

Sustainable intensification: What is its role in climate smart agriculture?

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The 'sustainable intensification' (SI) approach and 'climate-smart agriculture' (CSA) are highly complementary. SI is an essential means of adapting to climate change, also resulting in lower emissions per unit of output. With its emphasis on improving risk management, information flows and local institutions to support adaptive capacity, CSA provides the foundations for incentivizing and enabling intensification. But adaptation requires going beyond a narrow intensification lens to include diversified farming systems, local adaptation planning, building responsive governance systems, enhancing leadership skills, and building asset diversity. While SI and CSA are crucial for global food and nutritional security, they are only part of a multi-pronged approach, that includes reducing consumption and waste, building social safety nets, facilitating trade, and enhancing diets.

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Introduction

Agriculture faces some stiff challenges ahead. It has to address the fact that almost one billion people go to bed hungry every day, while more than two billion people will

be added to the global population by 2050 [1^{••}]. In addition, food consumption patterns are changing as the average person in the world gets richer and consumes more food and more meat. There is increased competition for land, water, energy, and other inputs into food production. Climate change poses additional challenges to agriculture, particularly in developing countries. At the same time, many current farming practices damage the environment and are a major source (19–29%) of anthropogenic greenhouse gas (GHG) emissions [2[•]].

While some see 'sustainable intensification' (SI) as too narrowly focused on production, or even as a contradiction in terms altogether, Garnett *et al.* [3^{••}] make it clear that the approach should be broadly conceived. They argue that the SI approach entails increasing food production from existing farmland in ways that have lower environmental impact and which do not undermine our capacity to continue producing food in the future. Food demand needs to be met from existing agricultural land, since opening up new land for agriculture carries major environmental costs. Intensification, without the sustainability focus, has led to numerous problems around the globe [4]. SI does not mean business-as-usual food production and marginal improvements in sustainability, but rather a radical rethinking of food systems not only to reduce environmental impacts but also to enhance animal welfare and human nutrition and support rural economies and sustainable development [3^{••}].

'Climate smart agriculture' (CSA) is another approach that has recently achieved much prominence, given the adaptation and mitigation challenges facing humanity [1^{••}]. CSA is defined by three objectives: firstly, increasing agricultural productivity to support increased incomes, food security and development; secondly, increasing adaptive capacity at multiple levels (from farm to nation); and thirdly, decreasing greenhouse gas emissions and increasing carbon sinks. Since the relative priority of each objective varies across locations, with for example greater emphasis on productivity and adaptive capacity in low-input smallholder farming systems in least developed countries, an essential element of CSA is identifying potential synergies and trade-offs between objectives [5]. CSA integrates climate change into the planning and implementation of sustainable agriculture and informs priority-setting.

Here we examine the degree to which the SI and CSA approaches are complementary, and the degree to which they contribute to global food and nutritional security.

The arguments are supported by a selection of case studies.

Climate change adaptation

Climate change will have significant and generally negative impacts on agriculture and growth prospects in the lower latitudes [2[•],6,7]. Since 1980, climate change is estimated to have reduced global yields of maize and wheat by 3.8 and 5.5%, respectively, relative to a counterfactual without rainfall and temperature trends [8]. By 2050, climate-related increases in water stress are expected to affect land areas twice the size of those areas that will experience decreased water stress [9]. Increased climate variability in the coming decades will increase the frequency and severity of floods and droughts, and will increase production risks for both croppers and livestock keepers and reduce their coping ability [10]. Climate change poses a threat to food access for both rural and urban populations, by reducing agricultural incomes, increasing risk and disrupting markets [11^{••}]. Resource-poor producers, landless and marginalized ethnic groups are at particular risk. Negative impacts can be ameliorated through adaptation, ranging from relatively minor changes in production practices to major, transformative shifts in farming and food systems.

One of the three components of CSA is building adaptive capacity, so that farmers, service providers to farmers and key institutions have the ability to respond effectively to longer-term climate change as well as being able to manage the risks associated with increased climate variability. Actions to build adaptive capacity are diverse, but an important component entails building ecosystem services in agricultural systems that enhance resilience, through soil, water and plant nutrient management, as well as improved on-farm water storage and irrigation, access to crop varieties that are more tolerant of heat, droughts, floods and salinity, diversification of farm enterprises (including mixed crop and tree systems), and building the capacity of institutions to enhance collective action, disseminate knowledge and undertake local adaptation planning [4]. Climate information services and information related to planting dates, pest and disease control, and water availability are crucial. Managing risk may also include enhancing social safety nets and providing agricultural insurance.

Several of these actions at the heart of CSA are forms of sustainable intensification; others such as building institutional capacity and information dissemination are key to support widespread sustainable intensification. Sustainable intensification also links to adaptation through its effects on farm incomes. Any practices that improve farm incomes allow farming households to build up their assets that can be used in times of stress (e.g. an essential element of adaptive capacity) or that can put households on a different development trajectory altogether. As

much as CSA can support SI, the reverse is also often required: farmers will not be adopting practices for climate change adaptation that may not yield improved returns on investments in the short term. SI, like CSA, has a focus on diversification (exploiting complementarities between crops, across crop-livestock systems and in terms of risk management). Diversification is a crucial part of building adaptive capacity.

Climate change mitigation

Food systems contribute significantly to global warming and are responsible for 19–29% of global emissions, the bulk of which come directly from agricultural production activities (i.e. N₂O and CH₄) and indirectly from land cover change driven by agriculture (CO₂) [2[•]].

Given the need to increase production in many developing countries, agriculture's GHG emissions are likely to increase, largely due to continuing expansion in livestock production, fertilizer use and land cover change [4]. However, the SI approach, with its focus on improving efficiency of production, is crucial to the mitigation objective of CSA: achieving lower N₂O and CH₄ emissions per unit of output. SI on existing agricultural land is also a major potential source of mitigation by reducing land cover change, particularly of carbon-rich forest and wetlands [12]. While less intensive, lower yielding production may generate local environmental benefits, this strategy may require that land is cleared elsewhere to compensate for locally lower yields, leading to greater environmental impacts overall. Globally, total crop yields — mostly cereal and oil crops — increased by 135% between 1961 and 2005 while the area of cropland increased by only 27% [13] (though degree of cropland expansion varies significantly amongst regions). However, increased efficiencies due to intensification can increase incentives for expansion [14,15]. Intensification therefore needs to be combined with policies and price incentives to strengthen its impacts on land sparing [16]. Past efforts to protect forests suggest that managing the forest-farm interface depends on a mix of measures: institutions related to land tenure, zoning of land, forest governance and enforcement of forest boundaries are critical [12,17]. Besides good governance, forest protection also requires attractive agricultural livelihood options to prevent farmers from encroaching and degrading the forest [18].

This discussion illustrates that for achieving the mitigation objective of CSA, we need to go far beyond the simple goal of intensifying agriculture. Both the SI and CSA concepts recognise this reality. They pay particular attention to analysing trade-offs of different options, in this case the trade-offs between intensification in one part of the landscape (or globe) (which may increase emissions of and its likely impacts on land sparing or land cover change in other parts of the landscape. SI and CSA could

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