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RESEARCH ARTICLE

Conceptualising circular economy in Indian agriculture sector: A comprehensive policy approach

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Abstract

Idea of the circular economy in sustainability has received attention worldwide in recent years. Ensuring sustainability in each sector is vital for humans and every other life form on Earth. With 1.4 billion people, India can soon become a global leader in the circular economy and has a huge role to play in promoting sustainability. One of the major sectors where sustainability must be ensured is agriculture. Declining productivity, diminishing soil fertility, limited land resources, massive waste generation and irregular weather patterns due to climate change are major challenges to achieving sustainability in agriculture. India, being an agrarian country and with the key resources for the sustainable agro economy deteriorating day by day, the need for transition into a circular economy becomes inevitable. The present study examines the gaps in existing agricultural policies and explores the possibilities of creating positive change in the agriculture sector. In this setting, this paper proposes the Circular Agro-Economy Policy (CAEP) framework in the Indian context for its implementation to promote sustainable transformation of agriculture in alignment with the Sustainable Development Goals (SDGs). The proposed framework provides a comprehensive approach to mapping the policy environment related to the Indian circular agro economy with recommendations to adopt best practices for circularity in Indian agriculture.

Keywords: circular economy; policy framework; sustainable agriculture; sustainable development goals

Introduction

Indian agriculture contributes to 18.2 % of India's Gross Domestic Product (GDP) and provides employment for 43.2 % of the population. The sector has registered an average annual growth of 4.18 % over the last five years (1). The total food grain production in the country for the 2023 - 24 period is estimated to reach a record 332.3 MT (2). The sector meets the food requirements of nearly about 1.45 billion Indians and accounts for 7.9 % of world food grain exports (3). The food demand is expected to rise significantly in the future with the rising population. The food demand is projected to grow at an annual rate of 2.44 % by 2047 - 48 in a business-as-usual (BAU) scenario, with potential for acceleration to 3.07 % if the economic growth accelerates. The demand for food grains is estimated at 402 MT in 2047 - 48 and 415-437 MT in business-as-usual (BAU) and high income growth (HIG) scenarios respectively. Seed Replacement Rate (SRR) projections indicate that the demand for certified seeds is expected to reach 34068 kq in 2030 - 31 and 49701 kq in 2047 - 48 (4). To meet such huge demands in the future, the country's agriculture sector must be highly productive and sustainable.

Sustainable agriculture

Indian agriculture underwent a major transformation with the introduction of the Green Revolution in the mid 1960s. The growing need to feed the ever-increasing population was the challenge faced by the government. It led to the adoption of high-yielding seeds, pesticides and chemical inputs, modern irrigation infrastructures and modern equipment like tractors, which paved the way for increased production and productivity. It resulted in a grain output of 131 MT in 1978 - 79 (5) and established India as one of the world's biggest agricultural producers. By reducing agricultural imports, India became self-reliant. It went from being a food deficit to a surplus producer. Through its surplus production, India was able to make the public distribution system a success and eradicate hunger to a larger extent.

Even though it was successful, it had setbacks. Negative impacts seeded out slowly over the years, becoming apparent only after the 1990s. Soil slowly degraded due to excessive use of chemical inputs. Farmers adopted monocropping, especially wheat and paddy, as they had many incentives and support from the government. These crops were more water-intensive, which led to groundwater depletion. The northwestern regions began facing salinisation of soils due to the over-extraction of groundwater.

Therefore, the policies need to be oriented towards sustainability and circularity for revitalising the agriculture sector.

Circular economy

Circular economy is one of the solutions to overcome resource constraints and ensure sustainability. It focuses on optimising input use, increasing the longevity of a product, minimising

wastage in the production chain and reuse of products. It creates a balanced systematic supply chain focusing on the energy produced, extracted material and the natural environment. Circular economy applies to many sectors and its application can be designed according to the needs. The concept of circular economy has been emphasised in the government policies of several countries like the European Union (House of Commons 2014) and China (6).

The Government of India has constituted a special cell for Circular Economy under NITI Aayog in 2022. It focuses on creating action plans for more than 10 sectors. As an initial step, the cell coordinated the government Vehicle Scrapping Program (7). This shows the government's vision towards implementing the principles of circular economy to promote sustainability in all sectors.

Need for circularity in Indian agriculture

The Indian agriculture economy will face many challenges arising from unsustainable agricultural practices in the upcoming years. Land degradation due to non-judicious usage of chemicals has reduced productivity over the years (8). As per the Ground Water Resource Assessment Report (2023), the total annual extractable groundwater resource for the country is 407.21 BCM and the total annual groundwater extraction is assessed as 241.34 BCM (9). The electricity subsidies have been one of the reasons for the over-exploitation of groundwater in the agriculture sector (10). The practice of monocropping in India has resulted in a surplus of certain food grains while depleting the natural resources. The widely monocultured crops, rice and wheat, rely on intensive irrigation for production and are highly prone to the impacts of climate change, ultimately amplifying food insecurity.

The harvest and post-harvest losses (PHL) also pose a significant challenge in the Indian agriculture sector. The annual value of harvest and PHL of major agricultural produce at the national level is estimated to be about ₹ 92651 crores according to the Central Institute of Post-Harvest Engineering and Technology (ICAR-CIPHET), Ludhiana (11).

Therefore, integration of sustainability and circular economy principles in agriculture is vital for creating a sustainable agricultural model, i.e., Circular agro-economy (CAE) and bringing about a long-lasting circular revolution.

Research Methodology

A systematic review of literature was conducted to develop a conceptual policy framework based on the insights gained through the analysis of the studies. Relevant online references were identified by searching the online literature databases such as Google Scholar Advanced Search and Google Advanced Search. As a search strategy, a combination of three keywords-policy recommendations, sustainable agriculture and circular economy-was used to search the online literature databases. Journal papers, reports, articles, guidelines and manuals, web pages and government releases from the Press Information Bureau (PIB) were reviewed for the study. An assessment of the overview of Indian agriculture and the circular economy was made to synthesise ideas on challenging aspects of developing policy initiatives. The existing government agricultural policy documents and guidelines were analysed, which laid the foundation for a novel conceptual policy framework.

Results and Discussions

From green to sustainability revolution

CAE provides a strategy to optimally use resources, reduce adverse environmental impacts of agricultural activities, enhance productivity and thus ensure sustainability. It is a closed resource loop agricultural system (12) based on three core principles: i) responsible production, ii) responsible consumption and iii) responsible recovery (Fig. 1). To implement CAE for the sustainability revolution, we need to adopt practices and technologies that minimize input use, encourage regenerative agriculture, reduce resource wastage and encourage the reuse as well as recycling of byproducts, especially biomass. Agricultural plant biomass is a significant material source that must be effectively utilised and the byproducts from the agricultural practices, processing and consumption must be repurposed and recycled back into the food system (13).

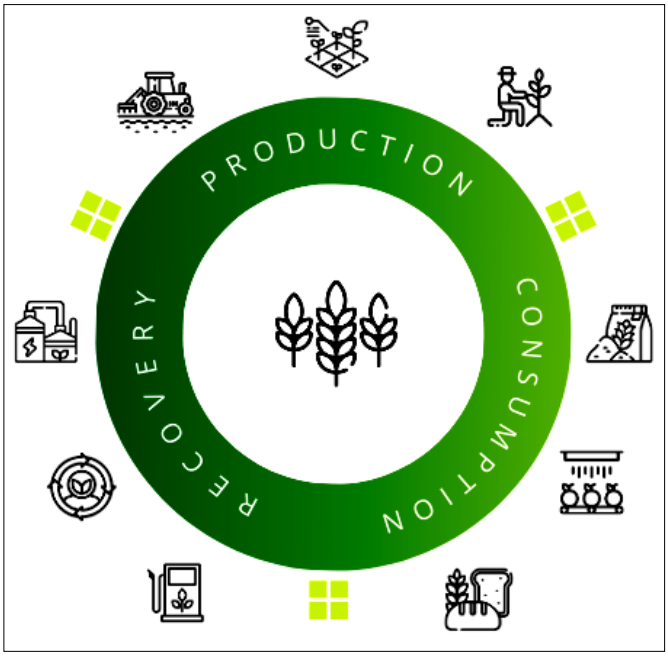

Fig. 1. Illustration of CAE.

Existing policy gaps

Implementing Circular Economy (CE) is challenging, especially in the agriculture sector. There is a lack of an integrated policy framework for circular agriculture, fragmented waste management policies that are not tailor-made specifically for agricultural waste, inadequate support for organic practices, poor access to knowledge and technology, inconsistent regulations on agrochemicals and fertilizers, ineffective water management policies, lack of market incentives for circular products, etc. India's agricultural landscape is vast and diverse and a one-size-fits-all solution cannot be adopted throughout the country. An open-ended policy which could accommodate region-specific interventions is a solution for a country like India.

The Indian government has already given a boost to create a circular economy in various ways, but these are disoriented and scattered. On-field conservation measures are the primary focus of many existing agricultural schemes, for example:

1. The GOBARdhan (Galvanizing Organic Bio-Agro Resources Dhan) scheme aims to convert organic waste into energy and resources, which is a part of the Swachh Bharat Mission.

2. Paramparagat Krishi Vikas Yojana (PKVY) has been implemented to promote organic farming and sustainable agriculture. It promotes the conservation of resources, soil fertility and adaptation to climate change.
3. Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) promotes drip irrigation and sprinkler systems in the agriculture sector with a focus on reducing and optimising water usage.
4. Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan (PM-KUSUM) provides financial assistance to set up solar pumps and solar panels in agriculture fields. It reduces fuel use and carbon emissions from agriculture and increases farmers' income.

Schemes and initiatives such as these must be integrated under a common policy framework. The policy framework should include initiatives and measures focussing on all levels of the agricultural value chain. Although India is proactive in promoting sustainable agriculture, the need for a greater policy focus on CAE is inevitable. The CAEP would be a one-of-a-kind umbrella policy that can address the issues of unsustainability in agriculture and can facilitate the transition from linear to CAE.

CAEP framework

Aim and objectives

The aim of the CAEP is to provide a smooth mechanism that enables switching over to a circular economy in agriculture. Accordingly, the major objectives of CAEP are as follows (Fig. 2):

1. Promotion of circularity in agriculture for ensuring responsible production, consumption and recovery of agricultural resources and thus ensuring the sustainability of the agro economy.
2. Diversification of on-farm crop waste usage for managing the waste produced from the cultivation of food/forage/ cash/commercial crops.
3. Reduction of PHL at the farmers' level and supply chain through expansion of modern energy efficient and green cold chain, storage, processing and value addition infrastructure facilities.
4. Promotion of natural and organic farming using biofertilizers/ manures and through eco-friendly pest management to facilitate the shift from fertilizers/ chemicals for conservation of agrobiodiversity.
5. Expanding the Research and Development (R&D) capacities for addressing the issue of sustainability in agriculture through scientific interventions and cutting-edge technologies.
6. Development of off-grid renewable energy sources in rural spaces that utilize the waste generated from agriculture to achieve net-zero emissions in agriculture.
7. Creation of jobs and employment opportunities in sustainable agriculture and related sectors across the entire supply/ value chain.

Major components

The proposed CAEP framework encompasses four major components which form the basic structure of the framework (Fig. 3).

Input and Output Optimization

Strategic management and optimization of major agricultural inputs like water, land and nutrients are vital to improve output quality and boost crop productivity sustainably. Efficient harvesting and post-harvest handling during transportation/ storage are essential to minimize waste throughout the supply chain, from production to consumption.

Seed

High-quality seeds, which include certified and genetically improved seeds, must be produced. With the right scientific and governmental backing, research on seeds that could produce drought-resistant, less resource-intensive crops should be expedited. Promoting natural antifungal and antibacterial seed treatments will protect them from pests and diseases. Natural Farming Technique - Beejamrit, a seed treatment with cow dung and urine, improves the viability of seeds. Promotion of precision farming would aid in optimal seed rate, space and depth, which maximises crop growth and yield. It also ensures optimal utilization of the land resources.

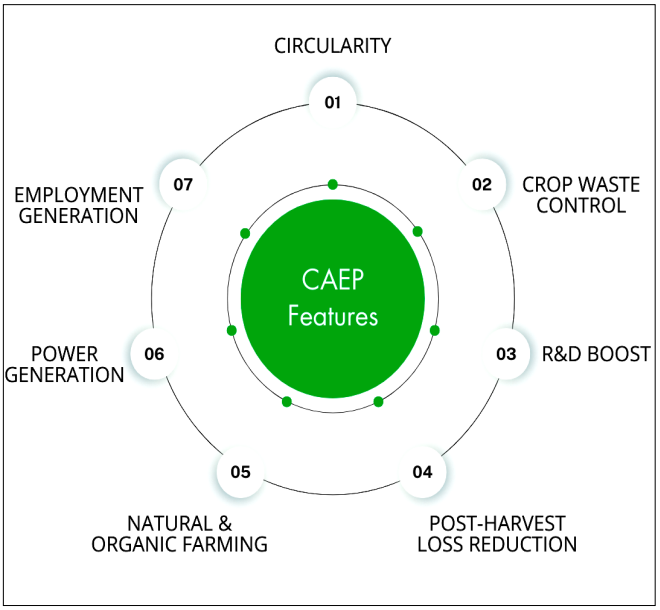

Fig. 2. Key features of the CAEP framework.

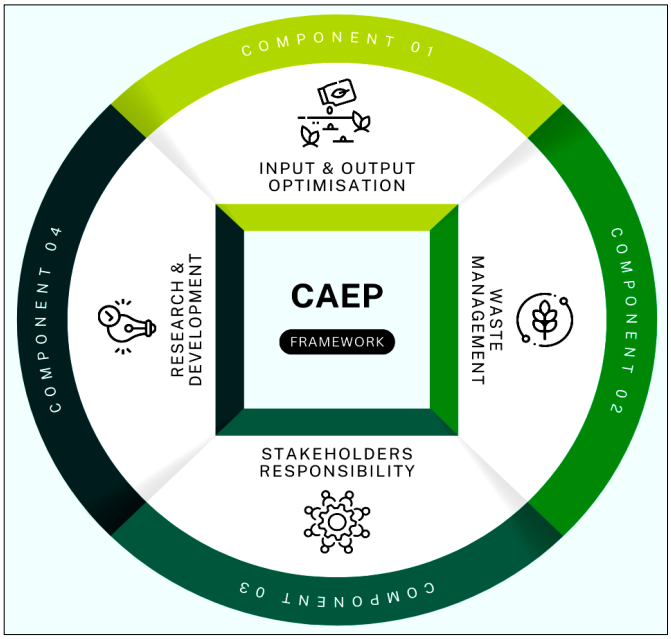

Fig. 3. Illustration on components of the CAEP framework.

Water

Promotion of on-farm water management should be ensured by promoting drip/ sprinkler irrigation depending upon the crops. Promotion of mulching using crop residues to increase water holding capacity and prevent weed growth. Scheduling of irrigation based on soil moisture level and crop needs will minimize water wastage. Rainwater harvesting through on-farm storage tanks will decrease the pressure on groundwater resources.

Land

Soil testing must be made mandatory at village panchayat level and soil log must be maintained. This aids in promoting agroecological crops suitable for that location. Periodic soil testing will help in the continuous monitoring of soil fertility levels and in forecasting the nutrient requirements priorly. Promotion of fertigation in farms will prevent the wastage of fertilizers and will dilute the toxic effects of it on land thus preventing land degradation. Crop rotation and cover cropping are effective agricultural practices that keep the soil fertility balanced and preserved. Integrated Nutrient Management (INM) by combining organic and inorganic fertilisers could be adopted.

Produce quality

The use of high-quality disease resistant seeds should be ensured to improve the quality of products and increase healthy crop yields. To produce safe, nutritious and better-quality food, Good Agricultural Practices (GAP) for pest control, nutrient management and water use must be followed. Regular soil testing and amending is essential to balance soil nutrients and enhance quality crop production. Implementing quality control measures for quality checks and grading will maintain consistency in produce quality.

Product shelf life

The PHL of agricultural produce during 2022in cereals are 3.89 - 5.92 %, in pulses are 5.65 - 6.74 % and in oilseeds are 2.87 - 7.51 % (Fig. 4). Such losses are due to lack of proper post-harvest technologies, improper harvesting and spoilage during transportation. Implementing technologies like controlled atmosphere storage, cold storage and vacuum packing to extend product shelf life; adopting cold chain facilities and biodegradable packaging materials to reduce spoilage during transportation; and ensuring harvest only during optimal timing based on produce maturity will help in maximizing freshness and longevity. Using techniques like dehydration, canning or freezing will aid in preserving surplus produce.

Storage Infrastructure

Modern storage facilities must be developed with cold chains, warehouses and silos which are energy efficient (solar powered) and have automated real-time monitoring of temperature and humidity. It involves huge investments and hence requires both private and public participation. These storage units must be decentralised i.e., smaller storage units nearby to farming areas to increase accessibility.

Value Addition

Value addition of raw agricultural products helps to increase shelf life, enhance the marketable value of the product and boost exports. Innovations in processing and packaging are highly essential to expand value-addition techniques in the agro-processing sector. A vast array of agricultural value-added products including sauces, concentrates, jams and ready-to-eat meals are available in the Indian market. The development of innovative and diverse value-added food products opens new high-value markets while building a large consumer base.

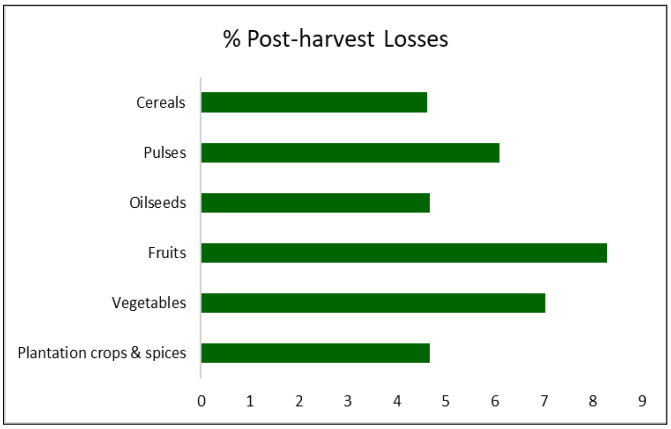

Fig. 4. Percentage of PHL of agricultural commodities in India.

By-product utilization

Effective utilization of by-products plays a significant role in reducing wastage. Utilization of by-products includes conversion of fodder waste into animal feed, generation of biofuel and biogas from crop residues, transformation of agricultural waste into organic compost to improve soil fertility and production of biodegradable products such as tableware as well as packaging materials from crop waste, including sugarcane bagasse and wheat husks.

Waste management

According to the Council on Energy, Environment and Water (CEEW), India is the second largest global producer of agricultural waste (15). Harnessing this waste as a resource to strengthen other value chains such as biochar, fodder and biofuel would ensure a more resilient and resource-efficient agrarian system. Crop residues are one of the major wastes generated on agriculture farms. Indian agriculture is dominated by rice and wheat cultivation. The highest share of biomass generation is from paddy (33 %) and wheat (22 %) (16). In the major rice and wheat-growing regions stubble burning is followed, as farmers find a small window for the next season and lack options for crop residue management.

Management of crop residue can be done by *in situ* and *ex situ* methods. In *in situ* management zero tillage farming where seeds are sowed without disturbing the soil or else adopting Happy seeders mixes stubble into soil which in turn enriches the organic matter. In *ex situ* management, residues can be collected, baled and transported for other uses such as feed for livestock, raw material for paper and packaging, fuel for biomass power plants, producing organic manure, bioethanol, etc. But this requires government support for the creation of a supply chain from the farm to the plant. Decentralised collection centres should be established near the farm to transport the farm waste as per the requirements.

Another important field waste generated is animal waste, especially cow dung which can be either used for manure preparation and composting in the field itself or else it can be diverted to produce bioenergy.

Plastics generated from agriculture practices hinder waste management initiatives in agriculture. According to Food and Agriculture Organization (FAO), the agricultural plastic industry in India is expected to rise by 50 % in demand for greenhouse, mulching and silage films by 2030 (17) and managing them is a herculean task. Eco-friendly materials as alternatives to these plastics must be developed and promoted for sustainable agriculture.

Efficient waste management is a critical component of sustainable development to minimize environmental impact while maximizing resource recovery. Recovery mechanisms are techniques that extract energy or materials from waste, providing both environmental and economic benefits. These mechanisms include waste-to-energy recovery methods such as mass burn processes, anaerobic digestion and gasification as well as waste-to-material recovery techniques like composting, pyrolysis and bioremediation. Additionally, material recovery facilities play a crucial role in sorting and recycling waste.

Key stakeholders

Streamlining the key stakeholders of the agriculture sector is vital for forming and implementing the CAEP Policy. Before forming policy, discussion among the stakeholders is very crucial. An empowered forum for discussion inclusive of all stakeholders should be formed for the purpose of framing guidelines and standard operating procedures (SOPs). The CAEP involves the participation of the following stakeholders:

Farmers

The pillars of sustainable agriculture are the Indian farmers. The farmers are the real changemakers who can transform the agricultural landscape of India. The farmers must be equipped with the knowledge of circularity and skills to execute sustainable practices in agriculture. To enable them to do so, facilities such as on-farm compost pits and community compost stations for the benefit of the entire village must be available. Farmers can significantly play a role in off-grid renewable energy production through small-scale biogas, biodiesel and bioethanol plants. Farmers as responsible stakeholders can effectively manage the *in-situ* farm resources and reduce farm wastes. Farmers can form Farmer Producer organisations (FPOs) or Cooperatives, which can serve as platforms for aggregation and boost economies of scale.

Government

The Government of India is vested with the power of enforcing CAEP to exercise circular economy in agriculture. The government has a vital role to play as a policymaker and regulator of the CAEP rules/ guidelines. The government's responsibility encompasses capacity building of farmers and training of the rural youth on circularity practices in agriculture, creating a conducive environment for the private sector and boosting investment.

Consumers

Creation of public awareness is crucial to make the consumers responsible citizens. This must start with educating the children to youth of the nation to instil a sense of responsibility for sustainability at a very young age. Every agricultural household should promote circularity in their own backyard or agricultural land depending upon their ability. Consumers have a minimal role but can have a bigger impact. A taste of buying recycled products especially from agro-based waste must be promoted. More the demand gets created more circularity gets adopted by the producers.

R&D

Academia & research institutes

Research Institutes and academia, especially agri- and allied-science research institutes, can contribute significantly to waste management. Newer technologies and scientific methods can only be roped in by research institutes. Educational institutions should include principles of circularity in the syllabus to promote circular thinking among the young generation and equip them with these values to navigate our nation towards a sustainable future (18).

Private sector

Investments, R&D and demand creation are the major roles of the private sector. Resources available with the government are limited and participation of the private sector is a must. Investments through corporate social responsibility by corporate social organisations and private companies should be promoted in the agro-based circular economy. R&D departments of the agro companies can indulge in research works. Startups are the need of the hour. The circular economy is a less explored area where innovations should be appreciated, nurtured and promoted. Chennai-based venture Indowud NFC uses agricultural husk to create an eco-friendly form of wood that not only deals with the problem of stubble burning but also reduces the number of trees being cut to make furniture (19).

Implementation strategy

The success of adopting CAEP lies in its effective implementation and to achieve its targets, the CAEP can be implemented in a phased manner. The timeline of CAEP implementation is kept as 5 years due to the ongoing sustainability crisis. Over the proposed timeline of 5-year term, the full implementation of CAEP can be carried out successfully in three phases (Fig. 5).

Phase I

The initial stage of the CAEP implementation is Phase I and will last for 3 years. The first three years are most crucial and require significant participation from the government. It requires investments in awareness creation, capacity building and training the farmers on the circularity practices to be adopted in agriculture. Pilot studies, on-farm trials (OFT) and front-line demonstrations (FLDs) can be conducted to facilitate the adoption of circularity practices more easily. These programmes also facilitate mutual knowledge sharing between the technical personnels and farmers.

Phase II

In this phase, the CAEP will be open for voluntary adoption by all the stakeholders. This phase will last for 2 years enabling the village communities to create on-farm and off-farm assets for circularity practices. Small-scale campaign could be launched nationwide to educate the masses on the transition to sustainable agriculture for CAE. Innovation drive through startup hackathons and flagship government initiatives needs a special focus at this phase for nurturing entrepreneurship and startup culture among the youth of the nation. Streamlining

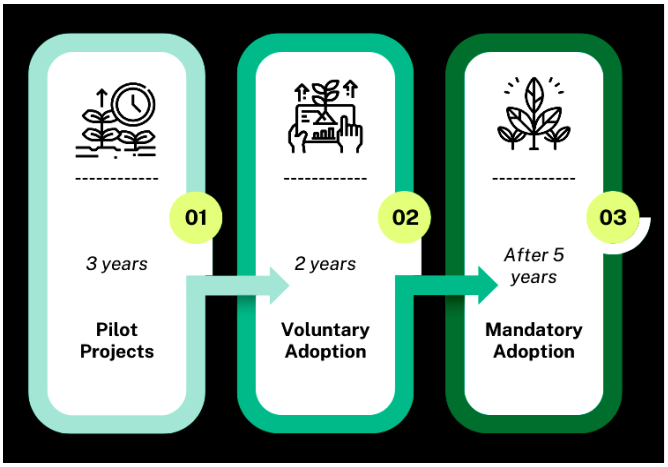

Fig. 5. Phases of implementation of the CAEP framework with timelines.

the supply and value chain of the agriculture sector with circularity principles will be another major task during this phase. The government should also take steps to frame guidelines for the stakeholders based on the results of the pilot studies and feedback to proceed further.

Phase III

At the end of 5 years following the first two phases, full-fledged implementation of the CAEP will take place. The success stories of Phase I and Phase II will serve as the tool that shapes the last stage of CAEP implementation. The government can then subsequently roll out the CAEP across all the states of the country for its wide-scale adoption. During this phase, all the stakeholders must comply with the guidelines issued under the CAEP. Projects under the Public-Private Partnership (PPP) mode can be launched to enable large-scale services and asset provisioning. The government can monitor and evaluate the outcomes of the policy and bring in necessary changes to improve the CAEP accordingly.

Implementation agencies

The CAEP implementation requires inter-department and interministerial coordination and co-operation for action and sharing information, resources and expertise. The agencies that can undertake responsibility for the CAEP inception and implementation are the Departments under Ministry of Agriculture & Farmers Welfare (MA & FW), Ministry of Cooperatives, Ministry of New and Renewable Energy to ensure inter-sectoral synergy. Specialized wings under each ministry should be created at the national and state levels, as well as a coordination committee at the district level, for overseeing and implementation of the policy.

Recommendations

The CAEP can be implemented under the National Mission for Sustainable Agriculture (NMSA) of the Department of Agriculture & Cooperation, Ministry of Agriculture & Farmers Welfare, Government of India. NMSA is an ambitious programme of the Indian government and incorporation of CAEP into this endeavour will help in advancing the mission.

The National Sustainable Agriculture Board (NSAB) can be established and can function as the apex body for executing the provisions of the CAEP and monitoring the progress of the policy implementation. The NSAB can advise the government on matters related to sustainable agriculture and set standards for strict adherence by the stakeholders.

A National Green Agriculture Fund (NGAF) can be established for benefit sharing and supporting the farmers through incentives/ subsidies for setting up facilities like compost pits at their farms. This can be expanded further by setting up community compost stations at each of the villages. NGAF thus can be instrumental in promoting organic/ natural farming and on-farm waste reduction. Small-scale biogas, biodiesel and bioethanol plants that contribute to renewable energy production can be established at the village level. Such initiatives under CAEP can make the villages self-sufficient in energy by decentralizing energy production. Rural communities can contribute significantly to the circularity in agriculture through responsible use of farm resources and emerge as role models in promoting sustainable agriculture. Also, the NGAF can be used to meet the fund requirements for training and skill development purposes during every phase of CAEP implementation.

The Indigenous Technical Knowledge (ITK) and Traditional Knowledge (TK) of the local people need to be documented and disseminated through an appropriate knowledge-sharing system created for the purpose. This timelessly relevant knowledge holds innovative solutions to the issues faced by today's society. Indian culture by tradition is known to practice circularity in agriculture and contribute to sustainability. These invaluable practices are worthy of global attention and reviving those old practices can open new paths. NGAF can also be used to reward the local communities for their services by acknowledging the communities involved in preserving such knowledge and encouraging them to pursue the same.

Government subsidies on chemical fertilizers and pesticides pose a challenge in the adoption of CAEP as they hinder the transition to sustainable agriculture by promoting agrochemical dependency and need to be addressed through the adoption of more conducive policies like PM-PRANAM and the National Mission on Natural Farming (NMNF) to foster the transition towards CAE (20). The information network and dissemination system can be strengthened by the formation of national and state-level executive committees to track the compliance and progress of the CAEP. The executive committees can also facilitate the flow of funds under NGAF in reaching the beneficiaries. Integrating proposed interventions with various government schemes and targets is necessary to transform CAEP into an actionable policy. The implementing agencies must continuously monitor and evaluate the interventions to assess the impacts through appropriate assessment and feedback mechanisms, as monitoring and evaluation are important elements to ensure result-driven outcomes of CAEP.

Achieving SDGs

The CAEP, in its very essence, strives to achieve the SDGs adopted by the United Nations (UN). Through the creation of CAE, various SDGs such as No Poverty (SDG 1), Zero Hunger (SDG 2), Good Health and Well-Being (SDG 3), Gender equality (SDG 5), Affordable and Clean Energy (SDG 7), Decent Work and Economic Growth (SDG 8), Industry, Innovation and Infrastructure (SDG 9), Responsible Consumption and Production (SDG 12), Climate Action (SDG 13), Life on Land (SDG 15) and Partnership for the Goals (SDG 17) can be achieved (Fig. 6).

Fig. 6. Illustration on the SDGs achievable through CAEP framework.

For a sustainable agriculture sector, actions such as eliminating toxic chemicals and fertilizers, banishing the use of plastics in agriculture, decreasing food waste, lowering unemployment, reducing farm emissions, empowering women farmers as well as entrepreneurs alongside collaborating for innovative technology transfer, contribute to the fulfilment of SDGs.

Conclusion

The policy readiness of the country is indispensable to tackling the contemporary challenges of sustainability and climate change. The first step to bring in the desirable changes in terms of sustainability is through the adoption of the CAEP by the Indian government. Framing guidelines for the functional aspect of the policy is the next step. CAEP can make the Indian government a forerunner in bringing sustainability to agriculture. The progress and prosperity of an agrarian nation lies in the sustainability of the agro-economy and the success stories of Indian agriculture would become an inspiration to the rest of the world.

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Authors' contributions

JRHH conceptualised the idea, designed the framework, created figures, undertook writing and editing. PGA contributed to the literature review, writing and editing. JRHH and PGA equally made substantial intellectual contributions to the study.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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