

Climate-Smart Agriculture in Sinaloa, Mexico



Climate-smart agriculture (CSA) considerations

- M** **Conservation Agriculture** (including no-tillage, crop rotations, etc.) in maize, wheat, tomato, and other crops represents a unique opportunity to increase productivity and resilience to climate change in Sinaloa through soil conservation. To promote conservation agriculture adoption requires the development of technologies and provision of financial services.
- M** **Efficient use of pesticides and herbicides and increased organic fertilization** can make crop production systems in Sinaloa more sustainable and resilient through mitigating greenhouse gas emissions and soil quality.
- A** Sinaloa produces the majority of Mexico's high-value tomatoes, peppers, and cucumbers, often making use of protected agriculture (hoop houses, shadehouses, and greenhouses). Sustainably expanding these **protected agriculture systems** can be a viable response to recent unpredictable freezes and heat waves, effectively lessening farmers' vulnerability to climate fluctuations.
- A** Water is a key limiting factor for the development of Sinaloa's agricultural sector, and recent struggles with drought threaten the state's position

as Mexico's leading tomato producer. Practices that increase **water-use efficiency and management** are needed. **Drip irrigation** has proven to be both economical and productive in tomato, maize, and chickpea systems, increasing water-use efficiency and promoting resilience to climate change.

- I** The identification of suitable CSA options can be enhanced by development and access to **Integrated Decision Support Systems** that compile and analyze weather, agronomic, and market information, and deliver results to a range of stakeholders and decision makers.
- S** Given the high capacity and motivation of farmers to innovate in the region, in relation to farmers nationally, investing in **farmer-led CSA initiatives** would create opportunities to increase shared prosperity.
- I** The entrepreneurial outlook of Sinaloan farmers has established federal interest in providing financial support for programmatic CSA initiatives, such as agricultural loans and crop insurance. This foundation of financial support provides a **strong enabling environment for scaling out CSA**. Practices, such as drip irrigation and conservation agriculture, require further support to expand their adoption in Sinaloa.

A Adaptation **M** Mitigation **P** Productivity **I** Institutions **S** Finance

The climate-smart agriculture (CSA) concept reflects an ambition to improve the integration of agriculture development and climate responsiveness. It aims to achieve food security and broader development goals under a changing climate and increasing food demand. CSA initiatives sustainably increase productivity, enhance resilience, and reduce/remove greenhouse gases (GHGs), and require planning to address tradeoffs and synergies between these three pillars: **productivity, adaptation, and mitigation** [1]. The priorities of different countries and stakeholders are reflected to achieve more efficient, effective, and equitable food

systems that address challenges in environmental, social, and economic dimensions across productive landscapes. While the concept is new, and still evolving, many of the practices that make up CSA already exist worldwide and are used by farmers to cope with various production risks [2]. Mainstreaming CSA requires critical stocktaking of ongoing and promising practices for the future, and of institutional and financial enablers for CSA adoption. This country profile provides a snapshot of a developing baseline created to initiate discussion, both within countries and globally, about entry points for investing in CSA at scale.

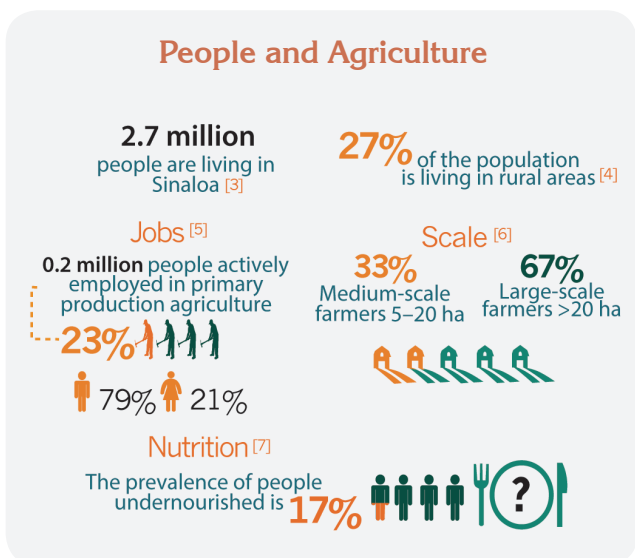
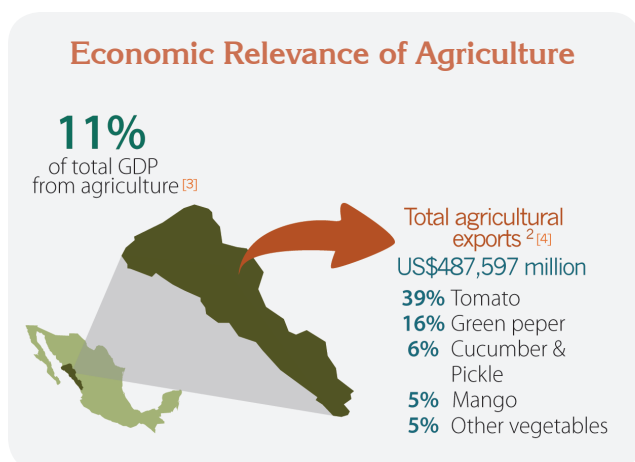


National context:

Key facts on agriculture and climate change

Economic relevance of agriculture

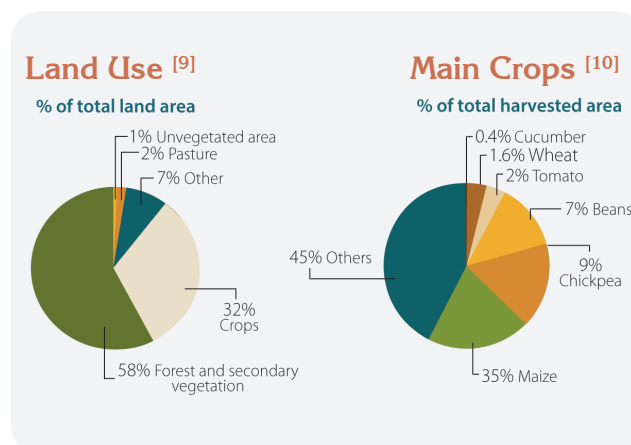
Agriculture makes up 11% of Sinaloa's state gross domestic product (GDP) [3]. The state is the main producer of export-oriented products such as tomato, cucumber, mango, and pickle [4]. The sector employs 23% of Sinaloa's economically active population [5].



Land use

Sixty-seven percent (67%) percent of farmers in Sinaloa are large scale (own more than 20 hectares) and the remaining 33% are medium-sized farmers (5–20 hectares) [8].¹ These proportions differ considerably from the national statistics, in which 73% of farmers are smallholders (0–5 hectares), 22% are medium landholders, and only 5% are large scale [8].¹

¹ Average production unit size per municipality was calculated by dividing the total area of agricultural production by the total number of production units. Municipal averages were combined to obtain average production unit size for the state level.



Agricultural production systems

Sinaloa is located in the irrigated region of Mexico, a farming system that covers large tracts of arid lands across the northern and central parts of the country. The presence of irrigation infrastructure allows for a relatively high degree of production intensification [11].

Important agricultural products in Sinaloa include maize, chickpea, tomato, beans, wheat, and cucumber. They are considered important due to their 2012 production values (US\$1.1 billion, \$149 million, \$139 million, \$236 million, \$28.9 million, and \$43 million respectively [10]), and harvested areas (35%, 9%, 7%, 2%, 1.6%, and 0.34% of total harvested area respectively [10]).

Agricultural greenhouse gas emissions

According to Sinaloa's GHG emissions inventory, agriculture emitted 7.89 megatons of CO₂ equivalents.² Crops (fertilizers) emitted 81.1% of total GHG, while livestock (enteric fermentation and manure management) 18.9% [12].

Challenges for the agricultural sector

Sinaloan farmers have identified the most significant challenges in the agriculture sector as:

- Unemployment
- Migration
- Lack of public services, such as infrastructure

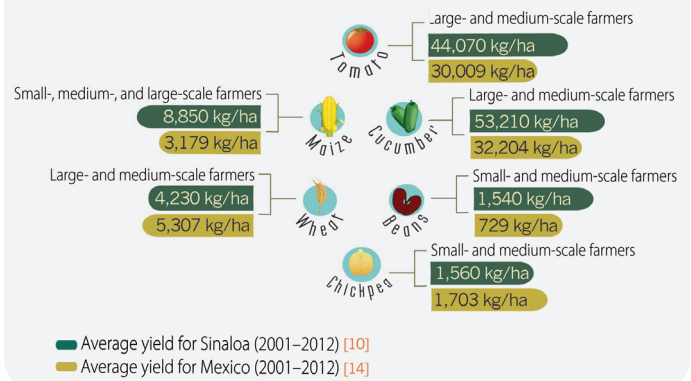
² Values for emissions in the agriculture sector in Sinaloa were converted to CO₂ eq manually from the GHG emissions subcategories in the inventory report.

- Low support from government entities, such as subsidies, technical assistance, and financial services
- Lack of farmers organization, and
- Poor hydrologic infrastructure [13].

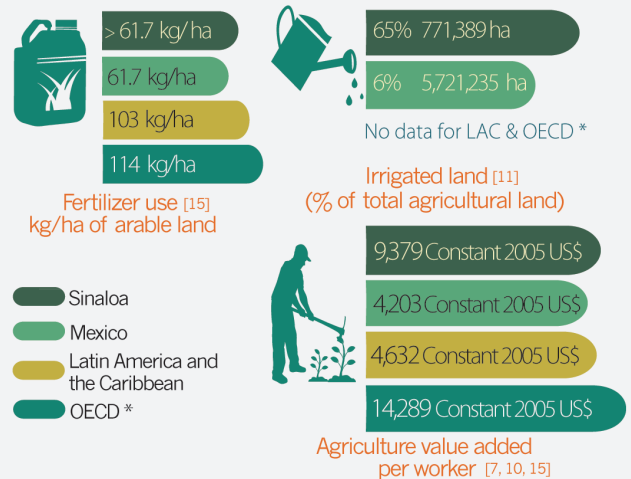
The prioritization of these problems shows that while Sinaloa is relatively better off than other underdeveloped states (e.g., Chiapas), there are still development needs. Unemployment could be linked to the fact that in comparison to the rest of the country, in Sinaloa, a smaller portion of the population owns land. This means that most farmers work as labourers. A second reason for unemployment, according to farmers' diagnosis, is the cyclical nature of agriculture in the state [13]. A large portion of irrigated production in Sinaloa only happens during the Autumn-Winter cycle. The cycle starts in September, October, or November and ends in April, May, or June. Farmers are unemployed from June to September. Emigration is a direct effect of unemployment, as farmers only have livelihood activities during the cropping seasons.

A large proportion of Sinaloa's production is intended for exportation. However, farmers have difficulties meeting exportation standards and also struggle to anticipate and buffer themselves against price variation, particularly in tomato, making profits unpredictable [13]. For these reasons, non-farmer agriculture sector stakeholders, such as agriculture specialists, include commercialization as a challenge in Sinaloa's agriculture sector. Price hedging and contract farming could mitigate price fluctuations of agricultural products, and ensure farmers would profit from their investments.

Important Agricultural Production Systems³

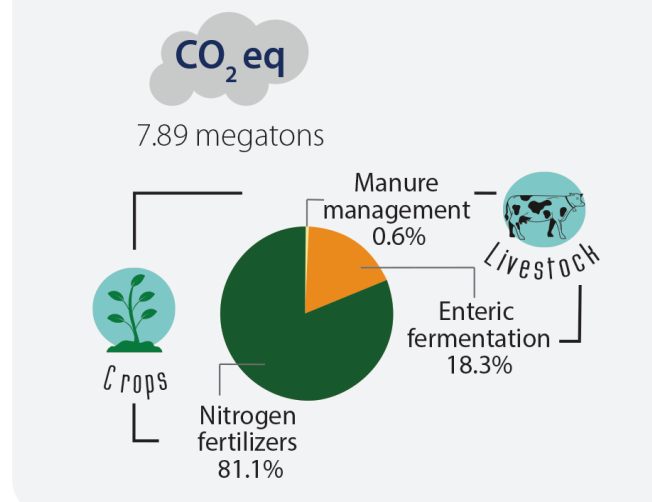


Productivity Indicators



* Organization for Economic Co-operation and Development

GHG Emissions from Agriculture [12]



3 See Annex II for details on selection of important production systems.

The relatively large size of landholdings in Sinaloa allows for production at economies of scale, which could increase input-use efficiency and profitability. However, in line with large-scale production trends, it is common practice in Sinaloa to use high levels of agricultural inputs, such as inorganic fertilizers and agrochemicals [13, 16]. The projected warmer and drier climate, with negative impacts on crop yields, could also lead farmers to expand irrigation and use of agrochemicals. The Sinaloan agricultural sector needs to engage in long-term planning to strengthen management of natural resources to ensure sustainable production in the face of climate change.

Aging irrigation infrastructure is of particular concern given that 60% of food production in Mexico is obtained from irrigated land. Sinaloa contributes significantly to this national proportion since 65% of its cropping land is irrigated. Improving irrigation infrastructure represents a significant opportunity for Mexico's productivity, development, and food security [13]. Not addressing this challenge could lead to saline soils, which would both prevent productivity gains and accelerate losses.

Agriculture and climate change

Extreme events affecting agriculture in Sinaloa are drought, hail, frost, and unseasonal temperature fluctuations. These events are expected to increase in severity and frequency. Sinaloan agriculture is highly vulnerable to extreme events as many farmers are experiencing them for the first time. In March 2014, Sinaloa experienced its first tornado. In February 2010,

an extreme frost wiped out 90% of Sinaloa's maize crop, and in November 2011, the northern part of Mexico (including Sinaloa) experienced its worst drought in 70 years.

Climate projections indicate temperatures in Sinaloa will increase by up to 1.7 °C by 2030, and precipitation will decrease by up to -71 mm by 2030 [19]. Given that Sinaloan agriculture provides Mexico with staple crops, such as tomato and maize, the impacts of climate extremes on the agricultural sector in Sinaloa go beyond state boundaries to affect the food security of the national population.

CSA technologies and practices

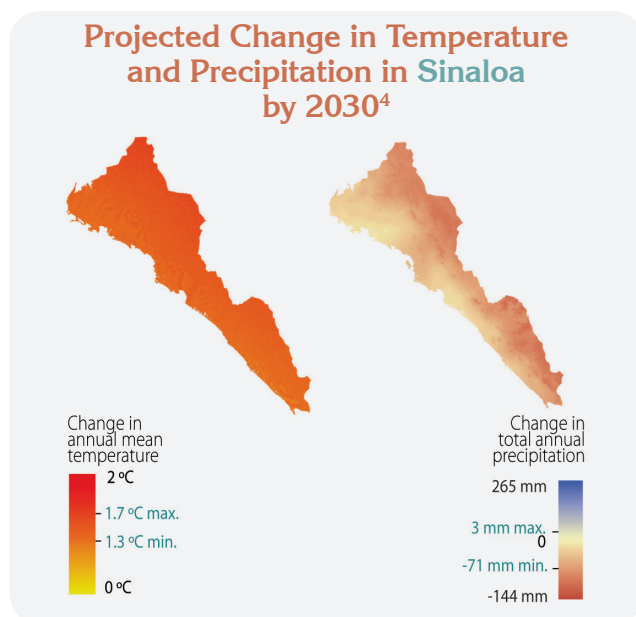
CSA technologies and practices present opportunities for addressing climate change challenges, as well as for economic growth and development of agriculture sectors. For this profile, practices are considered CSA if they maintain or achieve increases in productivity as well as at least one of the other objectives of CSA (adaptation and/or mitigation). Hundreds of technologies and approaches around the world fall under the heading of CSA [2].

Farmers in Sinaloa already employ a variety of CSA techniques.⁵ These include:

- Drip irrigation in tomato, beans, chickpea, and maize.
- The full bundle of or a selection of conservation agriculture practices (no-tillage, cover crops, crop rotation, etc.) in tomato, maize, cucumber, and wheat.
- Precision fertilizer application in tomato.
- Protected agriculture (e.g. greenhouses) in tomato and cucumber.
- Switching crops or crop varieties when climate conditions become unsuitable for maize.

Practices with high climate smartness and the potential to be applied across a large land area, especially those but that currently exhibit low adoption rates, present opportunities for increasing the overall climate smartness of the state. Practices of particular interest for further investigation and promotion in Sinaloa include:

- Conservation agriculture
- Drip irrigation
- Production in greenhouse
- Crop rotation

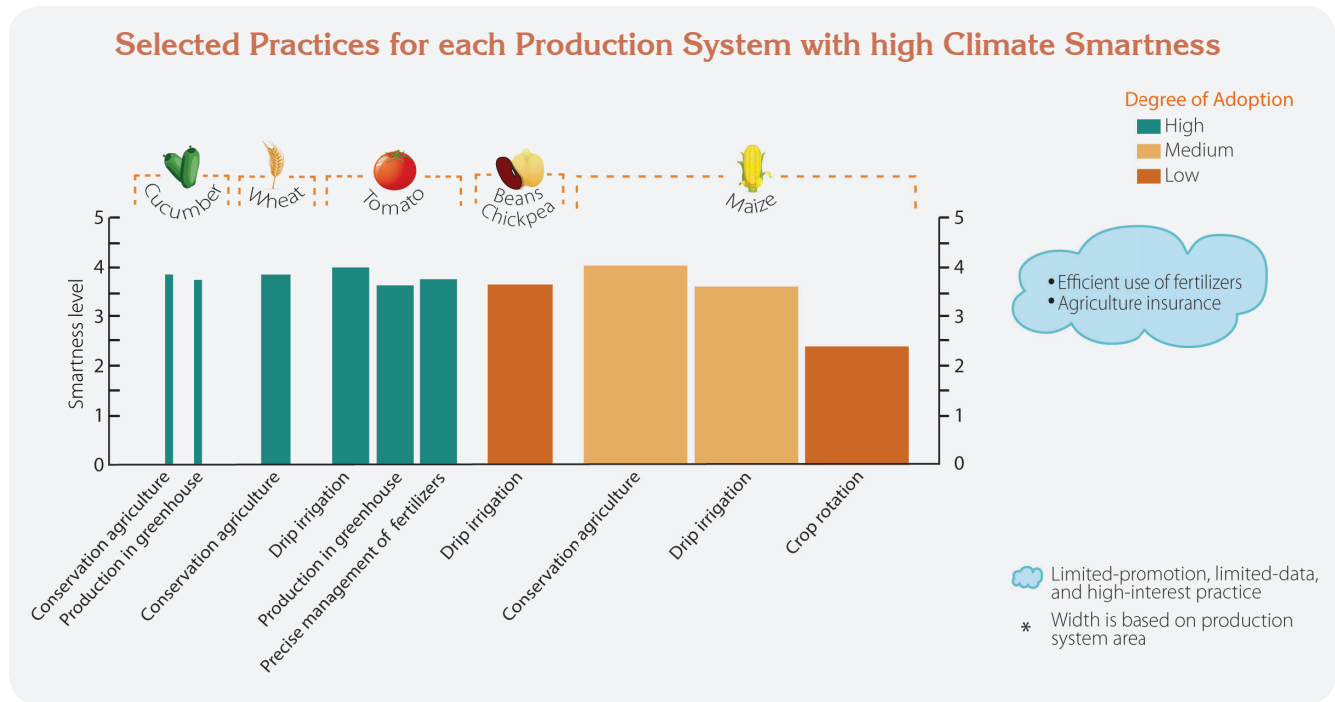


4 Projections based on RCP 4.5 emissions scenario [17] and downscaled using the Delta Method [18].

5 See Annex III.

In addition, CSA stakeholders, such as government officials and members of farmers organizations, emphasize the need to promote higher efficiency in the use of inputs for agriculture production, increased provision of agricultural insurance services, early warning

systems, and general awareness of CSA technology and management options. Similarly, decision support systems can help identify other suitable adaptation and mitigation options.



This graph displays the smartest CSA practices for each of the key production systems in Sinaloa. Both ongoing and potentially applicable practices are displayed, and practices of high interest for further investigation or scaling out are visualized. Climate smartness is ranked from 1 (very low positive impact in category) to 5 (very high positive impact in category).

Table 1. Detailed smartness assessment for top ongoing CSA practices by production system as implemented in Sinaloa, Mexico.

The assessment of a practice's climate smartness uses the average of the rankings for each of six smartness categories: weather; water; carbon; nitrogen; energy; and knowledge. Categories emphasize the integrated components related to achieving increased adaptation, mitigation, and productivity.

	CSA Practice	Climate Smartness	Adaptation	Mitigation	Productivity
Cucumber 0.34% harvested area	Protected agriculture ■ High adoption (>60%)		Lower potential for pests, less vulnerability to pests and extreme weather events.	Efficient use of water and other inputs, reduction in pressure for land clearing.	Higher yields in reduced land, extended harvests, higher profitability and income.
	Conservation agriculture ■ High adoption (>60%)		Greater water retention in the soil avoids crop loss during dry periods.	Higher carbon in soils, reduced nitrogen loss.	Enhanced yields reported in specific contexts, higher incomes.
Wheat 1.61% harvested area	Conservation agriculture ■ High adoption (>60%)		Greater water retention in the soil avoids crop loss during dry periods.	Higher carbon in soils, reduced nitrogen loss.	Enhanced yields reported in specific contexts. Higher incomes.
Tomato 2% harvested area	Protected agriculture ■ High adoption (>60%)		Lower potential for pests, less vulnerability to extreme weather events.	Efficient use of water and other inputs, reduction in pressure for land clearing.	Higher yields in reduced land, extended harvests, higher profitability and income.
	Conservation agriculture ■ Low adoption (<30%)		Greater water retention in the soil avoids crop loss during dry periods.	Higher carbon in soils, reduced nitrogen loss.	Enhanced yields reported in specific contexts, higher incomes.
Beans and Chickpea 2% and 9% of harvested area	Drip irrigation ■ Low adoption (<30%)		Lower water requirements increases resilience of the system to climate variability.	May imply increase in energy use.	Water requirements of the crop are satisfied and higher yields.
Maize 35% harvested area	Conservation agriculture ■ High adoption (>60%)		Greater water retention in the soil avoids crop loss during dry periods.	Higher carbon in soils, reduced nitrogen loss.	Enhanced yields reported in specific contexts.
	Drip irrigation ■ Medium adoption (30–60%)		Lower water requirements increases resilience of the system to climate variability.	May imply increase in energy use.	Water requirements of the crop are satisfied, enhanced yields, higher income.

Carbon smart Water smart Weather smart Nitrogen smart Energy smart Knowledge smart

Institutions and policies for CSA

The Mexican federal government and the Sinaloa state government have traditionally spearheaded agricultural development in Sinaloa. However, in relative terms, the private sector is gaining strength as a promoter of productivity advancements. The Confederation of Agricultural Associations of the State of Sinaloa (CAADES), for example, organizes over 15,000 farmers statewide.

Two key institutional activities related to CSA are:

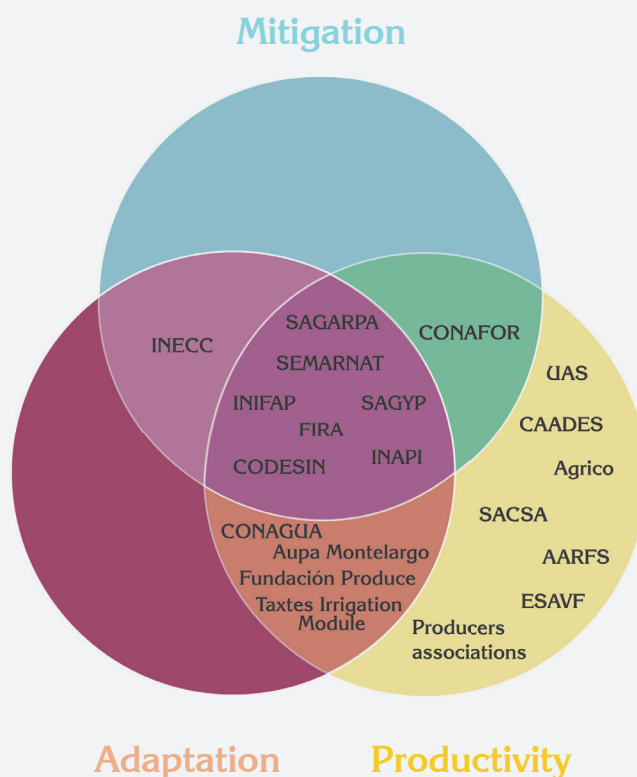
- An evaluation of climate change vulnerability in Sinaloa to develop recommendations for early adaptation [20].
- A national GHG emissions inventory [12].

The graphic on the right represents the main thematic foci of public and private institutions in Mexico related to the three pillars of CSA: adaptation, mitigation, and productivity. CSA-related institutions are strongest in the productivity pillar, but many are increasing inter-institutional cooperation and incorporating climate change issues into their agendas to address more than one (and even all three) CSA pillars. The state government has previously noted an interest in developing a state-level climate change adaptation strategy program, but there is uncertainty on the advances of this program.

Institutions for productivity and dual synergies

In the productivity pillar, the Río Fuerte Sur Farmers Association (AARFS A.C.) regulates the agricultural supplies and services market. AARFS A.C. also supports development and transfer of technology and applied research in agriculture and the integration of agriculture and agrobusiness processes at the national and international levels. CAADES supports agribusinesses, exports, subsidies, water efficiency, reforestation, technology, and development. The Autonomous University of Sinaloa (UAS) and the Superior Agriculture School of the Río Fuerte Valley (ESAVF) educate students on agricultural technologies and research for innovation. Agroeco is an example of a private business that promotes greenhouse technologies. Coastal Agriculture Services (SACSA) is a regional business that provides agricultural inputs and technical assistance.

Primary Focus of Institutions Engaged in CSA



Synergies between mitigation and productivity are supported by the National Forestry Commission (CONAFOR), a federal commission working on reforestation and other forest-focused activities. Productivity and adaptation synergies are led by water companies, such as Taxtes Irrigation Module and Aupa Montelargo irrigation company, both of which provide drip irrigation, drinking water, and water supply services to local farmers in response to Sinaloa's recent unreliable rainfall record. The National Water Commission (CONAGUA) is the leading water institution in Mexico, and in the northern regions of the country, it promotes the adoption of irrigation technologies. It also leads investment in public infrastructure for water capture and storage. Fundación Produce provides weather information to assist farmers in making management decisions and supplies them with improved seeds, training, and planting calendars.

Institutions for synergies between CSA pillars

In Sinaloa, institutions promoting synergies across all three pillars of CSA are mostly federal. Trust Funds for Rural Development (FIRA), through its national-level programs for energy efficiency grants, has also had an impact on Sinaloa in overcoming climate adversity. In 2011, for example, FIRA participated in a contingency plan to help farmers overcome one of the worst frosts in the state's history.

The National Institute for Forestry, Agriculture and Livestock Research (INIFAP) performs CSA-related research, just as the Secretariat of the Environment and Natural Resources (SEMARNAT) and the Commission for Natural Protected Areas (CONANP) are environmentally focused institutions that work on sustainable land management initiatives, such as Natural Protected Areas and Sustainable Land Management Units. The Institute for the support of Research and Innovation (INAPI) supports scientific research, including development of sustainable agriculture technologies.

The Secretariat for Agriculture, Livestock and Fisheries of the state of Sinaloa (SAGYP) both supports productivity through technical assistance and subsidies as well as implements programs for sustainability in agriculture in conjunction with federal entities. The

sustainability programs by SAGYP include initiatives on efficient livestock feeding, improved seeds provision, and strategies for helping farmers cope with extreme weather, such as frosts and droughts. The Council for the Development of Sinaloa (CODESIN) is a development agency that promotes sustainable development broadly and in the agriculture sector. To do so, CODESIN promotes sustainability across different public policies and laws, promotes public-private partnerships for sustainable businesses, and promotes sustainable productive practices.

Finally, the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), in addition to leading the agricultural agenda in Mexico, has diverse initiatives within Sinaloa. These initiatives include many CSA practices, such as the promotion of sugarcane green harvest, crop rotation, water management, protected agriculture, energy efficiency and alternative energy sources, livestock vulnerability information, efficient machinery, organic and biofertilizers, soil improvement, natural disaster risk insurance for states and municipalities (CADENA program for the attention of natural disasters), and development of Nationally Appropriate Mitigation Actions (NAMAs) in livestock production, among others.

Enabling Policy Environment for CSA

Policies listed are related to enhancing **agricultural productivity** and:

- Adaptation
- Mitigation
- Adaptation and Mitigation



GHG (2011) Sinaloa's GHG Emissions Inventory **WWF CC** Evaluation of climate change vulnerability in Sinaloa and recommendations for early adaptation measures in preparation for the PEACC by WWF-Carlos Slim Foundation.

Financing CSA

Funds to support CSA practices and projects in Sinaloa are sourced mainly from federal sponsors, such as FIRA and SAGARPA. The role of state-level institutions is merely to funnel federal-level resources to regional and municipal implementation schemes. An alliance between the World Wildlife Fund and Carlos Slim is financially supporting Sinaloa in the development of its state-level climate change action program.

Sinaloa's farmers and ranchers have demonstrated a strong entrepreneurial outlook in their activities. Growing private institutions are actively involved in the development of the agricultural sector. For example, many private institutions are beginning to provide financial support for CSA technologies (e.g., drip irrigation) and capacity building activities.

Improving the Sinaloan government's direct funding programs, increasing its cooperation with international donors, and developing a CSA finance strategy could promote further investment in the agricultural sector and facilitate wide-scale CSA adoption.

Outlook

Sinaloa is Mexico's leading agricultural state, comprised of technically capable entrepreneurs and farmers who aim to rejuvenate collaborations between the federal government, private sector, and the local community.

There are some unresolved problems, such as commercialization, climate vulnerabilities, and outdated hydrological infrastructure that need to be addressed. Nonetheless, the potential for CSA technologies and practices to be applied over large land areas and growing private sector financial support means considerable impact from CSA up-scaling could be achieved in a reasonable time frame. These conditions allow for optimism that the political and institutional environment, as well as the likelihood of strong farmer-led innovation, can support the expansion of ongoing, successful CSA approaches.

Funds for Agriculture and Climate Change

AGROSEMEX S.A. National Insurance Institution
ASERCA Government Program for Support and Services for Agricultural Commercialization
Carlos Slim Philanthropy **FBPS** Federal Budget Participation for the State **FIRA** Trust Funds for Rural Development **IDB** Inter-American Development Bank
INGOs International Non-Government Organizations **LFI** Local Financial Intermediaries
LNGOs Local Non-Government Organizations
SAGARPA Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food **SAGYP** Secretariat of Agriculture, Livestock and Fisheries of Sinaloa
WB World Bank **WWF** World Wildlife Fund



LNGOs
National and State Funds



IDB · INGOs · WB ·
International Funds

★ Accessed Funds ★ Financing opportunities

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For further information and online versions of the Annexes, visit <http://dapa.ciat.cgiar.org/CSA-profiles/>

Annex I: Acronyms

Annex II: Production systems selection

Annex III: Ongoing CSA practices

This publication is a product of the collaborative effort between the International Center for Tropical Agriculture (CIAT), the lead Center of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS); the Tropical Agricultural Research and Higher Education Center (CATIE); and the World Bank to identify country-specific baselines on CSA in seven countries in Latin America: Argentina, Colombia, Costa Rica, El Salvador, Grenada, Mexico, and Peru. The document was prepared under the co-leadership of Andrew Jarvis and Caitlin Corner-Dolloff (CIAT), Claudia Bouroncle (CATIE), and Svetlana Edmeades and Ana Bucher (World Bank). The main authors of this profile are Beatriz Zavariz-Romero (CIAT), Chelsea Cervantes De Blois (CIAT), and the team was comprised of Andreea Nowak (CIAT), Miguel Lizarazo (CIAT), Pablo Imbach (CATIE), Andrew Halliday (CATIE), Rauf Prasodjo (CIAT), María Baca (CIAT), Claudia Medellín (CATIE), Karolina Argote (CIAT), Juan Carlos Zamora (CATIE), and Bastiaan Louman (CATIE).

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