

Chapter 12

What Is the Evidence Base for Climate-Smart Agriculture in East and Southern Africa? A Systematic Map



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12.1 Investments in CSA

More than 500 million USD will soon be invested in climate-smart agriculture (CSA) programmes across sub-Saharan Africa, a non-trivial fraction of which is targeted for East and Southern Africa. CSA is increasingly endorsed and promoted by national, regional, continental and global institutions (e.g., governments, the Regional Economic Communities of the African Union, the New Partnership for Africa's Development, international non-governmental organizations and the Green

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Climate Fund). The aim is to help smallholder farmers (1) sustainably increase productivity and incomes, (2) adapt to climate variability and change and (3) mitigate climate change where possible (FAO 2013). With planned investments, political will and implementation capacity, CSA is emerging as a mechanism for coherent and coordinated action on climate change adaptation and mitigation for agriculture.

Farm- and field-level management technologies are a core component of most planned CSA investments (Thierfelder et al. 2017; Kimaro et al. 2015). Farm-level technologies represent a broad category of direct activities that farmers can undertake on their fields, in livestock husbandry, or through management of communal lands. Climate-smart actions may include both the adoption of new/improved inputs and new/improved application methods, such as adopting drought resistant crop varieties, reducing stocking rates of animals, changing harvesting and postharvest storage techniques (Lipper et al. 2014). The vast number of farm-level options that might meet CSA objectives coupled with the large number of possible outcomes that fit under the three pillars of CSA, has led many development practitioners, scientists and governments to the question: “What is CSA and what is not CSA?” (Rosenstock et al. 2015a).

This question, however, presents a false dichotomy. By definition, CSA is context specific and subject to the priorities of farmers, communities and governments where it is being implemented. Until now, little empirical evidence has been provided to systematically evaluate which CSA practices work where (see Branca et al. 2011 for a first attempt). Instead, CSA is often supported with case studies, anecdotes, or aggregate data, which paint an incomplete picture of both the potential and challenges of CSA (e.g., FAO 2014; Neate 2013). The lack of comprehensive information on CSA is not surprising, given the fact that it includes a wide diversity of solutions at the farm production and rural livelihood levels. Consequently many interventions that increase productivity are labelled as “CSA” without evidence on the other two objectives of CSA, at least one of which would need to be also documented to qualify any intervention as CSA. Although “triple win” interventions at the field level may be the exception rather than the rule, evidence has to be provided on all objectives to support policies and programmes that may wish to promote CSA (Arslan et al. 2017).

There is an urgent need to provide decision-makers—including investors—with information to help them design programmes and policies, as well as to increase the effectiveness of development programming. In response and in this paper, we have conducted a quantitative and systematic review to map the evidence published in peer-reviewed literature on the effectiveness of technologies and management practices to achieve the objectives of increased productivity, resilience and mitigation for the five countries in East and Southern Africa: Tanzania, Malawi, Mozambique, Zimbabwe and Zambia. Our systematic map sets the benchmark on what data and evidence are available on how farm and field management practices affect indicators of CSA outcomes.

12.2 A Systematic Approach

This systematic map relies on a data set compiled as part of the CSA Compendium “The Compendium”. The Compendium created search terms relevant to one of 102 technologies including new inputs and farm management practices (58 agronomic, 15 agroforestry, 19 livestock, 5 energy, or 5 postharvest management practices) on more than 57 outcomes in productivity, resilience or mitigation, such as, yields, gender differentiated labour use, or soil organic carbon, respectively. Studies were included based on four inclusion criteria: (1) conducted in a tropical developing country, (2) included conventional control practice and a practice being suggested as CSA, (3) contained primary data on the impacts on at least one of the indicators of interest and (4) conducted in the field (i.e., no modelling studies). Lists of the search terms for practices and outcomes and additional details on the inclusion criteria can be found in the systematic review protocol (Rosenstock et al. 2015b).

Studies were identified by searching the Web of Science and Scopus databases using search terms indicative of practices and outcomes. Our search found 150,367 candidate studies, 7497 of which were included in the final Compendium library based initially on abstract/title reviews and then full text reviews. Out of these, 313 studies were conducted in one of the five countries. Data were compiled into an Excel database manually from each study. Data retrieved from the selected studies include information on location, climate, soils, crops, livestock species and outcome values for both conventional (non-CSA control) and treatment practices. Frequency and distribution of components in the data set (i.e., practices, outcomes and products) are analysed by summary statistics.

12.3 The Evidence

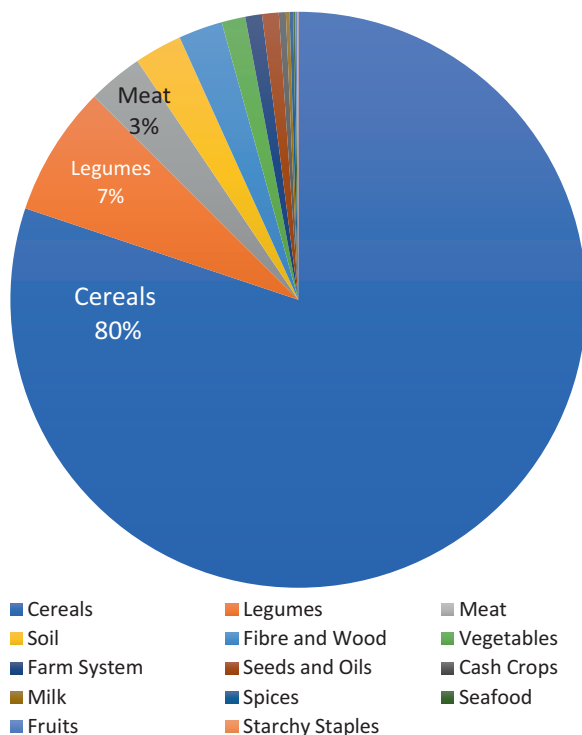
More than 150 studies met our inclusion criteria for this paper and were included in the data set analysed here. The data set contains 12,509 data points that compare a conventional practice with a potential CSA practice in a specific time and place. For example, the comparison of conservation agriculture versus conventional agriculture at Chitedze Agricultural Research Station, Malawi in 2007 (see Thierfelder et al. 2013). Studies were unevenly distributed across the five countries with a ten-fold difference in the number of studies conducted in the most studied country (Tanzania) versus the least studied country (Mozambique) (Fig. 12.1). The studies were primarily conducted on research stations where 58% of data was generated compared with 42% on farmers’ fields or in household surveys. This is significant because research on station under scientist-controlled conditions often outperforms the same practice in farmers’ fields due to the higher quality of implementing the practices and historical management of the site (Cook et al. 2013). Thus, the evidence will generally reflect the upper bound of what can be achieved by farmers.



Fig. 12.1 Location of the studies included in this systematic map

Studies were clustered in a few locations and agroecologies within each country. This is unsurprising given the investments and infrastructure necessary to conduct field research. However, geographical clustering further indicates the potential for skew in the available evidence. With clustering, it is unlikely that the full range of CSA options are analysed, which limits the utility of the work to help decision-makers to choose among various options. Key gaps in agroecologies include coastal

Fig. 12.2 Products included in the data set. The majority of data is on cereal crops, specifically maize. This creates gaps in our knowledge of lesser studied products. For example, only 2% of the data is on other cereals



and semiarid zones. Future analyses of these data should examine if the distribution of practices and agroecologies reflects key criteria such as percentage of the population that relies on the production of the agricultural output studied for food security, etc.

While the data set contains information on 39 agricultural products such as milk, pulses, spices, cotton, etc., the vast majority of data comprise only a handful of products. For example, data on maize accounts for 78% of the data set (Fig. 12.2). Pulses were second but made up only 7% of the data set. In contrast, many products (21) make up less than 2% of the data set. Therefore, we know a lot about maize production in the region but much less about other products. This presents a challenge for investments in CSA, because many of the proposed actions intend to diversify smallholder fields and farms, but this data set suggests a lack of information on crops other than maize. It also indicates that there is little evidence on switching to crops that may be more resilient or better suited to future climates, such as sorghum (0.8% of data set) and millets (no data available in these countries, despite its importance in the drylands of the region). However, it should be noted that crop switching is often studied through modeling efforts and therefore would not have been selected as part of this assessment. Regardless, there is a need for more empirical studies on maize alternatives, particularly given that maize yields

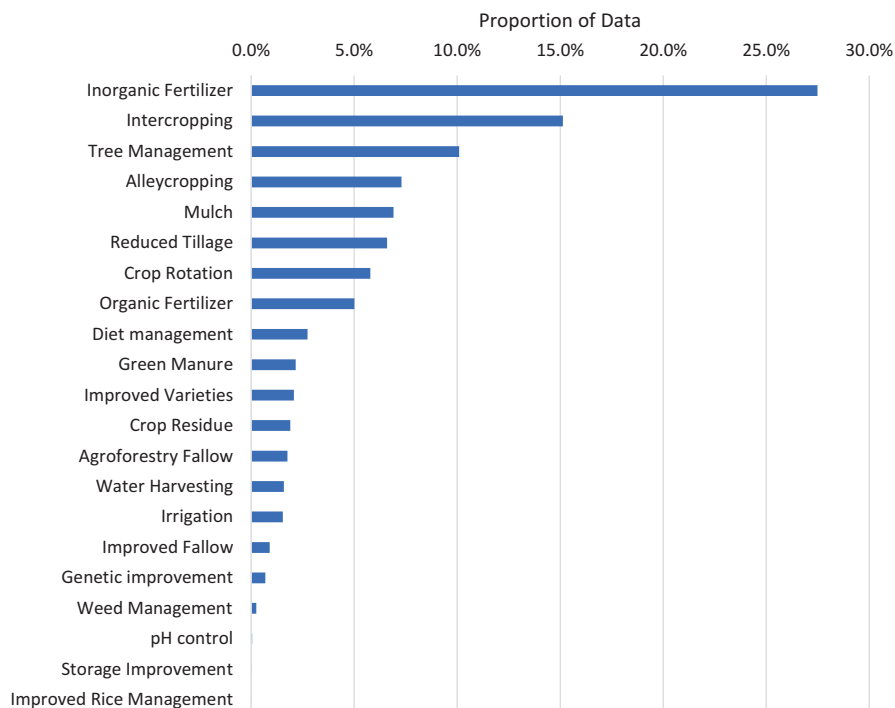


Fig. 12.3 Extent of data available for 21 practices (and 63 subpractices – not shown) in the data set

are projected to decline with climate change in the region, especially in Malawi (Ramirez-Villegas and Thornton 2015).

Existing evidence is also limited on integrated crop and livestock systems, because 93% of the data were on crops while only 3.5% on livestock. Almost all of the data on livestock were on improved diets, with a little on improved breeds. Some of the most commonly mentioned regional livestock adaptation strategies, such as pasture management technologies and animal housing, are absent from the data set. This is an important gap to be filled as these technologies are also relevant for the mitigation pillar of CSA.

Data on practices are similarly skewed with a few practices accounting for a significant percentage of the data set on 63 CSA practices. For example, studies of inorganic fertilizers are the most common (27.5% of data) and almost 3500 individual data points involved the addition of nitrogen alone (Fig. 12.3). However, this is due in part to the difference in how research is performed in different fields. Agronomic field trials on fertilizers typically use multiple types of fertilizers at many rates (e.g., 0, 20, 40, 80 kg/ha) over at least 3 years and sometimes decades (e.g., Akinnifesi et al. 2006, 2007; Matthews et al. 1992). On the other hand, studies on livestock feeding practices typically analyse a few alternative diets over just one

or two short periods (e.g., Gusha et al. 2014; Mataka et al. 2007; Sarwatt et al. 2002). Despite most data being on a relatively small number of practices, significant data are available for practices of high interest to the development community. For example, 28% of the data is on practices that diversify production systems such as rotations, intercropping and agroforestry (e.g., Myaka et al. 2006; Munisse et al. 2012; Thierfelder et al. 2013; Nyamadzawo et al. 2008; Chamshama et al. 1998). Therefore, some information exists to reduce the uncertainty about implementing such interventions. Other commonly studied practices include mulching, organic fertilizers and reduced tillage.

Common recommendations for CSA interventions include packages of technologies, such as conservation agriculture or systems to intensify rice production. When multiple practices are adopted together, they can have synergistic or antagonistic effects on CSA outcomes. A significant majority (72%) of our data is from practices done in combination with at least one other CSA practice (e.g., agroforestry + mulching, intercropping + manure). This provides insights into how practices operate alone or in combination, which helps in making decisions and recommendations on best practices under specific conditions.

Lastly, we analysed the distributions of outcomes. The first striking pattern is that 82% of data are related to the productivity pillar – yields, incomes, etc. (Fig. 12.4b). Contrastingly, resilience outcomes make up only 17.5% of the data, which is primarily related to soil quality (11.4%) and input-use efficiencies (4.5%). This means that there is scant evidence on many other indicators, especially those that are believed to impart some level of resilience. It is also indicative of the difficulty in defining resilience indicators in the literature. Finally, only 0.5% of the data set is related directly to mitigation outcomes, such as greenhouse gas emissions or total carbon stocks. Thus, there are major gaps in our understanding of how potential CSA practices affect resilience and mitigation outcomes across various contexts in East and Southern Africa. There is almost a complete lack of data on mitigation, which requires urgent action to calibrate low emission trajectories.

One of the fundamental goals of CSA is to produce win-win or win-win-win outcomes across productivity, resilience and mitigation. However, our data set suggests that it is only possible to analyse win-win outcomes, given the dearth of information on mitigation. That is because most studies only examine a single pillar, about 32% study two pillars and less than 1% study all three (Fig. 12.4a). This is a critical insight into the evidence base of CSA because it shows the lack of co-located (in the same study) research across pillars. It is often not possible to extrapolate results on the same practice between sites because outcomes can be significantly influenced by local context (e.g., Pittelkow et al. 2015a, b; Bayala et al. 2012). Given the general lack of co-located research across CSA outcomes, aggregation techniques such as the Compendium and meta-analyses, can be used to gain insights into multiple outcomes from practices, including looking into potential trade-offs between different objectives.

It was not a surprise that most studies on potential CSA practices examine yields and soil health, as they are the basis of agronomic research. Perhaps the biggest surprise in the data set is that there is a significant amount of economic information

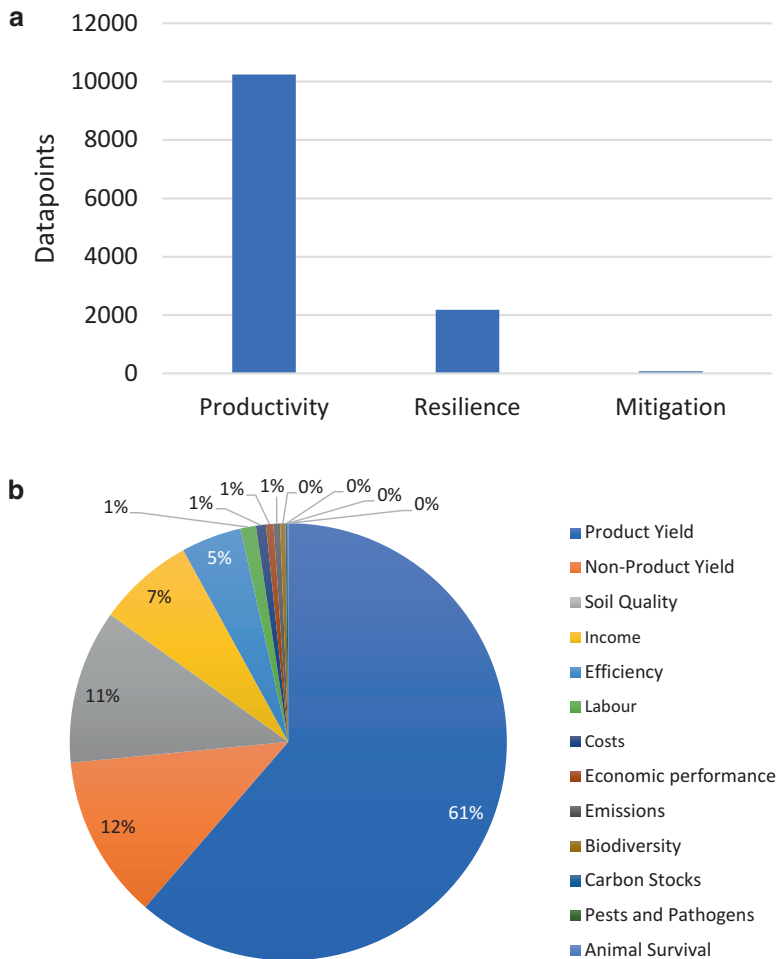


Fig. 12.4 Distribution of outcomes in the database: (a) what pillars are being studied? (b) which outcomes are being studied?

available. Nearly 20% of the papers presented economic information, derived from farm enterprise budgets, including indicators such as net returns, variable costs, net present value, etc. This subset of the data provides key information on the costs and benefits for the farmer in adopting CSA, information often missing in the discussion around programming and policy for interventions. These data will be used in future studies in combination with agronomic information to address this gap to the extent possible.

12.4 Implications for Practitioners

Our systematic map provides a first appraisal of the evidence base to assess the contributions of a wide set of field level technologies to CSA objectives in East and Southern Africa. Despite more than 50 years of agricultural research, this database shines a light on potential skew in our knowledge base. It also identifies key areas for future investments in research. Although the database may not be as comprehensive as desired due to shortcomings on the number of agroecologies, products or outcomes included, it does provide a wide range of information on many products, practices and outcomes, and therefore reduces the uncertainty of making decisions in the countries reflected in the analysis presented here. Over the next 6 months, the authors will conduct a quantitative meta-analysis—a statistical approach to combine information across studies—to help identify best interventions (and combinations thereof) during the design phase of programmes and policies.

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