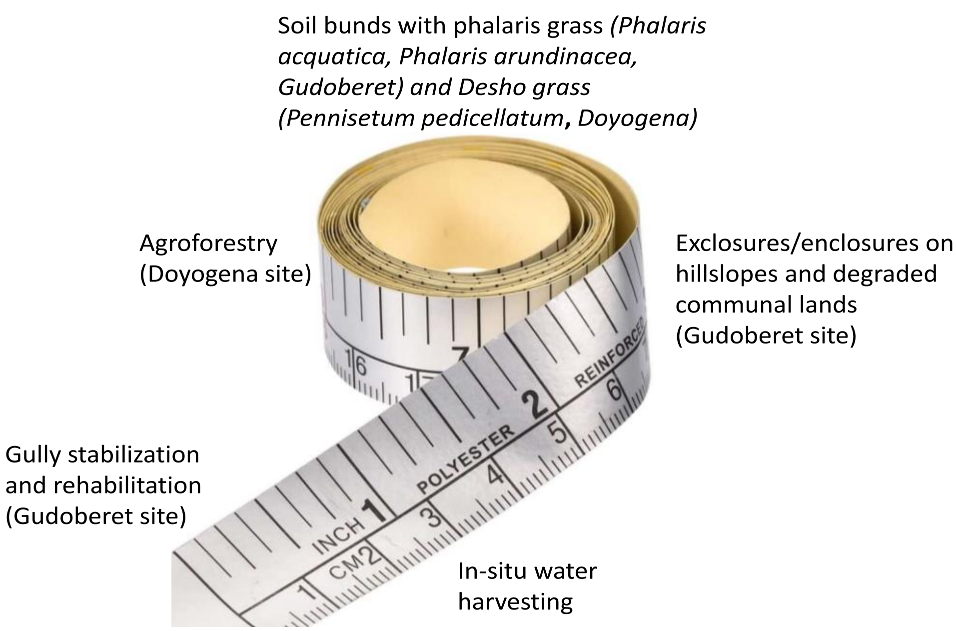

Figure 5. The five key CSA technologies/practices/options identified based on experiences in the two CSVs (Gudoberet and Doyogena) sites in Ethiopia. Note that these technologies are not the only ones being applied but these are the dominant ones and identified by communities and experts as the most commonly applied.

Exclosures whereby direct interference by people and livestock is prevented were instrumental in restring degraded and barren areas. The local farmers have been impressed with this achievement despite their concern of tradeoff associated with shortage of grazing land. In some cases the barren lands have been used as stable for livestock and when enclosed some farmers were constrained of space. But there is realization that such constraint is better off in relation to the benefits that can be gained from the enclosed areas (livestock feed, improved soil moisture, reduced soil erosion, improved biodiversity and flower for bees (Terefe et al., 2020b).

In-situ water harvesting such as trenches and percolation pits constructed mainly on degraded lands including exclosure sites and above gully heads have brought diverse benefits (Fig. 6). Trenches and infiltration pits have improved water infiltration and reduced soil erosion as well as enhanced the regeneration of trees and grasses on degraded landscapes. However, it is important to note that trenches constructed on cultivated lands can creat water lodging and affect crop production negatively.

In the Doyogena site, two major SWC practices mainly Fanya chini with desho grass (*Pennisetum pedicellatum*) and Fanya juu terrace implemented on cultivated lands (Fig. 6) are considered among the most useful CSA options. *Fanya chini* consists of trenches and earthen ridges facing down slope, which is mainly introduced to reduce soil erosion and enhance infiltration. It also reduces nutrient leaching and makes more water available for crops. The excavated soil, obtained by digging trenches 50-60 cm deep and 60 cm wide, is placed on the lower side of the contour trenches, facing down slope. This is one of the most important distinguishing characteristic of *Fanya chini* compared to Fanya juu where the excavated soil is relocated upslope. The presence of the bunds ensures the formation of micro-catchments that concentrate the runoff coming from the land upslope of the bunds. Fanya chini terraces in the Doyogena site are complemented with Desho grass (*Pennisetum pedicellatum*) to stabilize the soil bund and increase availability of animal feed in the crop-livestock system.

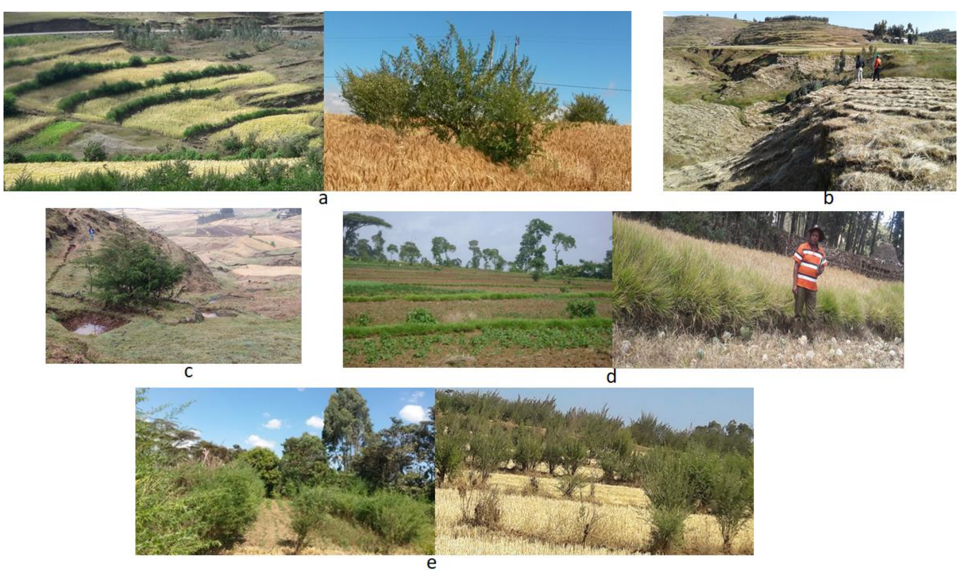

Figure 6. Best-bet CSA practices implemented in the Gudoberet and Doyogena sites that can be scaled to similar environments: (a) soil and stone bunds combined with tree lucerne (Chamaecytisus palmensis) and Phalaris grass (Phalaris acquatica, Phalaris arundinacea) and tree lucerne (right) planted on soil bunds in Gudoberet landscape; (b) gully restoration; (c) infiltration pits in degraded areas; (d) fanya chini with desho grass (Pennisetum pedicellatum) on cultivated lands and fanya Juu terrace and desho grass on cultivated lands; (e) agroforestry practices mainly implemented in the Doyogena site.

Another prominent CSA technology in the Doyogena site is Fanya juu, which consists of terrace bunds and ditches along the contour. The main purpose is to prevent water and soil loss and to make conditions more suitable for plants to grow. In most cases, Desho grasses were established behind soil bunds to stabilize the structure and improve feed availability. In some cases, tree Lucerne is planted around homesteads to improve feed availability (Fig. 6).

It is also important to note that agroforestry is an important and commonly used CSA practice in the Doyogena CSV. The climatic condition and farming system of the area are conducive for agroforestry practices and nearly all farmers in the area have some form of agroforestry in their homestead. In addition, many of the farmlands in the area have trees compared to the majority of the barren fields in the Gudoberet CSV.

In general, among the above CSA practices in the CSVs, soil bunds (combined with and Phalaris grass (Phalaris acquatica, Phalaris arundinacea) and tree Lucerne (Chamaecytisus palmensis)), gully stabilization (with on-site and off-site interventions), exclosure, in-situ water harvesting, and agroforestry are the most important ones. Soil bunds of different types integrated with biological options such as grasses and trees (depending on site characteristics) are the most widely used across the country. This is because of the multiple benefits these options can offer: increase income (mainly from grasses and trees), reduce erosion, enhance soil moisture, restore soil health, sequester more carbon in the soil and with trees above ground and serve as livestock feed among others. Because of their widespread use these options are also among the most studied.

Summary and conclusion

Irrespective of the methods or tools used, it is important to note that climate-smartness and choice of best-bets are context specific due to diversity in opportunities, constraints, vulnerabilities, and agricultural sector characteristics (Sova et al., 2017; Sova et al., 2018). Because of this the CSA practices prioritized for the two CSV sites would be different. For the Gudoberet site, options and techniques that can be used to reduce soil erosion will be prioritized while in the Doyogena site priorities will be given to those technologies that can be used to enhance soil fertility. CSA practices are thus tested and adapted to local settings and conditions. The existing farming and production systems also determine the type relevance of CSA technologies. The enset-based farming system of the Doyogena area also harbors suitable conditions for agroforestry, fruits and vegetables compared to the cereal-dominated Gudoberet site.

Considering the above realities, local communities and experts can have different assessment levels of the same CSA technology/practice. This means CSA technologies with the highest smartness scores may not always be widely prioritized by experts and widely identified technologies do not always hold the highest smartness scores. For example, in the Doyogena area lupine is prioritized as key livestock feed despite low ranking along the CSA best-bet continuum. There is also general 'bias' while scorning smartness towards productivity followed by adaptation with minimum consideration for the GHG emission pillar. This is because of the predominant role of yield and income for the local community whose livelihood depends on agriculture. The difference in the prioritization of farming systems (e.g., between crops and livestock or between cereals and legumes) can also determine the choice of CSA best-bets. Ultimately, available information, level of trainings and capacity play important role when ranking CSA technologies.

Considering the above evidences, it is important to note that there is no CSA "silver bullet" and the smartness of a system depends on more than the technologies deployed at plot level (Sova et al., 2018). Despite single options are considered during the ranking exercise, integrated practices can bring multiple benefits through enhanced complementarities. This means singular interventions will have limitations compared to implementing multiple ones following the landscape continuum. In addition, actual CSA implementation on the ground should consider the whole farming system and value-chain rather than isolated farms or plots. It is thus essential to move beyond a "practice" lens and consider locally appropriate bundles of technologies and practices, and implement them in an integrated manner considering their complementarity. This is important because complementary technologies promote synergies between productivity, adaptation, and mitigation pillars, enhancing opportunities for co-benefits and potential "triple-wins." In addition, bundled CSA packages with other advisories can best address the complex biophysical and socio-economic challenges in a sustainable manner. The 'prioritized CSA practices' highlighted in this report should thus be considered with caution as multiple and complementary options are 'profitable' compared to single ones.

Investments in capacity building (for farmers, experts, and decision makers alike) and knowledge dissemination (through public extension services, universities and academia, or the private sector) are critical for ensuring the widespread adoption of CSA, particularly to enable the vital but complex implementation of integrated measures at landscape scale.

References

Abera, W., Tamene, L., Tibebe, D., Adimassu, Z., Kassa, H., Hailu, H., Mekonnen, K., Desta, G., Sommer, R., and Verchot, L. (2020). Characterizing and evaluating the impacts of national land restoration initiatives on ecosystem services in Ethiopia. *Land Degradation & Development*, *31*(1), 37-52.Adimassu Z.; Langan S.; Barron J. (2018). Highlights of soil and water conservation investments in
four regions of Ethiopia. Colombo, Sri Lanka: International Water Management Institute (IWMI). 35p. (IWMI Working Paper 182). doi: 10.5337/2018.214

Adimassu, Z., Mekonnen, K., Yirga, C., Kessler A. (2014). Effect of soil bunds on runoff, soil and nutrient losses, and crop yield in the central highlands of Ethiopia. Land Degradation and Development 25(6): 554-564

Bekele, A., Lakew, y. 2014. Projecting Ethiopian Demographics from 2012-2050 Using the Spectrum Suite of Models. Health policy project. https://www.healthpolicyproject.com/index.cfm?id=publications&get=pubID&pubId=724.

Bonilla-Findji O, Ortega A, Eitzinger A, Recha J, Ambaw G, Abera W, Tamene L, Demeke G, Desalegn M, Mekonnen K, Radeny M, Solomon D, Läderach P. 2020. How are smallholder households coping with and adapting to climate-related shocks in Doyogena climate-smart landscapes, Ethiopia? CCAFS Info Note. Addis Ababa, Ethiopia: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Desta, G., Abera, W., Tamene, L., & Amede, T. (2021). A meta-analysis of the effects of land management practices and land uses on soil loss in Ethiopia. Agriculture, Ecosystems & Environment, 322, 107635.

Desta, G., Tamene, L., Abera, W., Amede, T., & Whitbread, A. (2021). Effects of land management practices and land cover types on soil loss and crop productivity in Ethiopia: A review. International Soil and Water Conservation Research (TSI).

FAO. 2017. *The future of food and agriculture – Trends and challenges.* Rome

FAO, 2010. "Climate-Smart" Agriculture Policies, Practices and Financing for Food Security, Adaptation and Mitigation

Getachew, K.; Abera, W.; Tamene, L. (2021) Assessment of farmers' perceptions and land management preferences using the participatory tool for evaluating land management options. [n.p.] 23 p.
IPBES (2018): Summary for policymakers of the assessment report on land degradation and restoration of the Intergovernmental Science-policy Platform on Biodiversity and Ecosystem Services. IPBES secretariat, Bonn, Germany. 44 pages.
Lewoyehu, M., Alemu, Z., Adgo, E. (2020). *The effects of land management on soil fertility and nutrient balance in Kecha and Laguna micro watersheds, Amhara Region, Northwestern, Ethiopia. Cogent Food & Agriculture, 6(1), 1853996.* doi:10.1080/23311932.2020.18539.
Lundqvist, Jan., Malmquist, L., Dias, P., Barron, J. and Wakeyo, M. B. 2021. *Water productivity, the yield gap, and nutrition.The case of Ethiopia.* FAO Land and Water Discussion Paper No. 17. Rome, FAO. https://doi.org/10.4060/cb3866en
Meaza, H., Abera, W., & Nyssen, J. (2021). Impacts of catchment restoration on water availability and drought resilience in Ethiopia: a meta-analysis. *Land Degradation & Development*.
Mutoko, MC. 2014. Adoption of Climate-Smart Agricultural Practices: Barriers, Incentives, Benefits and Lessons Learnt from the MICCA Pilot Site in Kenya. FAO-MICCA Progam final report.
Nelson S, Huyer S. 2016. A Gender-responsive Approach to Climate-Smart Agriculture: Evidence and guidance for practitioners. Climate-Smart Agriculture Practice Brief. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).
Rahmato, D.2011. Land to Investors: Large-Scale Land Transfers in Ethiopia; Forum for Social Studies: Addis Ababa, Ethiopia.
Rosenstock TS, Lamanna C, Chesterman S, Bell P, Arslan A, Richards M, Rioux J, Akinleye AO, Champalle C, Cheng Z, Corner-Dolloff C, Dohn J, English W, Eyrich AS, Girvetz EH, Kerr A, Lizarazo M, Madalinska A, McFatridge S, Morris KS, Namoi N, Poultouchidou N, Ravina da Silva M, Rayess S, Ström H, Tully KL, Zhou W. 2016. The scientific basis of climate-smart agriculture: A systematic review protocol. CCAFS Working Paper no. 138. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).
Sova, C. A., G. Grosjean, T. Baedeker, T. N. Nguyen, M. Wallner, A. Jarvis, A. Nowak, C. Corner-Dolloff, E. Girvetz, P. Laderach, and Lizarazo. M. 2018. "Bringing the Concept of Climate-Smart Agriculture to Life: Insights from CSA Country Profiles Across Africa, Asia, and Latin America." World Bank, and the International Centre for Tropical Agriculture, Washington, DC.
Sova C. 2017. Assessing climate change adaptation needs in the agricultural sector: Experiences from the CGIAR Research Program on Climate Change, Agriculture and Food Security. CCAFS Info Note. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).
Terefe, H., Argaw, M., Tamene, L., Mekonnen, K., Recha, J., Solomon, D. (2020a). Effects of sustainable land management interventions on selected soil properties in Geda watershed, central highlands of Ethiopia. Ecological Processes 9:14. https://doi.org/10.1186/s13717-020-0216-2.
Terefe, H.; Argaw, M.; Tamene, L.; Mekonnen, K.; Recha, J.; Solomon, D. (2020b). Effects of integrated land management, landscape position and land-use types on soil physicochemical properties, discharge, species richness and carbon stock in Geda watershed, north Shewa, Ethiopia, PhD Dissertation, Addis Ababa University.
Thornton, P. K., Whitbread, A., Baedeker, T., Cairns, J., Claessens, L., Baethgen, W., ... & Keating, B. (2018). A framework for priority-setting in climate smart agriculture research. *Agricultural Systems*, *167*, 161-175
UNDESA (2017) United Nations Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2017 Revision, Key Findings and Advance Tables. Technical Report, United Nations, New York.
WRI. 2018. Creating a sustainable food future: *A menu of solutions to feed nearly 10 billion people by 2050.* Synthesis report, December 2018.
Yaekob T, Tamene L, Gebrehiwot SG, et al. (2020). Assessing the impacts of different land uses and soil and water conservation interventions on runoff and sediment yield at different scales in the central highlands of Ethiopia. *Renewable Agriculture and Food Systems* 1–15.