Agro-Economic Policy Brief

Aiding the Future of India's Farmers and Agriculture

(Photo Source: https://www.nytimes.com/2019/08/08/climate/climate-change-food-supply.html)

The Role of Food, Land-Use and Agriculture in Climate Change Mitigation by 2050

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Contributors
Ranjan Ghosh, Chandan Jha, Vartika Singh and Ankit Saha

For kind attention of:

The Hon'ble Prime Minister's Office,
the Ministry of Agriculture and Farmers' Welfare,
and all others interested

Edited by
Centre for Management in Agriculture (CMA)
Indian Institute of Management Ahmedabad (IIMA).

Contact:
Poornima Varma,
Coordinator or
Ranjan Kumar Ghosh,
Chairperson, CMA or
Drishti Vishwanath
Research Associate
alertsbriefs@iima.ac.in

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Introduction

- At present, India stands committed to reduce CO_2 emissions intensity of its gross domestic product (GDP) by 45 percent by 2030 under its updated Nationally Determined Contribution to the United Nations Framework Convention on Climate Change and achieve net-zero by 2070 (United Nations Climate Change Conference, 2021-COP26). However, the high growth of its economy and population poses challenges with respect to ensuring food security, while minimising environmental disruptions.
- The food and land-use sector is pivotal for any major economy-wide greenhouse gas (GHG) emission reduction strategy, given that this sector contributes to nearly one-third of human-induced global GHG emissions. Moreover, the land-use sector is a central factor in achieving several sustainable development goals (SDGs), such as SDG2 – zero hunger; SDG7 – affordable and clean energy; SDG12 – responsible consumption and production; SDG13 – climate action; and SDG15 – life on land (United Nations Department of Economic and Social Affairs (UNDESA), 2019).

Source: https://en.wikiversity.org/wiki/Sustainable_Development_Goals

- A majority of the scientific assessments aimed at measuring sustainability in the food, land-use and forestry sectors often address isolated targets and lack a multi-sectoral approach (Obersteiner et al., 2016). The real challenge is to judiciously determine the trade-offs and synergies among different sub-sectors that are highly interlinked with complex relationships which impact water availability, livestock feed, and emissions simultaneously.
- In this policy brief we discuss results from an integrated assessment framework using partial equilibrium modeling, wherein multiple corridors to sustain food and land-use systems are reviewed. This includes the analysis of results on pathways to key indicators of land-use change, GHG emissions, food security, water withdrawals in agriculture, agricultural trade and production diversity.

Modelling Methodology

- The assessment is built upon shared socio-economic pathways (SSPs) (O'Neill et al., 2020) to construct three specific trajectories for the food and land-use systems in India by 2050. Representative concentration pathways (RCPs), which are a set of alternative trajectories for the atmospheric concentration of GHGs (Van Vuuren et al., 2011) (van Vuuren et al, 2011) are also used for the analysis. These RCPs, combined with a set of SSPs provide an opportunity to include pathways of future societal development.
- Three alternative pathways are analysed to guide food and land-use systems in India towards sustainability among possible futures until 2050: (a) current trend, (b) current trend alongside a dietary shift towards EAT-Lancet nutritional guidelines named as Current + EAT, and (c) an ambitious sustainable pathway (see Table 1).

- An integrated assessment approach is employed by using a spatially explicit, recursive dynamic partial equilibrium Model of Agricultural Production and its Impact on the Environment (MAgPIE) (Dietrich et al, 2019), which analyses dynamic changes related to land-use, food systems, and associated environmental trade-offs.
- The MAgPIE model incorporates geographically explicit information on biophysical conditions (like carbon densities of different vegetation types, agricultural productivity such as crop yields, water availability for irrigation, etc.) into an economic decision-making process with population, economic growth and climate change scenarios as exogenous drivers.
- The MAgPIE model's objective function is to fulfill the demand for crop, livestock, and material products from agriculture at the minimum cost and under certain socio-economic and biophysical constraints. The model endogenously determines the optimal pattern of agricultural land- use for cropland (rainfed and irrigated), pastures, forest, and other natural vegetation, as well as the optimal investment rates in yield-increasing technological change, and international trade flows.

Table 1: Key assumptions of current trend, current + EAT and sustainable pathways

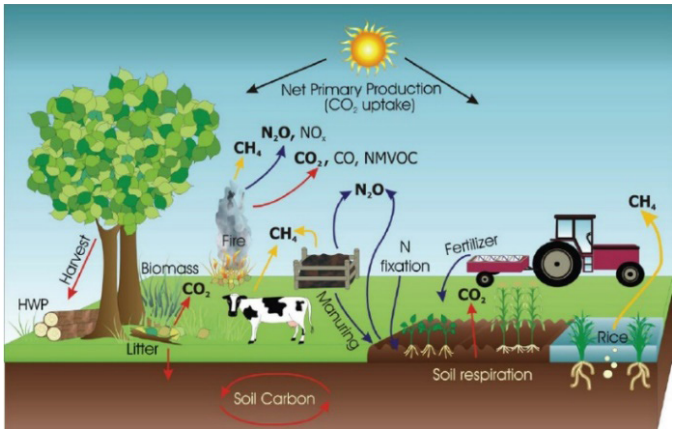
Scenarios	GDP	Population	Food demand (diet)	Climate change	Mitigation effort
Current trend	SSP2	SSP2 (1.73 billion by 2050)	SSP2	RCP 6.0 (likely 3 °C–4 °C in 2100)	Low mitigation
Current + EAT	SSP2	SSP2	EAT-Lancet	RCP 6.0 (likely 3 °C–4 °C in 2100)	Moderate mitigation (demand side)
Sustainable	SSP1	SSP1 (1.55 billion by 2050)	EAT-Lancet	RCP 2.6 (likely 2 °C in 2100)	High mitigation (demand and supply side)

Source: Authors' own compilation

Results

(a) GHG emissions

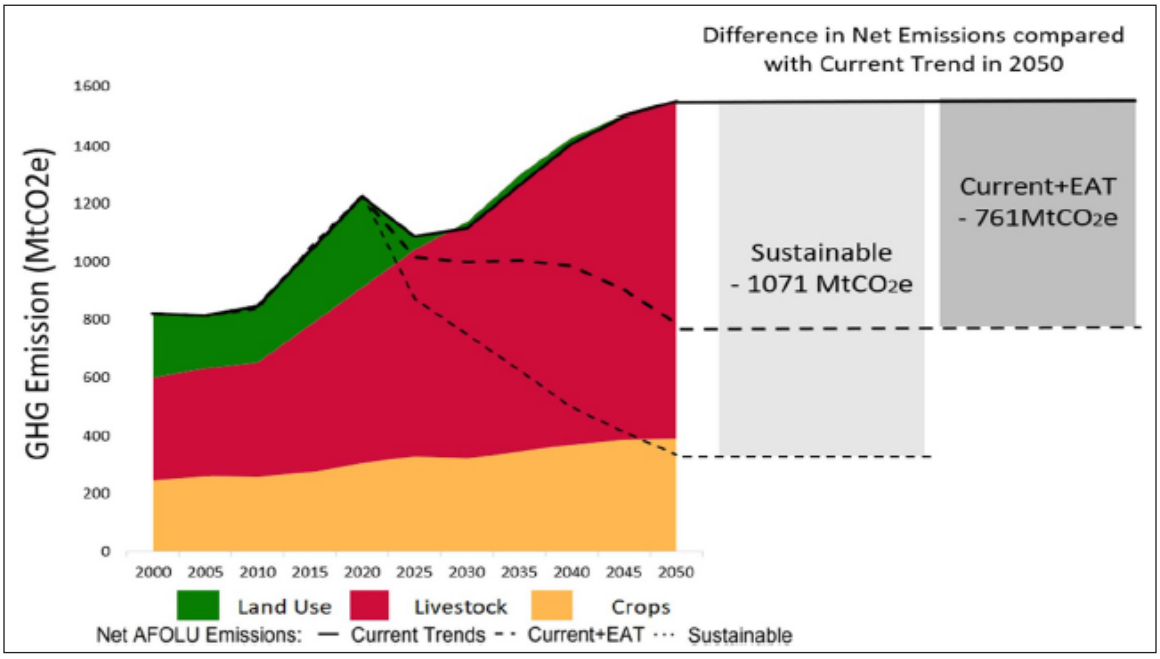
- Under the current trend, GHG emissions from food and land-use sectors increases to 1115 Mt Co_2e/yr in 2030 and to 1550 Mt Co_2e/yr in 2050 (see Figure 1). Higher emissions under this scenario are mainly due to higher demand for livestock products.



Source: *https://www.researchgate.net/figure/The-main-on-farm-agricultural-greenhouse-gas-emission-sources-removals-and-processes-in_fig1_281439963*

- Under the Current+EAT, the total sectoral emission is less than 70 percent of the current trend in 2050. The emission reduction comes from the livestock sector (84%) and from crop related emissions (15%) due to the implementation of EAT-Lancet recommendations which drives a reduction in demand for dairy products and cereals.
- Compared to current trends and Current + EAT, the emission reduction under the sustainable pathway is nearly around 80 percent and 30 percent respectively. The major driver for this additional reduction is an increase in crop productivity and feed efficiency. Mitigation strategies in the form of GHG prices along with RCP 2.6 serve as punishment factors for emissions and thereby bring the overall emissions down.

Figure 1: Projected GHG emissions (Mha) from (a) livestock, (b) crops, and (c) land-use under current trend, current + EAT, and sustainable pathways till 2050.



Source: Authors' own compilation

(b) Land-Use Change

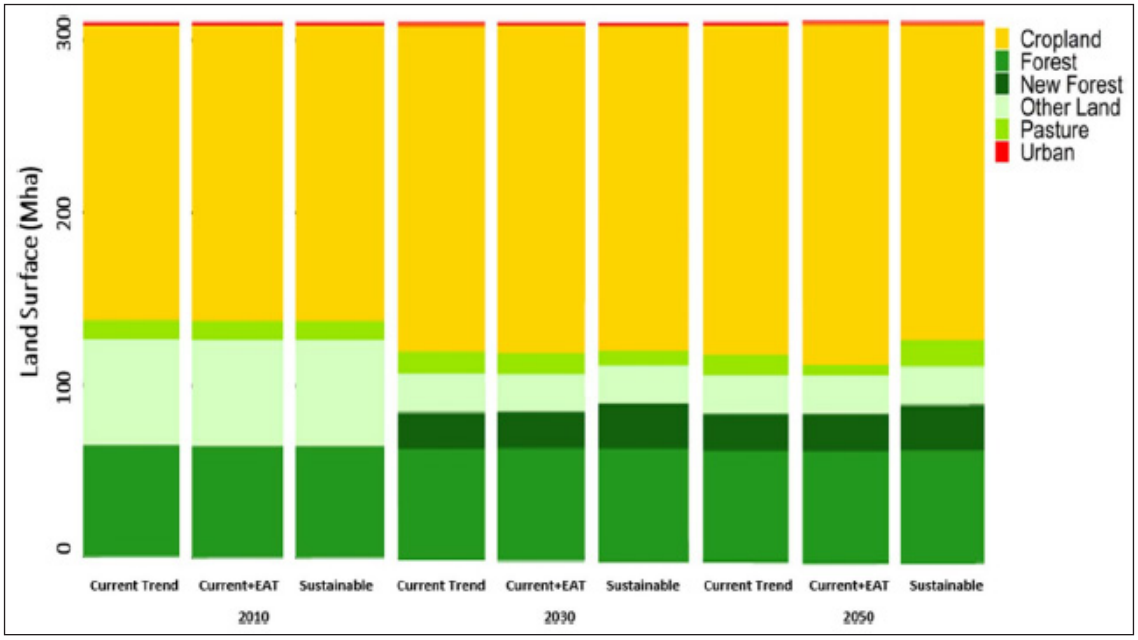
- Land-use is classified under 5 major categories, namely (a) cropland, (b) forests, (c) pastures, (d) urban and (e)other lands. The overall cropland increases by 17 Mha (11%) in 2030 across all scenarios compared to 2010. As compared to other pathways, cropland is observed to show the maximum increase in cropland under sustainable pathways by 2050.
- Compared to 2020, forest land increases in all scenarios so as to attain the target of additional 21 Mha by 2030; the Sustainable Pathway witnesses the largest increases in forest land due to India's revised afforestation target of 26 Mha (consistent with the Bonn Challenge).

Source: https://geneticliteracyproject.org/2018/03/07/viewpoint-while-wildlife-habitat-loss-is-a-real-problem-organic-farming-is-not-the-solution/

- The observed increase in cropland and forest land respectively are accompanied by a decrease in other lands.

- Pasture area decreases by approximately 50 percent under the Current + EAT pathway in 2050 (in comparison to 2030) due to lower demand for livestock products due to EAT-Lancet diets. For the same reasons, under the sustainable pathway, pastureland decreases by 38 percent in 2030 in comparison to 2010. It increases by 47 percent in 2050 in comparison to 2030 due to high export of livestock products (see Figure 2).

Figure 2: Projected Land-Use (in Mha) from (a) Cropland, (b) Forest Area, (c) Other Land, (d) Pasture, (e) Urban Area in 2030 and 2050 under Current trend, Current + EAT, and Sustainable Pathways



Source: Authors' own compilation

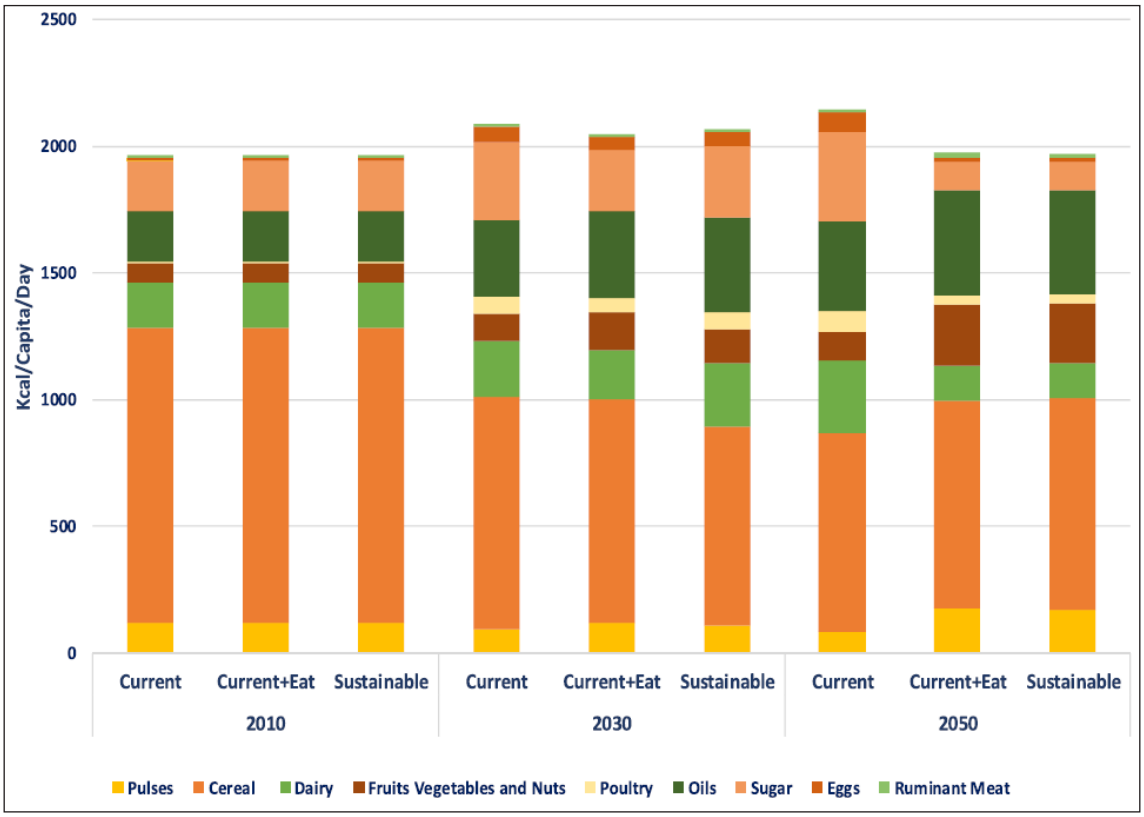
(C) Food security

- Under the current trend, there is a projected increase in the consumption of dairy and a decrease in the consumption of cereals between 2020 and 2050. An overall dependence on pulses, fruits, vegetables and nuts, oils and other crops tends to be high in the other two pathways with EAT-Lancet diet recommendations, with major reductions in the consumption of dairy, eggs, and sugars in 2050. Compared to the current trend, in both 2030 and 2050, protein intake from pulses seem to double in the other two scenarios, although there has been a reduction in the protein intake from eggs and dairy (see Figure 3).

Source: https://www.eatright.org/food/nutrition/dietary-guidelines-and-myplate/use-the-dietary-guidelines-myplate-and-food-labels-to-make-healthy-choices

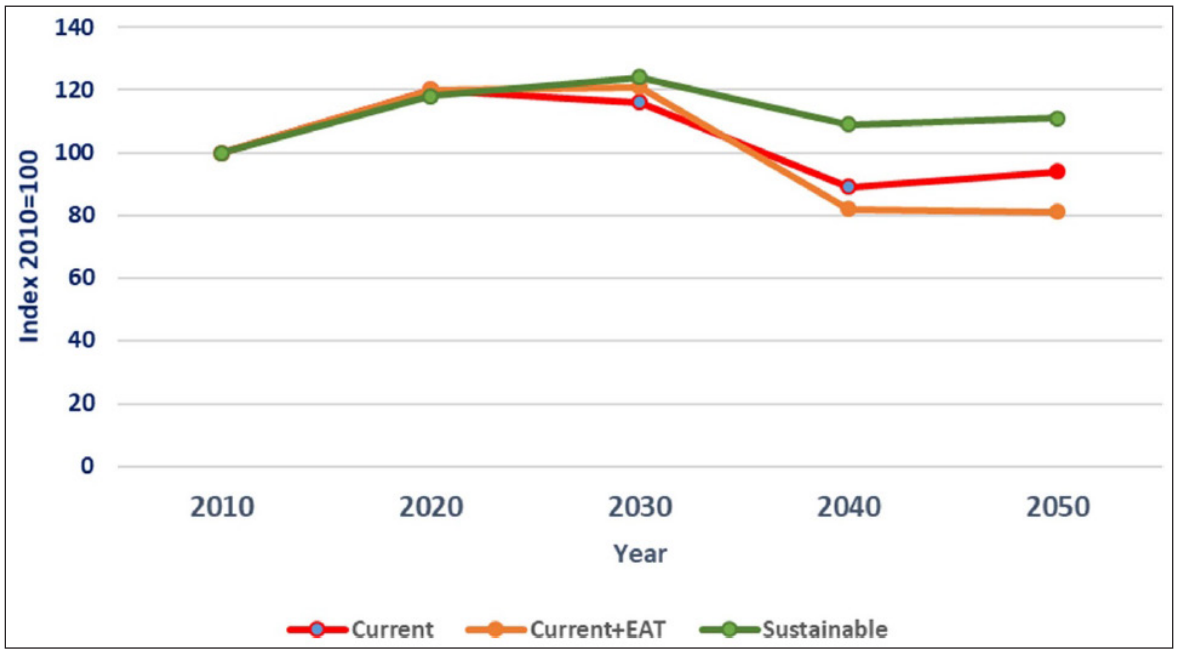
- Looking at the food price index, Current + EAT falls in the lowest bracket but the sustainable pathway falls under the highest bracket in 2050. While the immediate food prices under all the three scenarios are similar in 2025, there is a decline in the index under Current + EAT, ending in the lowest bracket by 2050 (see Figure 4). The increase in food prices is driven by both demand and supply side scenarios.

Figure 3: Projected Calorie Demand for Major Food Groups under Current Trend, Current + EAT and Sustainable Pathways in 2030 and 2050.



Source: Authors' own compilation

Figure 4: Changes in Food Price Index between 2010 and 2050 under the (a) Current trend, (b) Current + EAT and (c) Sustainable Pathway.



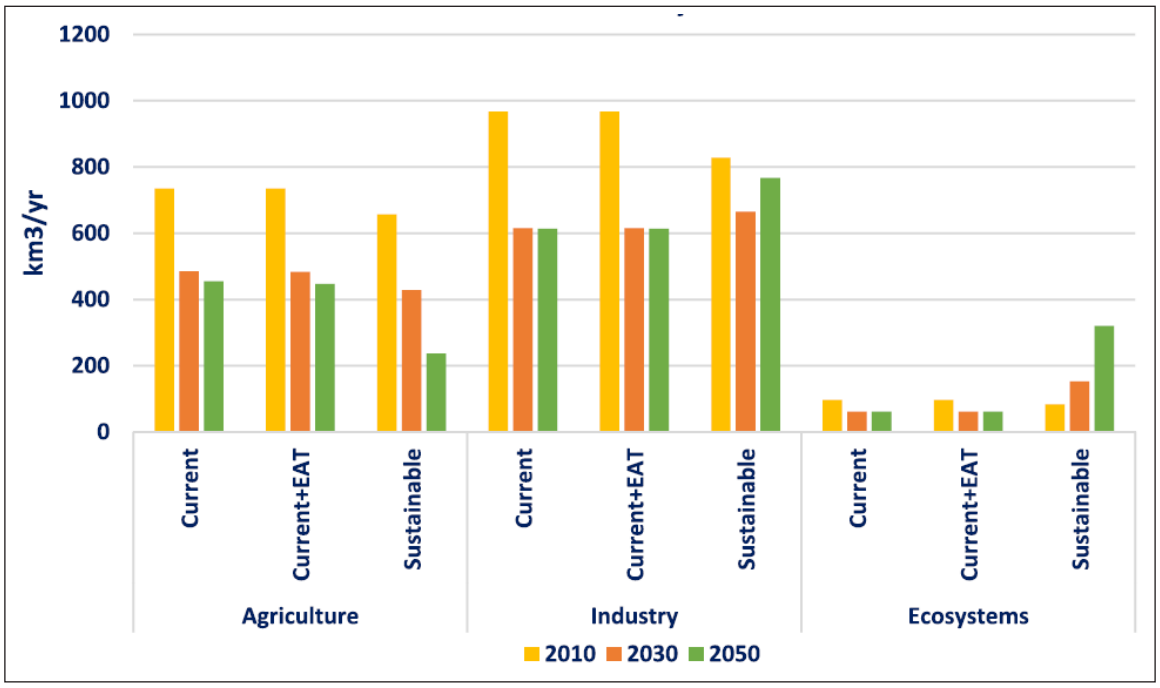
Source: Authors' own compilation

(d) Water use

Source: https://voxdev.org/topic/energy-environment/do-india-s-farmers-use-too-much-water

- While there is a decreasing trend in water use across all scenarios between 2010 and 2050, in the agricultural sector, sustainable pathway projects a 63 percent decrease in annual blue water use compared to only a 38 percent decrease in the other two trends. Most reductions in water use are observed for rice, wheat, and soybean across all scenarios (see Figure 5).

Figure 5: Trends in Water Withdrawals for Different Sectors under Current Trend, Current + EAT and Sustainable Pathways.



Source: Authors' own compilation

Discussion and Action Points

- The study findings indicate that dietary shifts, improved efficiency in livestock production systems, lower fertiliser use, and higher yield through sustainable intensification can reduce GHG emissions from food and land-use sectors up to 80 percent by the year 2050.
- Our results indicate that the increase in yields under the sustainable pathway not only helps to meet increasing food demand, but also helps reduce the pressure on land-use changes.
- Under the sustainable pathway, it is possible to meet the food demand requirements for a growing population despite the reduced use of water resources. About 90 percent of India's total water use is accrued to agriculture, with a majority being used in the production of rice and wheat. We demonstrate that substantial reductions in blue water usage are possible through restrictions on over-use, improvements in irrigation efficiency and technological change.

- Competition for land between food and bioenergy crops will increase in the coming decades if India wishes to be on a sustainable development trajectory.
- A sustainable future as predicted here cannot be realised without a strategic policy design. The goal of nutrition security, along with increased dietary diversity can be met by the inclusion of more diverse sources of plant proteins as well as fruits and vegetables. Dietary shifts could help meet EAT-Lancet recommended minimum calorie requirements alongside meeting mitigation ambitions.
- Since the mitigation potential from the livestock sector through improvement in the livestock production system and feed efficiency is very high, policies that promote feed additives which can slow down methane producing microorganisms in the rumen would be very beneficial.
- A strategic policy framework is needed that diverts subsidies from cereal crops to pulses, oil crops, fruits, and vegetables. This can help in achieving India's emissions targets from the food and land use sectors, while simultaneously meeting the population's nutritional requirements.

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IIMA
विद्याविनियोगाद्विकास:

CENTRE FOR MANAGEMENT IN AGRICULTURE (CMA)
Indian Institute of Management Ahmedabad (IIMA)
Vastrapur, Ahmedabad, Gujarat 380015
e-mail: cma@iima.ac.in | **Phone:** +91-79-7152-4650, 7152-4651, 7152-4652
Web: www.iima.ac.in