Info Note

What is the evidence-base for climate-smart agriculture in Kenya?

An analysis of what works where powered by Evidence for Resilient Agriculture (ERA)

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Key messages

- Limiting biophysical and climate condititions combined with low adoption of improved agronomic practices threaten the livelihoods of smallholder farmers and the sustainability of the agriculture sector in Kenya.
- Research shows clear opportunities for climate-smart agriculture (CSA) to improve productivity and resilience of farms, especially maize.
- Additional work is needed to cover farming systems besides maize-based (i.e., livestock, poultry, fruit, and cash crops) and further outcomes including economic productivity, crop and household resilience and greenhouse gas (GHG) mitigation.

Climate change, food and agriculture

Agriculture, forestry and fishing drives Kenya's economy. This sector accounts for 34% of Gross Domestic Product (GDP), generates more than 60% of the national export earnings, and accounts for 40% of the country's total employment (World Bank 2020). Most farmers (between 70 and 80%) are smallholders who produce almost two thirds of the food in the country (FAO 2015). Maize and beans are the cornerstone of agricultural production, covering 37% and 21% of the total cultivated land, respectively. Other major food crops are cowpea, pigeon pea, potatoes, cassava, millet, sweet potato, mango, coconut, banana, rice and cabbage. Major export crops include tea, coffee, cut flowers, avocados, beans and nuts.

Reliance on rainfall makes the agriculture sector in Kenya—particularly in arid and semi-arid lands, which form about 66.7% of the country—highly vulnerable to climate variability and change. The past decade has been marked by severe, frequent droughts which have comprimised the food security and livelihoods of millions of people. Due to climate-related events (particularly droughts) and subsequent production losses, the crop sub-sector has lost more than USD 5 billion between 1980 and 2012 or over USD 150 million annually (World Bank 2015). In the future, dry areas are expected to become drier, with more frequent and prolonged dry periods, while potential rainfall increases are expected in some areas only (Lake Victoria, central highlands) (CIAT and WB 2016). Such trends warn of future challenges for access and availability of food for the country.

Figure 1. *Promoting CSA by combining fodder trees, shrubs and grass for dairy cattle on a Kenyan farm. Photo: ICRAF.*

In recognitition of these challenges, the Government of Kenya launched the Kenya Climate-Smart Agriculture Framework in 2017, a 10-year initiative to build resilience of the sector and decrease agriculture's contribution to climate change (GoK 2017). Moreover, the country's Intended Nationally Determined Contributions contain several adaptation and mitigation options for the sector that would help reduce the country's GHG emissions by 30% by 2030, relative to a business-as-usual scenario. Such actions provide an enabling environment for agricultural transformation and to create a productive, resilient, and climate-smart future in Kenya.

CSA aims to increase productivity, build resilience to and mitigate climate change in the agricultural sector. Dozens of improved agronomic and livestock management technologies have the potential to reach these goals. The selection of appropriate CSA options requires evidence of what works where and for whom in order to make the best possible and most informed choices. But what information on CSA in Kenya is there available? This brief answers that question.

The evidence-base for CSA

We searched for evidence of the 'climate-smartness' of agricultural technologies in Kenya in the peer-reviewed literature using a systematic review protocol (Rosenstock et al. 2015). This search targeted information on over 100 potential CSA practices and more than 50 potential outcomes (e.g., yield, net economic returns, soil carbon, etc.) in Kenya. A study was included in the resulting database if it contained primary, quantitative data on both a conventional technology (a control) and a CSA technology and information on at least one outcome indicator relevant to the three goals of CSA: productivity, resilience, or mitigation. The database is also known as "Evidence for Resilient Agriculture" (ERA).

We found 161 peer reviewed studies on potential CSA practices in Kenya. These studies came from 244 sites which were well distributed across the country (Figure 2) and contributed 9,759 observations. Research effort was typically higher in more populous districts, with 46% of the research data coming from counties with over one million inhabitants (particularly Kakamega, Machakos, Nakuru, Homa Bay and Kisii) and almost a quarter from counties with a population between 500,000 and 1,000,000 (particularly from Siaya, Embu, Busia). Data came from both on-farm studies (52%) and research stations (48%). Trials in farmers' fields typically offer a more representative depiction of how farmers implement technologies, delivering a more realistic and accurate assessment of technology performance; therefore, a balance between studies on-farm and research stations is desired.

Kenya's land surface area falls within five major agro-ecological zones: arid (10.8%), semi-arid (55.9%), sub-humid (9.5%), humid (1.1%), tropical highlands (22.7%). Our data were largely from highland (85%) sites with less research from humid (7.9%), sub-humid (5%) and semi-arid (2.1%) areas.

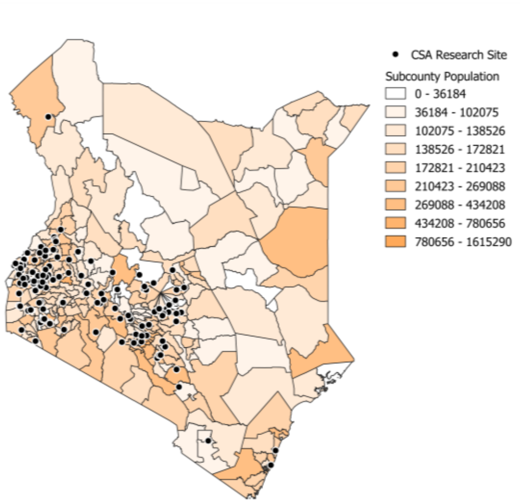

Figure 2. *Location of studies on CSA practices in Kenya (black dots) plotted on a map of population (orange) for each county.*

The ERA database for Kenya contains data on 28 different agricultural products, ranging from maize to livestock. However, not all of these products have been studied equally (Figure 3). Data on maize makes up the majority (73%) of available evidence. Other nutritionally important sources of protein, both animal-sourced products and legumes, make up less than 10% of the data. Still that means there are nearly 1,000 data points on these products.

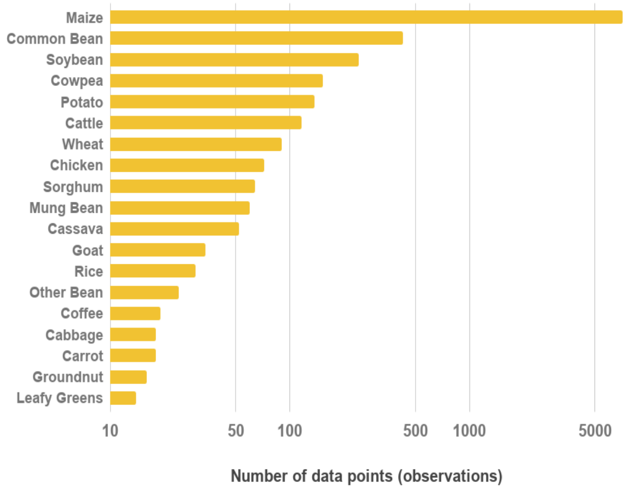

Figure 3. *Representation of agricultural products analyzed with ERA data in Kenya. The values are presented in a log10 scale.*

The database also contains information on 22 different potential CSA technologies studied across the country. The analysis of each technology requires specific implementation methods, for example when calculating the effect of agroforestry we aggregate across all the different tree species used within and between studies. Use of inorganic fertilizers is the most heavily studied management measure comprising nearly 40% of the data (Figure 4). Diversification practices including alley cropping with trees, crop rotations and intercropping represent 20% of the practices in the dataset, while soil water management technologies (reduced tillage, crop residue incorporation) are also well represented in the dataset. Eleven percent of the studies consider post-harvest practices, such as storage and feed processing. CSA technologies are most commonly implemented in practices implemented jointly; 54% of available data are from technologies applied in combination with others, such as conservation agriculture, which combines reduced tillage, soil cover and crop diversification.

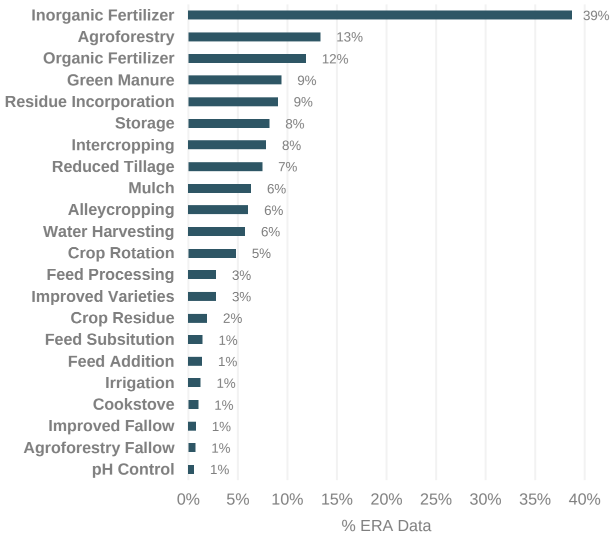

***Figure 4**. Distribution of ERA data for Kenya by practice/technology.*

CSA is based on the premises that agricultural practices and technologies can deliver multiple benefits related to sustainable productivity, resilience/adaptation, and mitigation. For Kenya, the ERA database contains data on 9 different outcomes of CSA with 16 different sub-indicators. However, the majority of the data comes from the productivity pillar: 69% of the data is on a component of productivity, such as product yield, costs or net returns, and nearly all of this data is on yield (39%) (Figure 5). Another third of the data (29%) is related to resilience indicators, such as soil health or efficiency, while only two percent relates to mitigation outcomes such as GHG fluxes or soil carbon stocks.

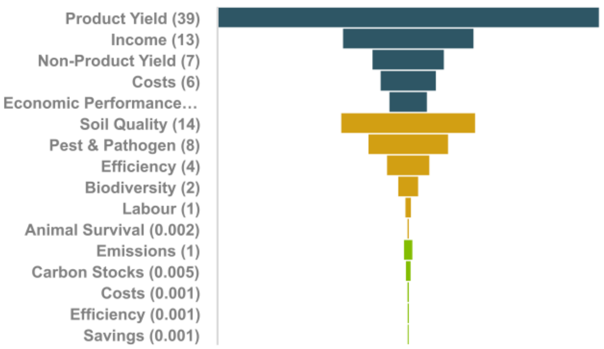

***Figure 5.** Distribution of ERA data for Kenya across the three pillars of CSA, and their individual indicators. Dark blue represents productivity indicators, gold resilience and green mitigation. Figures in parentheses indicate percentage of all data in ERA for Kenya.*

The majority of studies (71%) contain data on only one CSA pillar, while 29% have measured outcomes across two CSA pillars (typically productivity and resilience). Only one percent of the studies in ERA covered all three pillars of CSA. Extrapolations about the performance across multiple objectives of practices are difficult to infer from studies that took place at different times and in different locations; co-located research is best suited to understand the ability of technology to produce win-win-win outcomes.

Climate-smartness of technologies

With these data, we can query key questions about the performance of technologies in Kenya using meta-analysis. Meta-analysis is a statistical way of combining the results found in different studies. This facilitates a robust and objective analysis that integrates across different environmental conditions due to locations and years. Full details of the statistical approaches we use can be found in Rosenstock et al. (2015), Lamanna et al. (2019), and Nowak et al. (2020). Here we discuss expected effects on productivity, resilience, and mitigation.

Productivity

Our data show that implementation of CSA technologies will usually increase productivity (Figure 6). This increase ranges from approximately 2% with combinations of practices that include agroforestry pruning and intercropping to more than 100% in the case of green manure combined with inorganic fertilizers. Reductions in productivity are also observed, especially in the case of livestock related practices (feed processing combined with feed substitution reducing yields by almost 50%) or alleycropping implemented alone (a 40% reduction in yields). The average expected change in productivity when a CSA practice is adopted and across all the observations in our dataset is approximately 30%.

Crop and livestock management practices have different capacity to increase the productivity and improve resilience of farming systems in Kenya. This depends on the technology being used and whether or not the technology is being used alone or in combination with other technologies (e.g., Figure 7).

Increasing yields is only one measure of productivity or technology performance. With these data, we also analyzed the downside risks when a new technology is used. That is, what is the likelihood a farmer might expect yields lower than the conventional practice. Quantification of risks were based on distribution of expected outcomes from the research studies (see Nowak et al. 2020).
We broadly found very little risk of lower yields with CSA (Figure 7). Across most combinations of technologies it is expected that yields would be greater than when using conventional practices across the range of experimental conditions. However, some combinations of technologies had risk of yielding lower than controls, these included crop rotation with intercropping, reduced tillage alone, mulch and inorganic fertilizer, and alley cropping with tree management (with or without organic fertilizer).

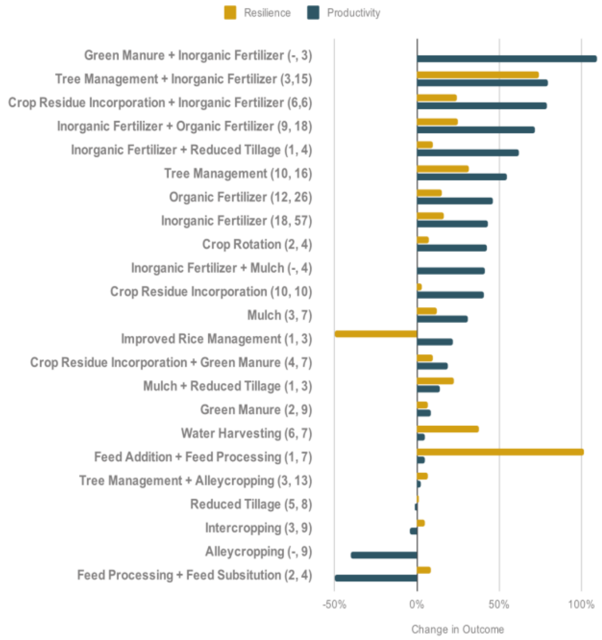

Figure 6. *Relative effects of technologies (aggregated across solo use or in combination with other practices) on productivity (blue) and resilience (orange). Figures in parantheses indicate the number of observations contributing to each effect calculation (resilience and productivity, respectively).*

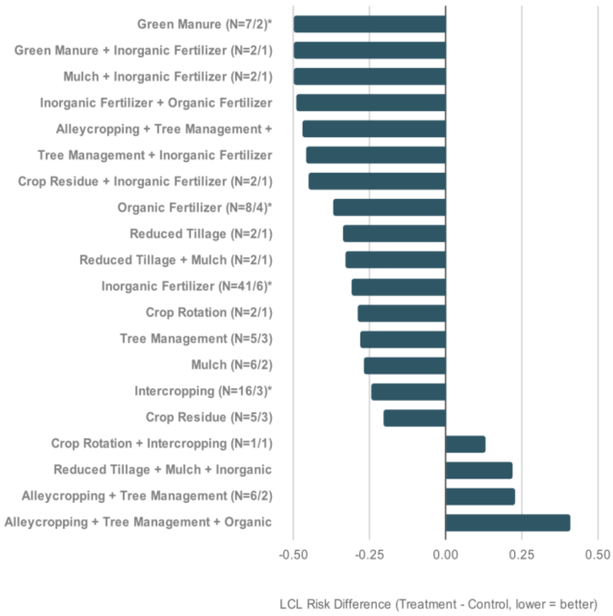

Figure 7. *Risk analysis of multi-annual CSA datasets by lower confidence limit. Values less than 0 indicate the CSA practice has a greater than 50% chance of yielding more than the mean control yield over the time-series (lower risk). Values higher than 0 indicate the practice has a greater than 50% chance of yielding less than the control over the time-series (higher risk). N indicates the number of observations and studies for a practice.*

Resilience

Using proxies of resilience such as soil carbon or resource use efficiency, the data indicate resilience benefits of switching to new technologies. Animal feed addition combined with feed processing gave the largest boosts to resilience outcomes (around 100%). In arable systems, use of water harvesting technologies or addition of tree prunings plus inorganic fertilizers were also found to increase resilience (Figure 6).

Where studies collected data over several years, we were able to calculate yield stability as another way to quantify the peformance under various climate conditions. Yield stability quantifies the variability of yields year to year and is a direct measure of performance and resilience of a technology under different environmental conditions. We find that green manure significantly and substantially enhances yield stability (Figure 8), while reductions in stability are observed in alley cropping combined with tree management, or when intecropping, tree management or crop residue are implemented individually.

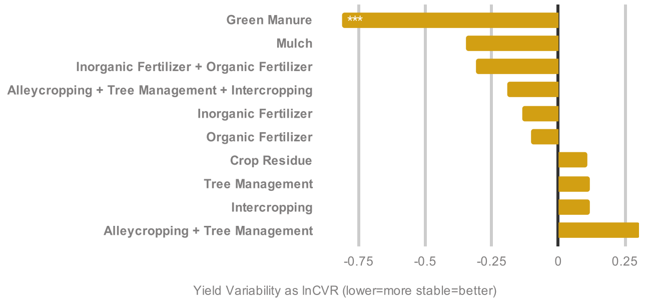

Figure 8. *Effect of CSA technologies (aggregated across solo use or in combination with other practices) on yield stability (lnCVR). Lower values indicate greater yield stability.*

Positive resilience and productivity benefits were found when using tree management (the application of prunings from agroforestry as mulch) together with inorganic fertilizers, with 75% increases in resilience outcomes and 80% in productivity (Figure 6). Such outcomes are particularly important when designing incentive mechanisms to increase and scale adoption.

When switching to CSA practices, there is potential for trade-offs between CSA objectives. We found that in some cases a technology that improves production may have a relatively small impact on proxies indicators of resilience, such as inorganic fertilizer used in combination with reduced tillage. The reverse is also true. Resilient practices may bring insignificant productivity benefits (feed addition combined with feed processing) or even reduce them considerably (feed processing combined with feed substitution).

Mitigation

There is very little information on the benefits of CSA for mitigating climate change in Kenya. The reason for this is because although there has been significant investment in developing new emissions data, it rarely compares management practices against a control of farmers practices. Available data is limited to a few sites and time periods which compromise the ability to generalize. Despite this, farm systems in the country have great potential to contribute to climate change mitigation. For instance, tree cover builds above-ground carbon stocks, while diversification and use of mulch often help maintain, if not build, stocks of soil organic content. However, future agricultural development may also incentivize the increased use of nitrogen-based materials which lead to climate-forcing emissions; these will need to be considered in the context of increasing productivity and maintaining soil resources.

Conclusions and policy implications

This brief provides a starting point for understanding the evidence base for CSA in Kenya, which is critical for future efforts to adapt and transform the agriculture sector in the context of climate change. These results may inform the selection of priority interventions (practices, technologies) to promote and scale, as well as ones to finally move past. Importantly, these data also provide a clear systematic understanding of where there are already a lot of existing data and hence can serve to direct future research and development agendas that can address the needs of the people. Lastly, this brief is focused exclusively on Kenya, reporting data from studies conducted within the country. However, the data are part of a pan-Africa initiative on establishing the evidence base for CSA technologies. More evidence is available and can be brought to bear on the policy and programmatic discussions in the country through the ERA website.

Further reading

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