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SUSTAINABLE CROP PRODUCTION INTENSIFICATION THROUGH AN ECOSYSTEM APPROACH AND AN ENABLING ENVIRONMENT: CAPTURING EFFICIENCY THROUGH ECOSYSTEM SERVICES AND MANAGEMENT

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I. Introduction

1. The Declaration of the World Summit on Food Security (Rome, November 2009) highlights the promotion of "... new investment to increase sustainable agricultural production and productivity, support increased production and productivity of agriculture", and implementation of "...sustainable practices... improved resource use, protection of the environment, conservation of the natural resource base and enhanced use of ecosystem services". The Declaration further commits to address the sustainable use of land and water; maintaining the health and productivity of all ecosystems; and better management of the biodiversity associated with food and agriculture.
2. Outcomes of recent gatherings of global leaders indicate a strong consensus on the need to increase agricultural productivity to feed a growing population while endorsing the need for sustainability in achieving such increases, and for food consumption in line with diversified and balanced diets. The international community also emphasized the importance of crop production in mitigating of and adapting to climate change. Lastly, in recent gatherings, leaders reiterated the need to increase investments in agriculture, and promote new investment to increase sustainable agricultural production and productivity¹.
3. The 21st Session of the Committee on Agriculture (COAG) stressed that an ecosystem approach be adopted in agricultural management in order to achieve sustainable agriculture². The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Application of the ecosystem approach focuses on essential processes and functions, and the interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems³. The 36th FAO Conference (2009) adopted a new strategic framework of which Strategic Objective A is the Sustainable Intensification of Crop Production⁴. Within the overall context of FAO's Strategic Objective A, this paper focuses on intensifying production (i) through the ecosystem approach and (ii) identifying the characteristics of an appropriate enabling environment to support and reinforce initiatives taken, such as adequate policies, legislation, institutional support, economic development, availability of best knowledge, etc.
4. Strategic Objective A aims to help countries achieve sustainable increases in agricultural productivity through an ecosystem approach, by providing technical and policy assistance in four areas: a) increasing agricultural productivity through improved use of resources (e.g. plant genetic resources, seeds) to achieve higher yields while promoting the sustainability of the production and farming systems; b) enhancing sustainable crop protection with a focus on pest and pesticide-related issues; c) managing biodiversity and ecosystem services, including through identification

¹ Including the: June 2008 Declaration of the High-Level Conference on World Food Security: the Challenges of Climate Change and Bioenergy (Rome, Italy); July 2008 U.N High-Level Task Force on the Global Food Security Crisis - Comprehensive Framework for Action (CFA); January 2009 High Level Meeting on Food Security for All (Madrid, Spain); May 2009 17th Session of the Commission on Sustainable Development (CSD); and July 2009 G8 Summit Joint Statement on Global Food Security (L'Aquila, Italy).

² "The Committee stressed that an ecosystem approach be adopted in agricultural management in order to achieve sustainable agriculture, including integrated pest management, organic agriculture and other traditional and indigenous coping strategies that promote agroecosystem diversification and soil carbon sequestration. Several Committee members noted the need for capacity building in new approaches and incentives to producers. The Committee endorsed the proposal that public and private investments be made in agroecological research, at both national and international levels." (Report of the 21st Session of the Committee on Agriculture (COAG), Rome 22-25 April 2009, CL 136/5; C2009/19).

³ Convention on Biological Diversity.

⁴ FAO Medium Term Plan 2010-2013 (C2009/15).

and use of mechanisms for valuing agricultural biodiversity and ecosystem services, and sound agronomic and land management practices; and d) strengthening livelihoods using the benefits of increased productivity and diversification within the value chain. The framework for sustainable crop production intensification also includes global and regional instruments, treaties, conventions and codes (e.g. the International Plant Protection Convention, the International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA), the International Code of Conduct on the Distribution and Use of Pesticides) that embody international cooperation for enhancing and sustainably using natural resources - and reducing risks from, and improving management of, transboundary threats to production, environment and human health. For instance, the Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases (EMPRES) Plant Health programme monitors transboundary pests and diseases which are potential constraints to sustainable crop production intensification.

5. Ecosystem approaches are also applied to specific elements in other Strategic Objectives (SOs) of the new strategic framework:

- SO B – as part of the One Health concept⁵ and in management of natural resources, including animal genetic resources in livestock production.
- SO C – in both marine fisheries and aquaculture in supporting fisheries resources and sustainable use and production.
- SO E – in forests, with work on technical, policy and legal support to ecosystem approaches.
- SO F – as a key strategy to reconcile food security and the environmental conservation through programmes such as: (i) the Multi-Year Programme of Work of the Commission on Genetic Resources for Food and Agriculture; (ii) Sustainable Land Management for enhancing land-derived goods and services; and (iii) the multi-sectoral organic agriculture programme that assists countries to optimize their performance in producing, processing and marketing according to existing biophysical and socio-economic resources.

6. This paper underlines the importance of ecosystem services⁶ and identifies some of the opportunities to improve efficiency in resource use through managing biological processes. It concludes by setting out goals, outcomes and outputs for a programme by which FAO can assist its Members implement sustainable crop production intensification programmes and requests COAG guidance on the further development of a long-term strategy.

II. The Challenge

7. While the world is projected to need a major increase in crop production to feed a population of around 9 billion people in 2050 when compared to 2000⁷, it must do so against a challenging backdrop including the decreasing availability of and competition for land and water (including from other land uses such as production of biofuels, urbanization and industrial development); poor soil fertility; reduced access to fertilizer, improved varieties (developed using conventional and modern plant breeding tools) and quality seeds; as well as climate change. Changing dietary and nutritional needs and requirements as a result of urbanization and niche markets also present a challenge. Equally, future demand for biofuels or other non-food products from agriculture remains uncertain. Post harvest processing (and the reduction of losses) and farmers' and smallholders' ability to add value to their products are also important factors.

⁵ One Health is a concept that addresses emerging disease dynamics, zoonoses in particular but extending to high impact animal disease spread, at the animal-human-ecosystems interface, in a multidisciplinary and cross-sectoral approach.

⁶ Ecosystem services are supporting (e.g. nutrient cycling.); provisioning (e.g. food); regulating (e.g. pollination, climate regulation, pest and disease regulation); and cultural (e.g. educational). (Millennium Ecosystem Assessment, 2005).

⁷ On average doubling of crop production in developing countries; 70% increase for the world as a whole.

8. Previous attempts at managed intensification (such as the Green Revolution of the 1960s and 1970s) have been a qualified success. In some cases it is now recognized that the yield increases achieved – through increased use of fertilizers, high yielding varieties, irrigation, pesticides and intensive tillage - were made at the expense of the environment or in ways which were otherwise unsustainable. Also some smaller-scale farmers were unable to participate or reap the rewards of scale. The International Assessment of Agricultural Knowledge, Science and Technology for Development (2009)⁸ highlighted the need for policies that value, restore and protect ecosystem services, and address the needs of the world's small-scale and family farmers. It emphasized the need for a change in paradigm to encourage increased adoption of sustainable ecological agriculture and food systems.

9. Significant gains in agricultural productivity result from a large number of local decisions made by farmers (including smallholders), regarding their use of ecological knowledge and inputs and/or culturally/traditionally established practices. Here, gender specificities play an important role, for example with regards to the use and dissemination of such knowledge – including from cultivation to processing stages of the food chain.

10. Changing underlying assumptions, attitudes or cultural patterns is always difficult. However, governments may influence widespread uptake of productivity-enhancing practices, farmers' decisions, knowledge and skills, with appropriate policy frameworks, encouragement through participatory research and extension and the broadcast media, formal and non-formal education, as well as through financial, tax and other incentives; and through sustained investment for capital formation (physical and human) – together these constitute the enabling environment.

III. Capturing Efficiencies Through Ecosystem Services and Ecosystem Management

11. In seeking to intensify crop production sustainably, one important entry point using the ecosystem approach is to examine ways to reduce waste of production inputs and improve efficiency in the use of key resources in agriculture, including horticulture. Increases to farmers' net incomes (through lower spending on production inputs) will also be at lower environmental or social cost, hence delivering both private as well as public benefits.

12. Agricultural inputs such as seed, fertilizer, land, water, chemical or bio- pesticides, power and labour complement the natural processes supporting plant growth. Examples of these biological processes include: the action of soil-based organisms (that allow plants to access key nutrients; maintain a healthy soil structure which promotes water retention and the recharge of groundwater resources; and sequester carbon); pollination; natural predation for pest control, etc.⁹ Farmers that utilize better information and knowledge on the supporting biological processes can help to boost the efficiency of use of conventional inputs.

13. Agricultural practices and adapted production systems have developed over time which manage ecosystem services to improve productivity and reduce environmental impact. Approaches such as integrated plant nutrient management, integrated pest management, conservation agriculture, organic agriculture, integrated crop-livestock systems, agro-forestry systems and integrated weed management as well as pollination management, all target sustainable improvement in productivity.

14. The following are examples of the underlying principles on which these approaches depend:

⁸ IAASTD. *Agriculture at a Crossroads. Global Report*. 2009. Edited by McIntyre, B.D.; Herren, H. R.; Wakhungu, J. and Watson, R.T

⁹ FAO. *Increasing crop production sustainably: the perspective of biological processes*. November 2009.

- a) As reflected in national programmes, strategies and/or action plans on plant genetic resources, plant breeding and seeds systems, all contributing to the Global Plan of Action for the Conservation and Sustainable Utilization of PGRFA, crop varieties need to be adapted to local conditions. Adopting earlier maturing varieties or switching to crops with better tolerance of abiotic and biotic stresses can enable farmers to cope with less rainfall, salinity, or disease pressure and still produce a crop. The key efficiency element is to ensure farmers have access to improved adapted crop varieties through strengthened seed systems. Conservation and sustainable use of PGRFA is necessary to ensure crop production and meet growing environmental challenges such as climate change.
- b) Conservation Agriculture (CA) practices can create stable living conditions for micro and macro-organisms, providing a host of natural mechanisms supporting the growth of crops, which result in significant efficiency gains and decreasing needs for farm inputs, in particular power, time, labour, fertilizer, agrochemicals and water. Furthermore, in many environments, soil erosion is reduced to below the soil regeneration level or avoided altogether and water resources are restored in quality and quantity to levels that preceded putting the land under intensive agriculture.
- c) Integrated Pest Management (IPM) encourages natural predation as a corollary to reducing the overuse of insecticides. In countries like India, Indonesia, and Philippines that followed Green Revolution strategies but then removed insecticide subsidies and reduced insecticide use nationally by 50 -75 percent, rice production continued to increase annually. The ecosystem service delivered by natural predation replaced most chemical control, allowing the other inputs and adaptive ecosystem management by farmers to secure and increase rice yields.
- d) Integrated Plant Nutrient Management (IPNM) and similar strategies promote the combined use of mineral, organic and biological resources to balance efficient use of limited/finite resources and ensure ecosystem sustainability against nutrient mining and degradation of soil and water resources. For example, efficient fertilizer use requires that correct quantities be applied (overuse of Nitrogen (N) fertilizer can disrupt the natural N-cycle), and that the application method minimizes losses to air and/or water. Equally, plant nutrient status during the growing season can be more precisely monitored using leaf-colour charts, with fertilizer application managed accordingly. Efficient plant nutrition also contributes to pest management.
- e) Well-integrated crop and livestock systems increase the diversity and environmental sustainability of smallholder production systems. This intentional integration reflects a synergistic relationship among the components of crops (including pastures and trees) and livestock that when appropriately managed results in enhanced social, economic and environmental sustainability and improves the livelihoods of those farmers who manage them. The recently concluded International Consultation on Integrated Crop-Livestock Systems for Development identified several types of Integrated Crop-Livestock Systems that included crop-livestock systems with or without trees or aquaculture; agropastoral systems with or without trees; and landscape level sectoral activities that require functional re-integration of components.
- f) In agricultural water management, there are efficiency and productivity gains in crop water use that can be captured both 'within' and 'outside' the crop water system. For example, agricultural practice that reduces the soil evaporation component of the overall crop evapotranspiration reduces non-productive water consumption. In cropping systems adapted to seasonal or low evaporative demand of the atmosphere, it may be other types of agricultural practice (fertilizer, improved varieties, weed and pest management) that result in more productive consumption of water available in the root zone.
- g) Organic agriculture combines land, water, biodiversity, and ecosystem services management to sustain production. It strives to apply the ecosystem approach and systematically minimizes synthetic inputs. Through rotations and associations of

diverse crops, animals and trees, including locally adapted seeds and breeds with better resistance to pests and diseases, composting, manuring, nutrient cycling and the creation of microhabitats for (wild) agrobiodiversity, it optimizes competition for food and space among different plant and animal species. Increased soil organic matter raises fertility and decreases irrigation requirements and the restoration of the overall agro-ecosystem balance prevents pest and disease outbreaks.

15. Implementing approaches that benefit ecosystem services is knowledge intensive. To ensure that this knowledge is increasingly owned and applied by farmers and smallholders, sustained investment for capital formation (physical and human) needs to be made.

IV. Capturing Efficiencies Through the Ecosystem Approach Throughout the Food Chain

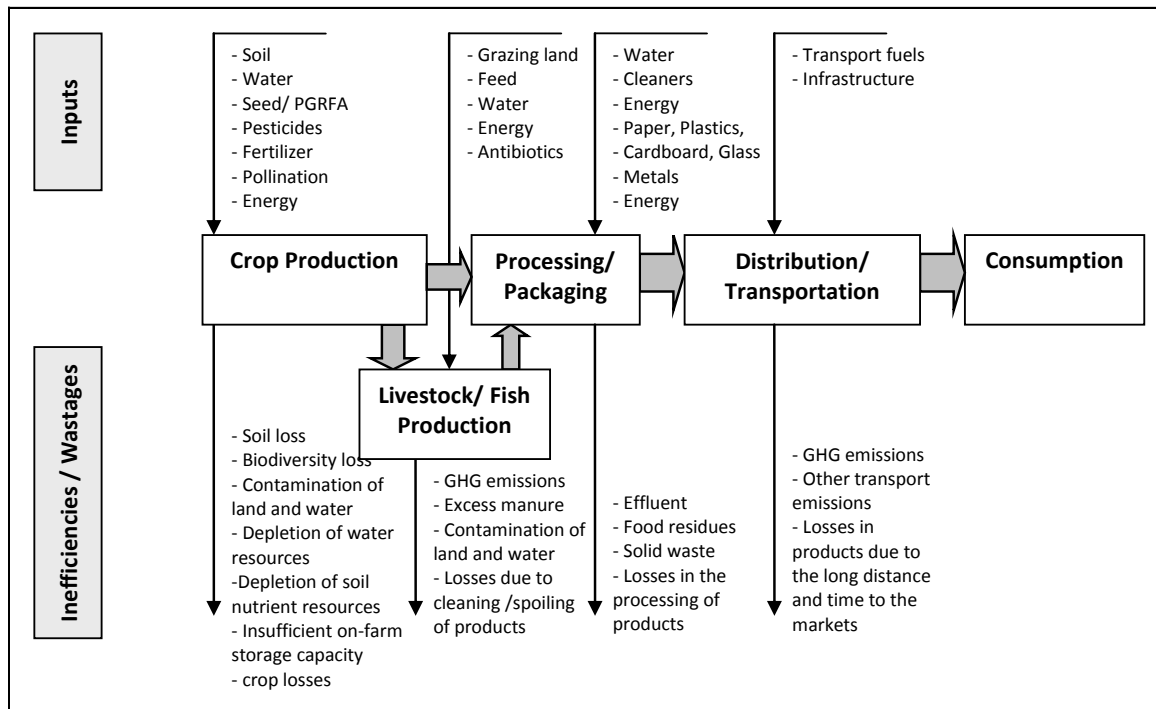
16. Crop production is not the only element to consider when looking to meet increased demand for food. Sustainable intensification of crop production is of reduced value if optimising one component (food crop production) in a complex larger ecosystem also featuring livestock, fisheries, forestry and industrial components (e.g. biofuels) results in inefficiencies elsewhere. Similarly throughout the food chain, post-harvest processing, transportation and distribution which do not support the supply of nutritious food to consumers will limit the benefit of efficiency gains in crop production.

17. Looking at horizontal integration, Integrated Food Energy Systems (IFES) are one example of how to combine sustainable crop intensification with sustainability principles, applied to the issue of sustainable energy inputs for agricultural development. IFES aim at simultaneously producing food and energy for local use, and can be achieved in two different ways (separately or combined):

- by growing food and energy crops on the same piece of land (e.g. through intercropping or agro-forestry systems);
- through 'closed loop' or 'zero waste' systems, where by-products of one type of product are used to produce the other. Examples include animal feed from sub-products of corn ethanol and biogas for energy as sub-product of sugar production.

18. Other similar systems exist in improved crop-livestock strategies, where crop by-products provide a source of feed. Intensive livestock production has also developed systems to minimise the impact of waste on the environment.

19. The diagram below illustrates some of the potential linkages and flows through which efficiencies can be gained. In order to optimise overall efficiency gains from an ecosystem approach, other actors also need to reduce negative impacts of their activities and optimise resource use. Even at the consumption end of the chain there are significant issues; changing consumption patterns (such as increased consumption of animal products) drive changes in land-use and also potentially in biodiversity. The increased number of supermarkets globally will continue to have a major impact on food standards (affecting small farmers in developing countries) and urbanization will place greater stress on urban and peri-urban agriculture.

Figure 1: The food chain

20. FAO is working to develop strategies and programmes to assist member countries to take sustainable crop production intensification forward. It is recognized that these will need to be adapted over time to take account of the uncertainties related to agriculture, food production, climate change, environmental health, population demographics, changing consumption patterns, the sustainability of value chains and global economies, above and beyond FAO's Strategic Objective A. Within the FAO Strategic Framework, horizontal and vertical linkages are also addressed through the Strategic Objectives B (Increased sustainable livestock production), C (Fisheries), D (Food safety), E (Forests and trees), F (Natural resources management), G (Rural development), H (Food security and nutrition), and I (Emergencies).

V. An FAO Strategy for Sustainable Crop Production Intensification

21. This section sets out some major elements of a strategy for FAO to further the development of a framework on sustainable crop production intensification to assist member countries in developing and implementing strategies on sustainable crop production intensification, and proposes a programme for activities until 2025. Significant effort will be required in the next 10 to 15 years to *inter alia* capture efficiency gains while increasing output if the longer term target of increased production is to be met by 2050. For this reason 2025 is taken as a target date for an initial FAO sustainable crop production intensification strategy. Within this programme, the following main elements – which will support the creation and/or strengthening of the enabling environment – will be addressed, considering gender sensitivity, as appropriate:

- **technical:** capturing efficiencies, promoting empowerment of farmers' learning and disseminating knowledge on good agricultural practices, approaches and technologies that can be used to produce high crop yields, while maintaining and/or enhancing environmental sustainability;
- **economic:** creating tools to assess the economic value of ecological dimensions;
- **governance:** promoting an enabling policy and institutional environment to ensure productivity while maintaining or improving the natural resource base;
- **investment:** capital formation (physical and human resources including applied knowledge).

22. The goal of an FAO Strategy for Sustainable Crop Production Intensification is to support and facilitate efforts of member countries in assisting farmers to intensify production sustainably. This will be achieved by using an ecosystem approach, and creating and/or strengthening the enabling environment.
23. The long term outcomes of the strategy can be stated as:
- a) countries take into consideration the options for sustainable crop production intensification;
 - b) countries design their own sustainable crop production intensification strategies, policies and programmes;
 - c) countries monitor and evaluate their sustainable crop production intensification programmes.
24. Outputs of the suggested strategy include:
- a knowledge base of technical studies on options for sustainable intensification, policy case studies where these options have been adopted, and policy, technical and economic tools to support *inter alia* assessments and investment needs;
 - development of programmes to build capacity and raise awareness of key national decision makers;
 - development of methodologies (including diagnostic tools) for measurement of sustainability of crop production intensification, used in periodic global assessments;
 - facilitation/technical assistance to review existing national programme designs, and to help develop monitoring strategies and approaches;
 - information exchange using appropriate media, database, international meetings and conferences.
25. The proposed programme of activities over the fifteen-year time horizon (to 2025) covers the following:
- During the initial period, the approaches to sustainable crop production intensification will be further evaluated and integrated (e.g. CA, seed systems, IPM, IPNM, pollination management, integrated weed management, water productivity, agro-forestry, crop-livestock systems, etc). Production systems will be examined for different aspects including productivity, efficiency gains and risks. Countries will be encouraged to pilot activities supporting technology innovation, new economic tools and scaling up. Capacity building as well as technical and policy advice will be provided.
 - Subsequently, experiences will be shared at local, national, regional and global levels for example through workshops for technical level decision makers; awareness creation and development of strategies (e.g. 4 “sub-regions”, i.e. groups of 10-15 countries within specific agro-ecological zones/sub-regions to make the approaches discussed more focussed and relevant).
 - Pilot and adaptation projects will be implemented in a range of agro-ecological zones/sub-regions in order to demonstrate the applicability of the approaches being promoted and to make adjustments where necessary.
 - The “tested” approaches will be promoted.
 - The adoption of suggested approaches will be evaluated over time and the results also fed back to decision makers.
 - Technical material and guidelines will be developed and disseminated.
 - Sustainable agricultural sector investment strategies will be formulated.

VI. Implementing this Strategy

26. FAO is well-placed to facilitate the adoption of sustainable crop production intensification policies globally. The Organization has an overview of appropriate production systems for sustainable production intensification and is already providing technical leadership to relevant developments such as CA, IPM, IPNM, pollination management, etc.

27. For sustainable crop production intensification to become a reality, concerted action at different levels is required, from the farm level, to science and technology, and up to the economic and policy levels. FAO is connected to all of these levels and can support the required changes at each. FAO has also, over time, developed tools and methods in participation, rural development and institution-building which are highly relevant to the adoption of new approaches.

28. FAO's main contribution in sustainable crop production intensification is in:

- Supporting the establishment of adaptation sites for sustainable crop production intensification managed by farmers and farmer associations at local level to promote the development of national policies and programmes (e.g. Farmers Field Schools) that use the ecosystem approach.
- Encouraging investment in local participatory research especially by farmers to blend traditional and local knowledge with new and improved practices.
- Assisting member countries to develop and implement sustainable crop production intensification policies and strategies, using country priorities to define the entry point (efficiency opportunities, environmental concerns, etc).
- Helping build capacity of national decision makers to develop their awareness, engagement and commitment to ensure that national agricultural development goals, strategies, policies, plans and programmes (as well as laws, rules and regulations) protect and strengthen the ecological functions supporting agriculture.
- Assisting in bringing together national and regional responses to processing and distribution of food products, pest and disease control, or watershed management where these require collaboration among a number of different countries.

29. FAO also contributes at the international level through further encouraging dialogue between the agriculture and environment sectors, and between the public, private and civil society sectors, and by harmonizing and further improving adaptation of existing international instruments, conventions, and treaties relevant to production intensification. FAO does not work alone. This will require partnership with institutions such as the Consultative Group on International Agricultural Research (CGIAR), Civil Society Organizations (CSOs) and farmer associations as well as working closely with relevant bodies and networks that foster inclusiveness and strengthened partnerships, such as the reformed Committee on World Food Security (CFS) and others.

30. The proposed programme (Table 1) presents activities for achieving sustainable crop production intensification through an ecosystem approach, in relation to gaining efficiencies in both crop production systems (middle column) and throughout the food chain. The programme will include selected thematic reporting to COAG covering different aspects of the food chain such as integrated crop-livestock systems, crop-aquaculture systems, post harvest management and human nutrition and consumption patterns (last column).

Table 1: Proposed Programme 2010-2025

Sustainable Crop Production Intensification (SCPI) through an Ecosystem Approach and an Enabling Environment <i>Work plan 2010-2025</i>		
Biennium	Production System	Food Chain (selected thematic areas)
1 2010-2011	(1) Documentation and demonstration of potential efficiency gains at local, national and regional levels on issues such as soil- and water management, fertilizers and plant nutrition, seed and plant genetic resources for food and agriculture, pesticides and pollination. (2) Initial development of policy options for sustainable crop production intensification, based on technical case studies. (3) Methodologies for baseline and monitoring of sustainable crop production intensification programmes.	Crop Production: Increasing efficiency of inputs and adaptive management through biological processes
2 2012-2013	(1) Report to COAG. (2) Documentation and demonstration of sustainable crop production intensification in several countries, focussing on risk reduction and ecosystem management. (3) Baseline study on crop production intensification.	Consumption: Sustainable diets
FAO donor programme to support country-led SCPI programmes		
3 2014-2015	(1) Report to COAG. (2) Implementation of SCPI projects in at least 4 regions with different agro-ecological zones, to facilitate scaling up. (3) Development of a structured approach to capture the efficiency gains and mainstreaming efficiencies into policies.	Post Harvest Management: reducing losses
4 2016-2017	(1) Report to COAG. (2) Review of the approach and efficiency gains (evaluation of programmes). (3) Adapting and scaling up of approaches.	Livestock and fish production systems: linkages with crop production systems
Framework on SCPI through an ecosystem approach and an enabling environment		
5 2018-2019	(1) Report to COAG. (2) Country implementation (scaling up and adaptation) of best SCPI practices. (3) Regional exchanges of experiences and lessons learned (4) Monitoring and evaluation.	Higher efficiency throughout the food chain: including processing and distribution.
6 + 7 2020-2023	(1) Report to COAG. (2) Implementation at country level in additional countries. (3) Subregional, Regional and Global networks of SCPI practioners (4) Monitoring and evaluation.	Review of the overall food chain efficiency gain in the process
8 2024-2025	(1) Report to COAG. (2) By 2025, majority of countries have begun to implement sustainable crop production intensification.	

VII. Guidance Sought from the Committee on Agriculture

31. Guidance is sought from the Committee on Agriculture on the programme of work on sustainable crop production intensification through an ecosystem approach and an enabling environment.
32. In particular, COAG may wish to:
- Recognize the importance of an ecosystem approach to fostering managed biological processes as a key contributor to sustainable crop production intensification, in conjunction with the management of transboundary pests and diseases, the reduction of risk in the use of agrochemicals and the development and sustainable use of PGRFA and other inputs – with global and regional instruments, treaties, conventions and codes.
 - Recognize that capturing input use efficiency can improve ecosystem services and have an added benefit of reducing costs of production and increasing productivity for food security.
 - Acknowledge the “knowledge-intensive” nature of the processes underpinning sustainable crop production intensification, and the importance of supporting institutions and policies (the enabling environment) in implementing programmes on sustainable intensification.
 - Stress the importance of approaches such as CA, IPM, IPNM, organic agriculture and pollination management in capturing efficiencies in productive and sustainable agricultural production systems.
 - Recognize that the work carried out on furthering the application of the ecosystem approach in SO A is a contribution to the “internalization of the ecosystem approach to biodiversity management in agriculture” of the Commission on Genetic Resources for Food and Agriculture.
 - Support the FAO strategy for sustainable crop production intensification through an ecosystem approach and an enabling environment presented in section V.
 - Agree to adopt, further refine and report against the proposed programme 2010 to 2025 for sustainable crop production intensification (Table 1) and engage in periodic monitoring of performance towards sustainable intensification of crop production.