AN ECOSYSTEM APPROACH TO SUSTAINABLE CROP PRODUCTION INTENSIFICATION:

- A CONCEPTUAL FRAMEWORK -

December 2010

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I. ISSUES AND CHALLENGES

A. GLOBAL CONTEXT

While the world is projected to need 70% more food for 9.2 billion people in 2050 as it did in 2000, it must address multiple challenges, including pervasive poverty; hunger and malnutrition; uncertainties from climate change (including higher intensity and incidence of droughts, floods and pests); decreasing water resources; rising energy, food and environmental costs; expanding pest and diseases of crops and livestock; increasingly stringent environmental, biosecurity and biosafety standards, measures, and regulations; the declining availability of land (land per caput will decrease from 4.3 hectares in 1961 to 1.5 hectares in 2050); lower crop productivity growth (annual growth rate of major cereals will decrease from 3 to 5% in 1980 to about 1% in 2050); and eroded ecosystem services[1]. There is also a demand for increased variety, quality and safety of agricultural products, driven by urbanization and rising incomes.

Earlier attempts at intensification of agricultural production have allowed output to keep up with global demand but these have also created problems of sustainability such as decrease in soil health including through excessive soil nutrient mining, increase in soil erosion, excessive water use, decline and degradation of biodiversity, the impact on the environment of the overuse and inefficient use of fertilizer and especially pesticides, leading to pest resistance and pest outbreaks. Ecosystem services such as pest regulation, pollination, nutrient cycling and maintenance of aquatic and terrestrial biotopes are often disrupted, and agricultural inputs are often not used efficiently.

In addition to the pressure to intensify crop production, a new challenge that farmers face is the speed and magnitude of expected changes in climate, which are much higher than in the past. A challenge for sustainable crop production intensification therefore is adapting farming systems while intensifying optimally and improving mitigation measures to cope with climate change. Traditional ways of coping are suitable entry points to initiate adaptation processes, but most likely they will not be enough to ensure medium to long term adaptation.

B. THE FOOD CHAIN

Crop production is not the only element to consider when looking to increase the global food supply. Both horizontal and vertical linkages in the food chain can influence the overall effectiveness of the food production and distribution system. Sustainable intensification of crop production is of reduced value if optimising one component (food crop production) in a complex system (see figure 1), also featuring livestock, fisheries, forestry and industry (e.g. biofuels) results in inefficiencies elsewhere. Similarly 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 production.

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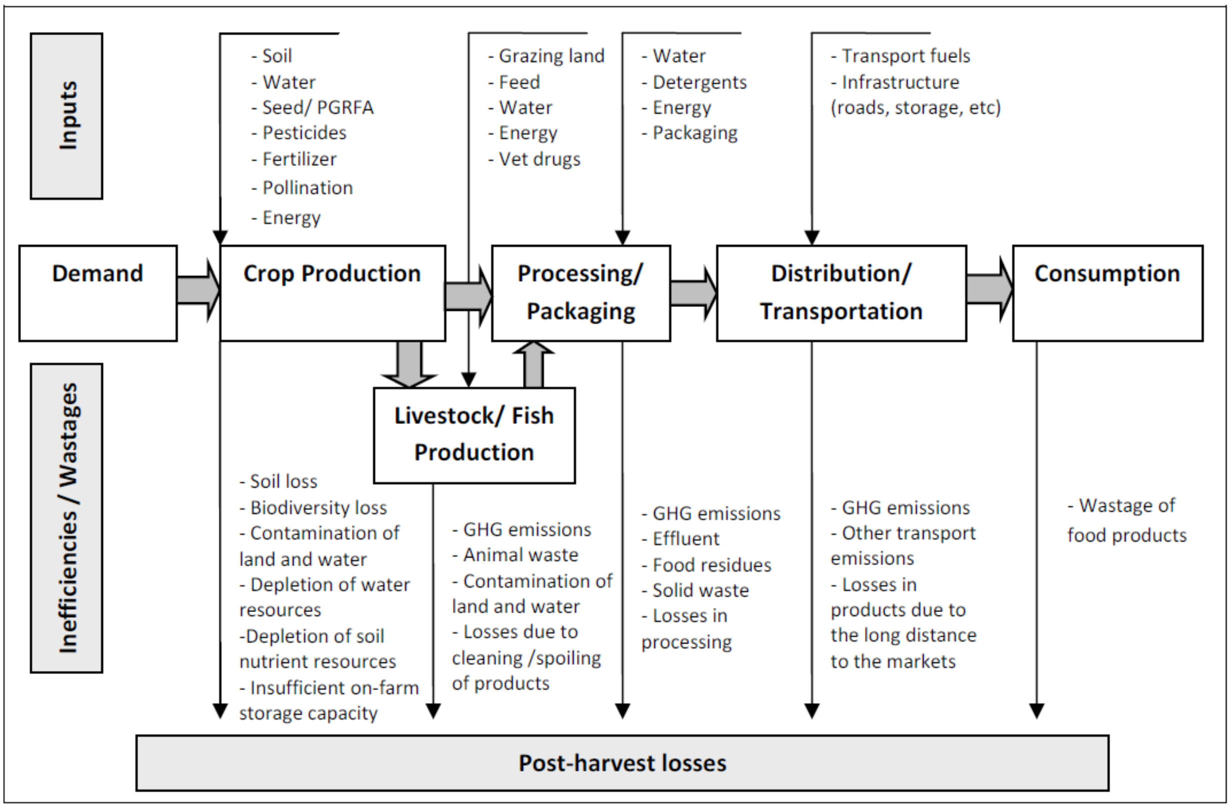
[1] Ecosystem services can be: provisioning (e.g. food, fibre and fuel, genetic resources, biochemicals, fresh water), regulating (e.g. invasion resistance, pollination, seed dispersal, climate regulation, pest regulation, disease regulation, erosion regulation, natural hazard regulation, water purification); supporting (primary production, provision of habitat, nutrient cycling, soil formation and retention, production of atmospheric oxygen, water cycling); and cultural (e.g. spiritual and religious values, knowledge system, education and inspiration, recreation and aesthetic values). *(Millennium Ecosystem Assessment, 2005*).

[2] 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. It is based on the application of appropriate scientific methodologies focused on levels of biological organization which encompass the essential processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems (CBD).

Looking beyond production and the use of agricultural inputs, efficiency arguments can be used in other areas of the food chain. The diagram below illustrates some of the potential linkages and flows through which efficiencies can be gained, for example by reducing post harvest losses at different points in the food chain. Even at the consumption end of the chain there are significant issues; future trends are the changing consumption patterns (such as increased consumption of animal products) driving change 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



C. A SHIFT IN CROP PRODUCTION: MANAGING RESOURCES SUSTAINABLY

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.

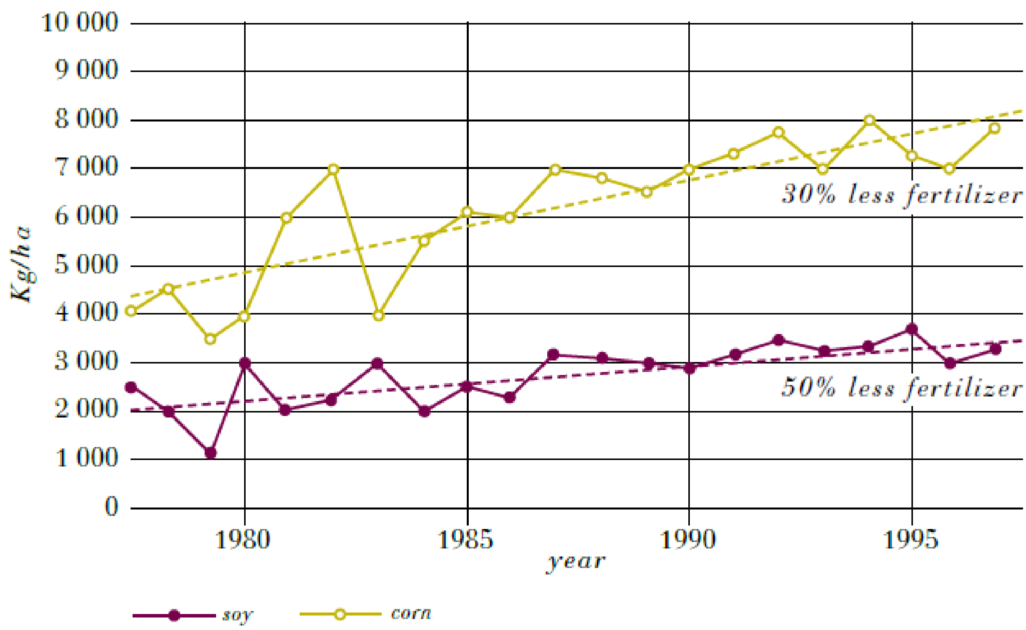
Intensifying crop production without a major focus on the sustainable use and conservation and balances of natural resources and the careful use of non-renewable external inputs such as fertilizers and energy is no longer an acceptable solution. Conversely, the understanding and wise use of biodiversity and management of ecosystem services[1] (such as plant genetic resources for food and agriculture, pollination, nutrient cycling, natural pest regulation) through an ecosystem approach[2] provides options to farmers for optimizing their production and achieve long-term, sustainable agriculture (Box 1).

Box 1: Agricultural practices for sustainable crop production intensification, through an ecosystem approach

A list of conventional inputs to agriculture would typically include seed, fertiliser, land, water, chemical or bio- pesticides, and animal, mechanical or solar energy as well as labour. However, it has long been recognized that inputs merely 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.[2] Farmers that utilize better information and knowledge on the supporting biological processes can help to boost the efficiency of use of conventional inputs. Some examples of agricultural practices/adapted production systems that are based on biological processes and that manage ecosystem services to improve productivity and reduce environmental impact through an integrated, ecosystem approach include integrated plant nutrient management (IPNM), integrated pest management (IPM), conservation agriculture (CA), organic agriculture, crop-livestock systems, agro-forestry systems, integrated weed management as well as pollination management.

Recent trends would indicate that cultivation practices are undergoing a shift from dependency on non renewable inputs and from chemical-based intensification to forms of biological intensification and other emerging technologies that draw on biodiversity and natural resources and environmentally friendly ecological processes to increase the productivity of ecosystem services (Box 2). The incorporation of scientific principles of ecosystem management into farming practices, such as Conservation Agriculture and/or Integrated Pest Management, has shown that intensified crop production (yield) can be intensified through sustainable management of ecosystems (see figure 2).

Figure 2: Increased yields for corn and soy with reduced fertilizer use in Frank Dijkstra Farm, Ponta Grossa, Brazil (from 1977-1998)



Source: http://www.act.org.zw/docs/actis02.pdf

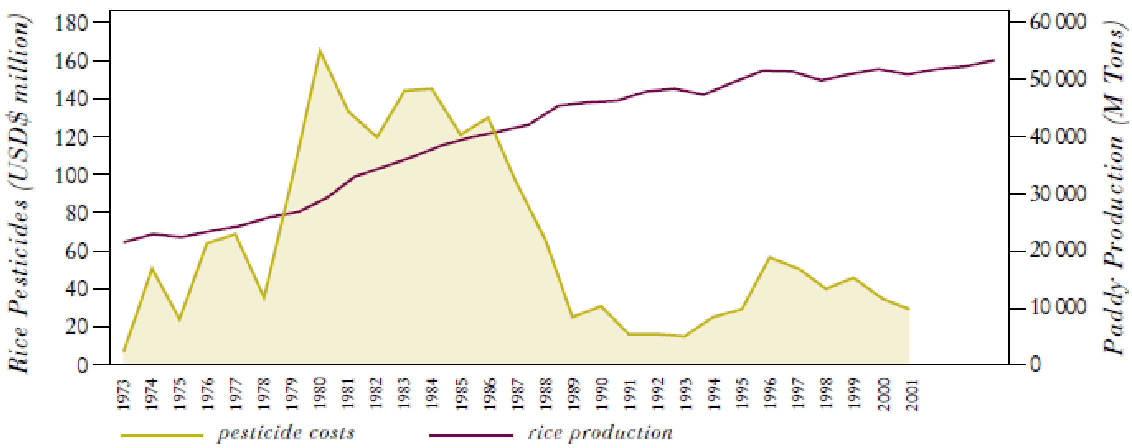
[2] FAO. *Increasing crop production sustainably: the perspective of biological processes*. November 2009.

If sustainable crop production intensification is to be achieved through an ecosystem approach, a "matrix-style" vision needs to be taken. This would involve consideration of the following axes: time (e.g. long-term sustainability) and space (e.g. agricultural landscape and farm scales); range of stakeholders including decision makers to farmers (their role and objectives); agricultural practices, approaches and technology options; training, capacity building and awareness raising (e.g. through Farmer Field Schools or other participatory learning mechanisms); and a conducive policy environment (from international to local policy).

Box 2: Intensification of crop production while reducing the negative environmental externalities

In agricultural practices, approaches and technologies that aim towards sustainable crop production intensification, biodiversity and ecosystem services are managed in such as way to express their full potential, while external agricultural inputs are used as a last resort and with careful selection and dosage to avoid disruption of the local agro-ecosystem. This allows reaching, the objective of increased yields but at the same time contributing to long-term environmental sustainability, and increased farmers' profits. The following graph illustrated the increase in yield production in Indonesia, while the application of pesticides has dropped significantly, due to adoption of IPM.

Figure 3: Yield increase in Indonesia versus the costs of pesticides (1973-2001)



II. TOWARDS SUSTAINABLE CROP PRODUCTION INTENSIFICATION

A. OBJECTIVES OF THE FRAMEWORK FOR SUSTAINABLE CROP PRODUCTION INTENSIFICATION

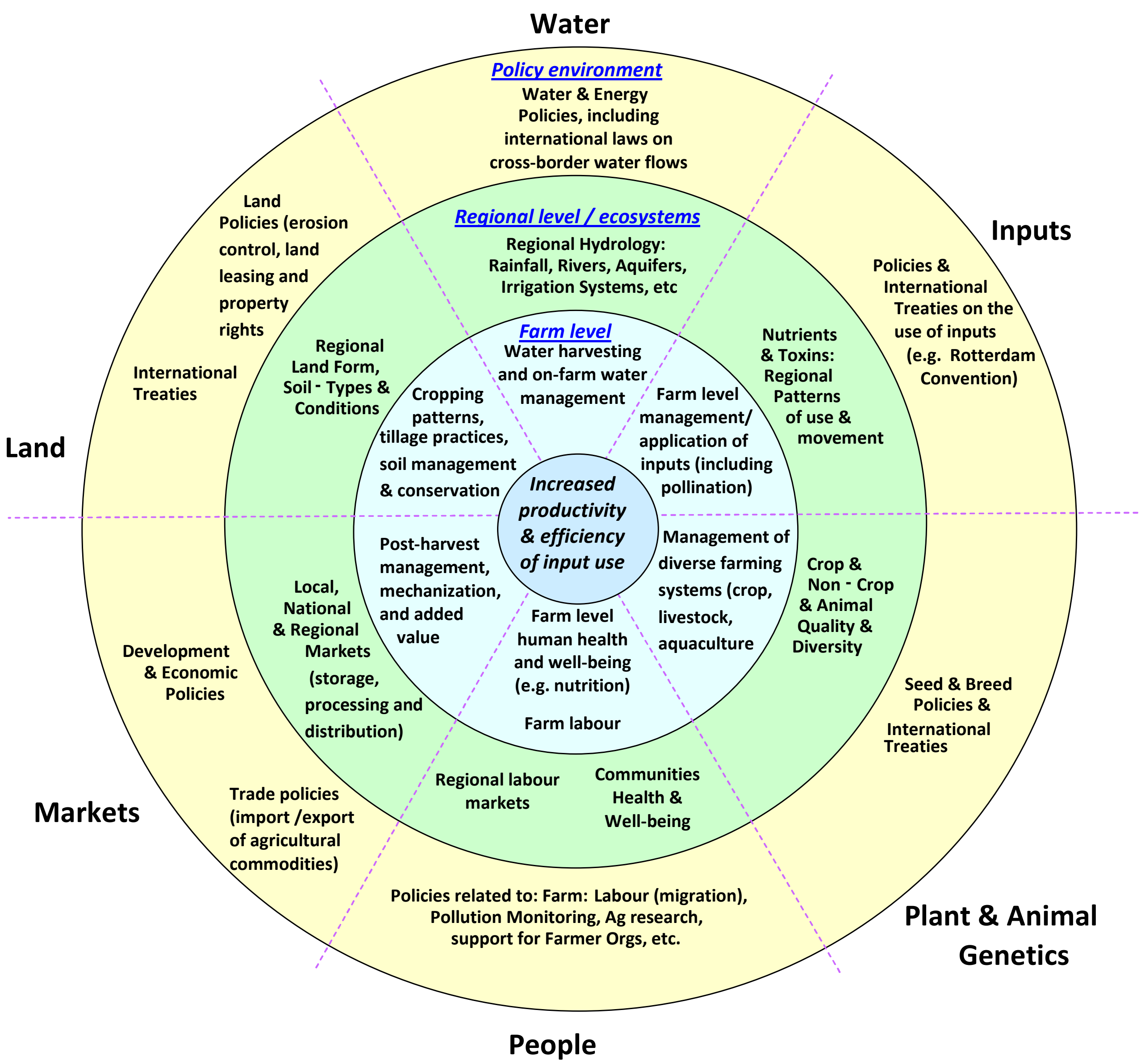
The main objectives of developing a Conceptual Framework for sustainable crop production intensification are to:

1. Increase understanding of the importance of biodiversity and ecosystems, and their sustainable management;
2. Identify options available for sustainably increased crop production; and
3. Provide guidance for decision makers at different levels (from land users to policy makers).

The Conceptual Framework also provides the context for developing tools that include guiding principles, checklists (Annex I), indicators and case studies for use in developing policies, programme and projects. The Conceptual Framework is intended to be flexible, to adapt to evolving situations, new scientific evidence and to incorporate valuable experiences from traditional knowledge.

An illustrated example of how the Conceptual Framework can be addressed within a crop production system can be seen through a quick aerial overview of an abstract production environment as presented in Figure 3. This figure can be used as a simple tool for organizing discussions and especially to allow facilitators to pull a discussion back to the overview level rather than focusing on detailed levels. Here, the circles suggest cross-cutting topics: the inner circle comprises farm-level factors; the mid-circle comprises the regional level (ecosystem boundaries or watershed-level factors); and the outer circle refers to national policy dimensions.

Figure 4: Sustainable crop production intensification overview.



The outer circle provides the policy context, on international, national and sub-national level, that impact on the ecosystem/watershed and farm level; the farm level is based on the local ecosystem. Working towards sustainable crop production intensification will require action in all different levels; from international treaties to training in farmer field schools (FFS). Annex II provides a possible decision matrix/ thematic framework for crop-related work by FAO Regional/Sub-Regional Offices.

B. WHAT IS MEANT BY "SUSTAINABLE CROP PRODUCTION INTENSIFICATION"?

Simply put, sustainable crop production intensification aims to increase crop production per unit area, taking into consideration all relevant factors affecting productivity and sustainability, including potential and/or real social, political, economic and environmental impacts. With a particular focus on environmental sustainability through an ecosystem approach, sustainable crop production intensification aims to maximize options for crop production intensification through the management of biodiversity and ecosystem services.

Five major dimensions can affect yields, therefore these need to be considered for sustainable crop production intensification. These factors can be classified according to their nature and the degree to which they contribute to the gaps:

- *Biophysical*: climate/weather, soils, water, pest pressure, weeds
- *Technical/management*: tillage, variety/seed selection, water, nutrients, weeds, pests, and post-harvest management
- *Socio-economic*: socio-economic status, farmer's traditions and knowledge, family size, labour/farm power availability, household income/expenses/investment
- *Institutional/policy*: government policy, prices, credit, input supply, land tenure, market, research, development, extension
- *Technology transfer and linkages*: availability, competence and facilities of extension staff; integration among research, development and extension; farmers' attitude towards new technology; knowledge and skills of decision makers (from farmers to policy); weak linkages among public, private and non-governmental extension staffs.

C. KEY DIMENSIONS OF SUSTAINABLE CROP PRODUCTION INTENSIFICATION

To address the global challenges described in the introductory section, this Conceptual Framework promotes crop production intensification using the ecosystem approach, including technical and policy considerations in four key dimensions: a) increasing agricultural productivity; b) enhancing sustainable crop protection; c) managing biodiversity and ecosystem services; and d) strengthening livelihoods.

i. Increasing agricultural productivity

Increasing agricultural productivity is, under normal circumstances, a challenge – today, with global issues such as soaring food and fuel prices, climate change, increased poverty and growing populations with an increasing trend towards urbanisation, this is even more so. In the past, increasing agricultural production with little or no consideration for long-term environmental sustainability led to negative consequences such as degraded land and a reduction of ecosystem services. In turn, these environmental consequences have negative repercussions on the ability of agro-ecosystems to produce desired quantities of safe and quality foods.

Increasing agricultural productivity can happen through improved use and management of agricultural biodiversity resources (such as seeds, pollination, beneficial fauna, etc), to achieve higher yields while promoting the sustainability of the farming systems and progressing from subsistence farming to market-oriented agriculture. This will also contribute to implementing adaptation strategies for climate change (Box 3).

From an agricultural landscape perspective, sustainable crop production intensification should identify good farming practices (for example, no-tillage and soil recuperation strategies, genetic diversity selection and utilization, etc), but also assess the surrounding and wider (global/regional) environments and related environmental events (this is particularly true for events that result from climate change, such as predisposition to drought, floods, temperature increases, etc). At the wider environment level, and especially in light of climate change, it is important to evaluate mitigation and adaptation measures not only to deal with potential effects of environmental stress, but also to contribute to their mitigation (e.g. through increased carbon sequestration).

Box 3: Adapting to climate change – the role of seed systems

Seed is one of the most crucial elements in the livelihoods of agricultural communities. It is the repository of the genetic potential of crop species and their varieties resulting from the continual improvement and selection process over time. The potential benefits from increasing the use of quality seeds of a diverse range of crop species and varieties within cropping systems by farmers are widely acknowledged as it increases food and nutritional security through improved system resilience, crop productivity and nutritional value. In addition to food security, however, the critical importance of the contribution of seeds to climate change adaptation cannot be underestimated. For example, the genetic diversity contained in seeds provides options for crop improvement, as well as choices for farmer adaptation strategies.

Strategies are needed to facilitate the adaptation of agriculture systems to climate change through better management of crop species and varieties. Agricultural diversification, crop and variety relocation, based on mapping agro-ecological zones and variety characterization, will be necessary to provide farmers with the germplasm (landraces and modern varieties) adapted to shifting agro-ecologies. Intensification of plant breeding activities will also be required to develop varieties adapted to changing agro-ecologies. Improved ways of transmitting information about crop variety adaptation through market and non-market channels are needed as well. These approaches will require countries to develop policies to ensure effective development and transfer of adapted varieties and information to and from farmers through effective seed delivery systems.

ii. Enhancing sustainable crop protection

Increasing agricultural production has a number of implications, amongst which is ensuring that crops are safe – both during their production and consumption. Crop protection is a critical aspect of production, and it has been shown that indiscriminate use of pesticides is no longer viable. The over-use of pesticides has impacts on crop-associated biodiversity, as well as on human health (of the farmers as well as the consumers). Integrated Pest Management (IPM) is an ecological approach to managing pests, and is an example of the use of biodiversity and management of ecosystem services to not only improve crop production, but also ensure its sustainability. IPM is based on a good understanding of the local agroecosystem for appropriate decision making; therefore capacity building for extension staff and farmers is an essential component of its success.

At the policy level, crop protection is addressed through the implementation at national level of globally agreed instruments such as the International Plant Protection Convention, the Rotterdam Convention, the International Code of Conduct on the Distribution and Use of Pesticides, the Convention on Biological Diversity and the International Treaty on Plant Genetic Resources for Food and Agriculture. Indeed, global and regional instruments, treaties, conventions and codes are essential to 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 in an increasingly globalising world.

At the national level, policies related to a number of sectors could have an impact on sustainable crop production intensification – for example: agriculture, environment, health, infrastructure, finance and planning. Relevant national policies could include agricultural development plans, poverty eradication strategies, agricultural biodiversity programmes, biodiversity action plans, and so forth. Good collaboration between policy, research and field level actors can enhance the achievement of sustainable crop production intensification at national level.

iii. Improving the efficiency of inputs

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 resources in agriculture. This will help to increase to farmers' net incomes and will also be at lower environmental and/ or social cost, hence delivering both private as well as public benefits.

While increased production can be achieved by increasing use of inputs (up to a point – in specific cases overuse of inputs can suppress ecosystem services, reduce productivity and harm the environment), the desired result may be achievable at lower cost through higher efficiency in the use of existing inputs. The aim becomes to capture greater yield per input-unit, to capitalize on the benefits of planned integrated production systems (such as crop-livestock-tree-fish), minimize negative impacts on landscapes and the environment and reduce, for instance, leakages and losses from the agro-ecosystem of nutrients, water and agrochemicals that can cause *in situ* and downstream pollution.

iv. Managing biodiversity and ecosystem services

The management of biodiversity and ecosystem services is at the crux of sustainable crop production intensification. It involves the identification and use of mechanisms for valuing agricultural biodiversity and ecosystem services (such as pollination); in addition to sound agronomic practices (crop, soil, nutrient and water efficient management).

From a broader perspective, managing biodiversity and ecosystem services also involves the scientific understanding that biodiversity and ecosystems can be considered as agricultural inputs for crop production but with the additional benefit of long-term environmental sustainability. It also involves scientific knowledge of ecosystem functions and assessments of biodiversity - and their interactions - within and around the agro-ecosystem. Further training and capacity building in managing biodiversity and ecosystem services play an important role. Here, farmer led participatory learning concepts like Farmer Field Schools can be effective mechanisms for uptake of such knowledge intensive practices.

v. Strengthening livelihoods

Sustainable crop production intensification is not only about production and protection within the context of a healthy environment, but has a further-reaching element of socio-economic sustainability. Sustainable crop production has impacts along the production chain, from the farmer to the market and ultimately to the consumer. Farmers in particular – in their role of producers, custodians of biodiversity, vendors and consumers – are the primary beneficiaries of sustainable livelihoods through crop production.

Strengthening livelihoods can be achieved by using the benefits of increased productivity and diversification within the value chain, including through providing the conditions for access to good farming practices and knowledge, quality seeds and other production inputs, post-harvest and agro-processing technologies, food safety systems, markets and credit.

III. EXAMPLES OF GOOD FARMING PRACTICES FOR SUSTAINABLE CROP PRODUCTION INTENSIFICATION

Sustainable crop production intensification can be achieved though good farming practices which follow ecosystem-based approaches designed to improve sustainability of production systems. They aim at meeting consumer needs for products that are of high quality, safe and produced in an environmentally and socially responsible way.

Good farming practices in biodiversity and ecosystem management for sustainable crop production intensification are principally applied at a local scale, and refer to agricultural management practices, approaches and technologies that can be used to produce high yields of crop, while maintaining and/or enhancing environmental sustainability. A range of options (short descriptions of which are presented below) exist for good farm management practices, approaches and technologies that sustainably utilize biodiversity and manage ecosystem services to maintain and/or improve the environment, and ensure sustainability, while at the same time improve crop production. In order to achieve true systems sustainability, these examples addressing different parts of agricultural crop production must be used together, complementing each other and not as alternatives. Any single "good agricultural practice" in isolation will not achieve the overall goal of sustainable intensification. Examples of good agricultural practices include:

A. Conservation and sustainable use of plant genetic resources for food and agriculture

Varieties need to be adapted to local conditions. Farmers in developing countries have typically tended to rely on traditional channels to procure local seed varieties. When conditions remain stable this is an efficient system. However, as conditions change (for instance in regions affected by decreasing rainfall or disease pressure) traditional varieties may no longer be the most suitable or efficient at using available rainfall, nutrients, etc. 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 plant genetic resources for food and agriculture is necessary to ensure crop production and meet growing environmental challenges and climate change. The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) provides the international arena where these matters of importance for food security are discussed.

B. Conservation Agriculture

Conservation Agriculture (CA) is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or disrupt, the biological processes (Figure 4 provides an illustration of the positive consequences of no-tillage on wheat yield). CA is characterized by three principles which are linked to each other namely:

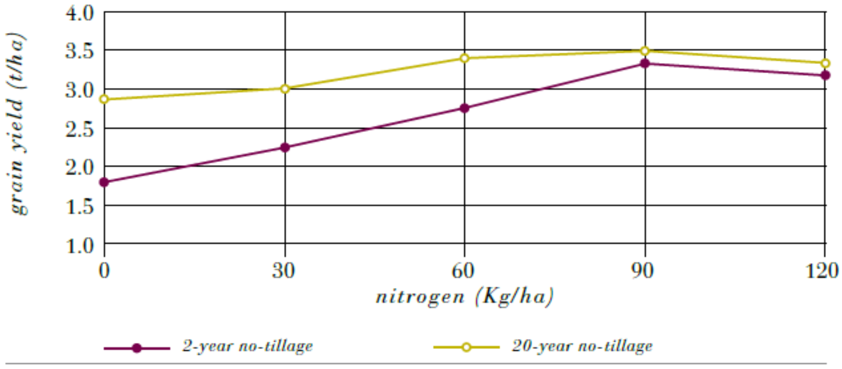
1. Continuous minimum mechanical soil disturbance and direct seeding.

2. Permanent organic soil cover.

3. Diversified crop rotations in the case of annual crops or plant associations in case of perennial crops.

(CA) practices can create stable living conditions for micro and macro-organisms, providing a host of natural control mechanisms for the growth of crops, which result in significant efficiency gains. CA has proven to contribute to significant increases of crop production (40-100%) with decreasing needs for farm inputs, in particular power and energy (50-70%), time and labour (50%), fertilizer and agrochemicals (20-50%) and water (30-50%). 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.

Figure 5: Wheat yield and nitrogen amount for different duration of no-tillage in Canada 2002

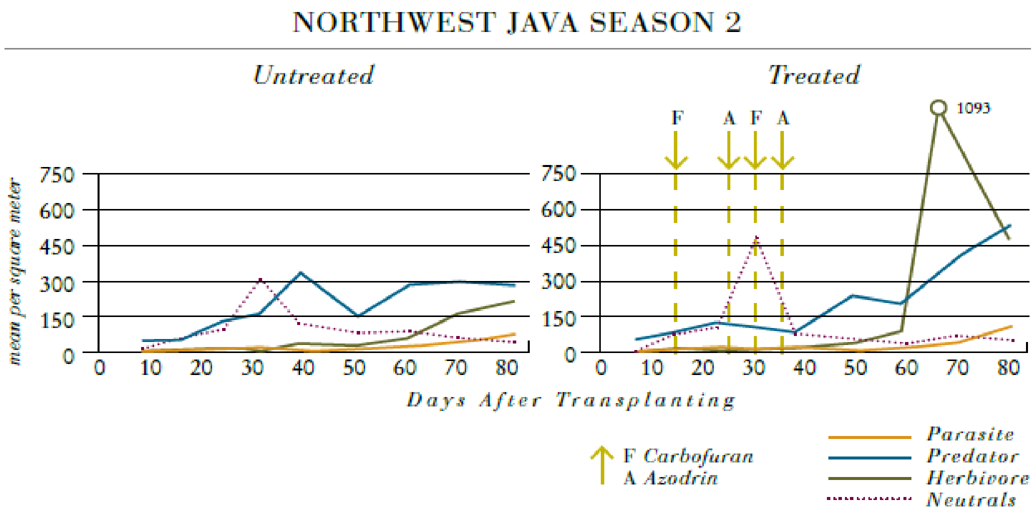


Source: http://www.topcropmanager.com/content/view/4427/38

C. Integrated Pest Management

Integrated pest management is an example of an ecosystem-based production practice within the context of an ecosystem approach. It involves the scientific application of ecosystem principles for the management of pest populations, to avoid their build up to damage levels. IPM is based on sound understanding of the local agroecosystem and the mechanisms that regulate its balance. Its diffusion has been largely accomplished in several field programmes in different regions, through a farmer field school approach, which proved very effective to develop and implement IPM programmes in different crops and conditions, providing effective linkages to the farming communities for participatory testing and learning, and for farmer empowerment. National development policies in general and agricultural policies in particular are needed to support the mainstreaming of ecosystem-based principles and technologies along with other complementary practices in all types of rain-fed and irrigated agricultural systems including the various forms of organic and mixed farming systems. Figure 5 shows how application of pesticides increases the number of pests to a significant level later on in the growing season.

Figure 6: Increase in number of pests in Indonesia, when insecticides were applied



Long-term integrated pest management (IPM) experience shows that a conducive enabling environment (such as the introduction of a national crop protection policy or a national IPM programme) can reduce overuse of insecticides, which in turn promotes increasing biological means of pest control (natural predation), an ecosystem function. 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%, 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

Integrated plant nutrient management also contributes to pest management: stressed crops are more susceptible to disease and to the effects of pest attacks. Crops growing in poorly structured soil, under low nutrient conditions or with inadequate water supply or retention will be stressed. Responding to disease or pest attacks by applying pesticides is a costly symptomatic approach to a syndrome which is better addressed by improving the ecological conditions and systems within which the crops are cultivated. In addition, agricultural products with less pesticides residues are less risky to consume. The need to adopt a wider concept of nutrient use beyond but not excluding fertilizers results from several changing circumstances and developments. These are:

- The need for a more rational use of plant nutrients for optimizing crop nutrition by balanced, efficient, yield-targeted, site- and soil-specific nutrient supply.
- A shift from focussing on soil nutrient levels only to looking at nutrient balances in the soil and interrelation of different nutrients.
- A shift mainly from the use of mineral fertilizers to combinations of mineral and organic fertilizers obtained on and off the farm.
- A shift from providing nutrition on the basis of individual crops to optimal use of nutrient sources on a cropping-system or crop-rotation basis.
- A shift from considering mainly direct effects of fertilization (first-year nutrient effects) to long-term direct plus residual effects. To a large extent, this is accomplished also where crop nutrition is on a cropping-system basis rather than on a single-crop basis.
- A shift from static nutrient balances to nutrient flows in nutrient cycles. - A growing emphasis on monitoring and controlling the unwanted side effects of fertilization and possible adverse consequences for soil health, crop diseases and pollution of water and air.
- A shift from soil fertility management to total soil productivity management. This includes the amelioration of problem soils (acid, alkali, hardpan, etc.) and taking into account the resistance of crops against stresses such as drought, frost, excess salt concentration, toxicity and pollution.
- A shift from exploitation of soil fertility to its improvement, or at least maintenance.
- A shift from the neglect of on-farm and off-farm wastes to their effective utilization through recycling.

Production efficiencies are gained through the integrated nutrient management practices promoting combined use of mineral, organic and biological resources in a reasoned way 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 fertiliser use requires that correct quantities be applied (overuse of Nitrogen (N) fertilizer risks disrupting the natural N-cycle), and that the application method minimizes losses to air and/or water. Options exist for incorporating fertilizer into the soil directly (rather than broadcasting). Equally, plant nutrient status during the growing season can be better monitored using leaf-colour charts, and adaptively managing fertilizer application accordingly.

E. 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. As a consequence, but purely in terms of the crop production system, this extra water can be used for more transpiration or if transpiration demand is met, declared as a net saving that can be used outside the specific crop water system. In this sense, a water use efficiency gain is made within the specific cropping system that may also result in more biomass production per unit of applied water.

However, 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. Hence the approach to water use efficiency gains and productivity boost has to be well understood in terms of the cropping system and the overall impact on drainage systems, leaching requirements and groundwater circulation. Figure 6 shows the water productivity in maize, rice and wheat; water productivity is rising faster at lower yields. The highest potential is in areas under rain-fed agriculture

F. Pollination Management

In pollination management, good practices occur at a variety of scales: field, farm and landscape. At the field scale, pollinator-friendly practices include minimizing the use of farm chemicals, through organic production, integrated pest management, sound application techniques, and set aside areas or finding alternatives to agrochemicals. A reduction in the use of herbicides at least in parts of the field, as well as other pesticides, is recognised as having benefits for keeping pollinators in the crop fields. At the farm level, the way farmers organise different land uses across their farm can influence pollination services. For example, pollinator populations can be encouraged by conserving diverse cropping patterns in farms, for example by combining mixed cropping, including cove crops, kitchen gardens and agro-forestry systems, and providing habitat on their farms for bees. At the landscape level, areas of natural vegetation in close proximity to farmland are beneficial for crop production, and such habitat patches provide flowering resources and nesting sites that sustain pollinators.

As the Figure 7 shows, the ecosystem service provided by animal pollination can be considered an agricultural input which can have a high impact on yield of crops and also helps to ensure quality seed and fruit set, and contributes substantially to the global economy for horticultural crops. For example, a recent assessment of the contribution of animal pollination services to the global economy, places the total economic value of pollination worldwide at €153 billion, representing 9.5% of the value of the world agricultural production used for human food in 2005[3]. Those crops that depend on pollination services are high-value, averaging values of €761 per ton, against €151 a ton for those crops that do not depend on animal pollination. These figures do not include the contribution of pollinators to crop seed production (which can contribute many-fold to seed yields), nor to pasture and forage crops. Nor do these figures include the value of pollinators to maintaining the structure and functioning of wild ecosystems, important values that remain uncalculated.

Figure 7: Global crops and commodities and yield response to animal pollination

REDUCED BY MORE THAN 90%	REDUCED BY 40-90%	REDUCED BY 10-40%
Kiwifruit	Coffee (robusta)	Strawberries
Cherimoya	Cashew nuts	Sesame seed
Watermelon	Cardamom	Eggplant
Squash	Canola	Fava beans
Cocoa beans	Buckwheat	Coconuts
Vanilla	Blueberries	
	Apples	
	Mangoes	
	Avocados	
	Raspberries	
	Figs	

Source: Klein, A.-M. *et al.* 2007. Importance of pollinators in changing landscapes for world crops. Proc. R. Soc. Lond. B Biol. Sci. 274, 303–313

3 Gallai, N., Salles, J-M., Settele, J., Vaissière, B.E. 2008. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological Economics (doi:10.1016/j.ecolecon.2008.06.014)

IV. IMPROVING LIVELIHOODS THROUGH SUSTAINABLE CROP PRODUCTION INTENSIFICATION

Sustainable agricultural practices have to be accompanied with improved overall management of the ecosystem, so that the relevant biological processes can continue to provide their services for future generations. Conservation of, and restoration to, of a high level of agricultural biodiversity will help to improve the resilience of the farming systems and provide a good level of nutrition for the local communities. Improving the access to, and functioning of, local markets will help to raise the income of farmers. Agricultural products that are produced in a sustainable manner can be sold at a higher value than other products, providing an economic incentive for farmers for sustainable crop production intensification. Another option to improve livelihoods is by reducing the post-harvest losses that occur in the food chain. This can be caused by a lack of storage facilities, long distance to markets, and losses in the processing and distribution of goods.

V. FROM CONCEPT TO ACTION

For this conceptual framework to be of any practical value, it must assist FAO Regional and Sub-Regional Offices and FAO Country Offices in the formulation and implementation of their crops-related programmes for policy support and for capacity building in SCPI. It is with this in mind that this draft Conceptual Framework is being shared for inputs and comments with FAO Regional and Sub-Regional Offices and from FAO Country Offices.

This section will be developed further based on the hoped-for feedback and comments from the field offices. In particular, it would be useful to identify principles and decision elements that are important in the formulation of crop-related work plans that have a high degree of relevance to the needs of the member countries and offer a high probability of success with significant impact on local and national agricultural and economic development, food security and environmental services while at the same time respond to global challenges such as climate change, environmental degradation, resources scarcity, and increased cost of production.

A possible decision matrix and thematic framework for crop related work planning by FAO Regional/Sub-Regional Offices is provided in Annex II. This framework includes two sets of strategic elements for engagement and provision of FAO support to member countries, and three essential technical thematic dimensions of the crop-related conceptual programme framework at the regional level.

VI. CONCLUSION

In order to achieve sustainable crop production intensification, the full aspects of sustainability (social, economic, political, environmental) have to be considered as the overall context within which this must occur. At the technical level, a range of agricultural approaches, practices and technologies are available to increase production with a focus on environmental sustainability (see section III). These can be used in a complementary fashion, promoting an integrated system for crop production. Not only agricultural approaches have to be promoted in an integrated manner, but also other issues throughout the food chain that limit the uptake and impact of sustainable crop production intensification. Improving market linkages, reducing post-harvest losses and conserving agricultural biodiversity will help to improve the impact of farming practices; making the farming system more resilient and resulting in lower losses and a higher value of the products.

Global, regional and national instruments, treaties, conventions, codes and policy are essential for enhancing and sustainably using natural resources, but there is also the need to ensure that these are in line with, complement and do not contradict each other (sectorally and at the different levels). This means that changes in the overview of sustainable crop production intensification (figure 3), do not only result in changes towards the centre of the overview (e.g. a policy change in national water management will result in improved watershed management and thus more water on field level), but also in changes in the same level, where they have to complement each other (e.g. a policy change in water management has to be in line with, and preferably even improve, the policy regarding land).

Achieving sustainable crop production intensification through an ecosystem approach – and indeed promoting the trend from non-renewable external agricultural inputs towards biological inputs (through the management of biodiversity and ecosystem services), is what this Conceptual Framework attempts to achieve. However, promoting and implementing this trend is an evolving process, during which experiences will be gained, more case studies will be collected, monitoring and indicators will be put in place, and ultimately, the economic benefits seen in terms of greater crop yield will become increasingly evident.

ANNEX I: GUIDING PRINCIPLES AND ASSOCIATED CHECKLIST FOR SUSTAINABLE CROP PRODUCTION INTENSIFICATION

In order to address the broader goals of sustainability in crop production intensification, social, economic and environmental aspects need to be considered when planning to intensify crop production.

To this effect, a set of guiding principles are provided to address the multiple dimensions of sustainability - the point of these guiding principles is not to set up an unattainable list of ideals, but rather help design a basis against which to assess the current status and to measure future changes. A tool that has been developed to assist in assessing the guiding principles for sustainability of crop production intensification is a short checklist associated to each element of sustainability – again, the aim of the checklist is to provide guidance and is not an exhaustive list of possible questions

GUIDING PRINCIPLE 1 - SOCIAL AND POLITICAL

1. LAWS AND POLICIES: Appropriate policies must be implemented to promote sustainable crop production intensification, respecting all applicable laws of the country in which they occur, and all international treaties, conventions and agreements to which the country is a signatory.
2. FOOD SECURITY: Sustainable crop production intensification should contribute to the goals of Food Security and be consistent with national programmes on Food Security.
3. HUMAN AND LABOUR RIGHTS: Sustainable crop production intensification must respect human and labour rights by promoting: decent and fair work and the well-being of farmers and agricultural workers along the agricultural value chain; and fair and decent distribution of labour between genders.
4. HUMAN HEALTH: Sustainable crop production intensification must contribute to human health by ensuring that: agricultural practices are carried out under safe conditions; inputs used in agricultural production have the least possible negative impact on human health; and result in agricultural produce of good nutritional quality and accepted safety standards.
5. KNOWLEDGE CREATION AND VALIDATION. Sustainable crop production intensification must facilitate a process that promotes continuous learning and exchange of knowledge between different actors (from local indigenous to scientific knowledge) and disciplines (from technical to social domains).
6. COLLABORATION: Sustainable crop production intensification is of multidisciplinary nature and therefore an opportunity for strengthening collaboration between different sectors, institutions and their development priorities and agendas. In addition, sustainable crop production intensification must engage as far as possible different segments of society[4].
7. COMMUNITY PARTICIPATION: Sustainable crop production intensification must include open and transparent discussion among communities and other stakeholders in order to solve shared problems and arrive at decisions to increase opportunities for production.

[4] Including land users, researchers, academia, government, farmer/ community organizations, non-governmental bodies and the private sector.

CHECKLIST 1 - SOCIAL AND POLITICAL SUSTAINABILITY

Is the envisaged crop production intensification likely to:

1. Contribute to increasing understanding, through a policy analysis/review, of congruent/conflicting laws and policies?
2. Contribute to the implementation of a national Food Security Programme?
3. Enhance food security in terms of self-reliance and self-sufficiency, food availability, quality and safety of food, stability of food supply, and / or food affordability?
4. Contribute in alleviating poverty for a significant portion of the rural poor population?
5. Ensure that potential human health hazards do not occur?
6. Establish or support institutional mechanisms (policy, legislation, regulations, commissions and institutions) which ensure stability of medium and long-term efforts?
7. Allow and encourage people's participation, women in particular, in decision-making that directly or indirectly affects them?
8. Increase local, national, regional and international understanding and knowledge of sustainable crop production intensification processes?
9. Improve local management and technical capabilities?
10. Involve all relevant stakeholders in development, introduction and establishment of agricultural approaches, practices, and technologies choices?

GUIDING PRINCIPLE 2 - ECONOMIC

8. LIVELIHOODS: Sustainable crop production intensification must constitute an option to improve living conditions in rural areas by providing alternative livelihoods throughout the value chain, wider access to markets and a better income while contributing to the preservation of the resource base.
9. MARKETS: Sustainable crop production intensification should contribute to the economic development of farming communities and seek to stimulate local economies through understanding and development of local, national and regional markets

CHECKLIST 2 – ECONOMIC

Is the envisaged crop production intensification likely to:

1. Lead to profitability, livelihood support?
2. Consider economic dimension – input/output and support a better understanding of market and farm management options among farmers and communities?
3. Facilitate the development and uptake of agricultural approaches, practices, and technologies including mechanization in an integrated way, i.e. embedded in market driven economy and supported with knowledge creation/dissemination and provision of services?

GUIDING PRINCIPLE 3 - ENVIRONMENTAL

10. ECOSYSTEM FUNCTION: Sustainable crop production intensification must not impair, but stabilize or enhance ecosystem structure and function, thereby leading to improved ecosystem services[5] to increase opportunities for production.

[5] Ecosystem services can be: provisioning (e.g. food, fibre and fuel, genetic resources, biochemicals, fresh water), regulating (e.g. invasion resistance, pollination, seed dispersal, climate regulation, pest regulation, disease regulation, erosion regulation, natural hazard regulation, water purification); supporting (primary production, provision of habitat, nutrient cycling, soil formation and retention, production of atmospheric oxygen, water cycling); and cultural (e.g. spiritual and religious values, knowledge system, education and inspiration, recreation and aesthetic values).

11. SOILS: Sustainable crop production intensification must be managed to enhance soil ecosystems, improving soil health and fertility and reversing degradation and pollution of land.
12. WATER: Sustainable crop production intensification must contribute to maintaining and improving, and efficiently utilizing, water resources (quantity, access, stability and quality), especially promoting practices that minimize risks of water pollution from agrochemicals.
13. BIODIVERSITY: Sustainable crop production intensification must respect the integrity of areas of high conservation value, and enhance the management of agricultural biodiversity (e.g. plant genetic resources for food and agriculture, seeds, pollinators, soil biodiversity, natural enemies as well as wildlife).
14. CLIMATE CHANGE AND AIR QUALITY: Sustainable crop production intensification must be managed to increase adaptation to climate change, reduce greenhouse gas emissions and ozone-depleting substances to a minimum possible and seek to minimize contributions to air pollution and reductions in air quality.
15. ENERGY AND WASTE MANAGEMENT: Sustainable crop production intensification must be managed to ensure reduction in fossil fuel-based inputs, efficient application of energy and energy-based inputs, recycling of waste and the use of appropriate renewable energies where possible. It should promote appropriate waste management, safe storage of agricultural inputs, minimize non-usable wastes and dispose of them responsibly.

CHECKLIST 3 – ENVIRONMENT

1. Do you have management plans for soil, water, biodiversity, climate change, energy, waste management?
2. Does the envisaged crop production intensification use agricultural approaches, practices and technologies that will:

   Ecosystems/Biodiversity

   a. Conserve and/or enhance ecosystem structure and functions, leading to the improvement of ecosystem services and for its sustainable management to increase opportunities for production?
   b. Consider the sustainable management of ecosystem services to increase opportunity for production?
   c. Reduce negative impacts on crop and crop-associated biodiversity, soil, water and air quality through the use of appropriate agricultural approaches, practices and technologies management?
   d. Introduce preventive measures that reduce degradation and depletion of natural resources, protect natural ecosystems and biodiversity, protect human health and reduce risk?
   e. Adhere to established standards or codes of good farming practices for the use of technologies and inputs?
   f. Minimize negative impact of the production sites on the surrounding ecosystems and maximize the positive impact of use and management of the surrounding ecosystems on the production site?
   g. Protect High Conservation Value areas, native ecosystems, ecological corridors and other biological conservation areas?
   h. Occur in high productivity regions?
   i. Enhance the management of agricultural biodiversity?
      a. Seeds
      b. Plant genetic resources

c. Soil biodiversity
d. Pollinators
e. Natural enemies

Soil Health and Productive Capacity

j. Implement soil management practices that seek to improve soil health?
k. Enhance soil organic matter content to its optimal level under local conditions?
l. Enhance the physical, chemical, and biological health of the soil to its optimal level under local conditions?
m. Increase the efficiency of input use, particularly fertilizers and reduce emissions into the environment in solid, liquid or gaseous form?
n. Minimize the use of non-renewable energy and improves overall energy efficiency (including the use of nitrogen fixing crops/organisms to reduce mineral N fertilizer use)?
o. Manage wastes and byproducts from processing units such that soil health is not damaged?

Water Use and Productivity

p. Be water use-efficient by promoting crops and cultural practices that are more efficient under local conditions or by promoting the efficient use of water resources, including the modernization of irrigation schemes if appropriate?
q. Improve the efficiency of available water resources?
r. Not directly or indirectly contaminate or deplete water resources, or violate existing water rights both legal (formal) and customary?
s. Include a water management plan appropriate to the scale and intensity of production?
t. Enhance the quality of water resources to their optimal level under local conditions?

Pest Management

u. Reduce the reliance on chemical pest control agents for pest management, using an ecosystem approach such as IPM?

Air

v. Use low energy consumption agricultural approaches, practices and technologies or promote bioenergy sources?
w. Reduce GHG emissions and air pollution including dust, contributing to improved air quality?
x. Enhance the quality of air to its optimal level under local conditions?
y. Affect neither ecosystems surrounding the production site nor human populations?
z. Minimize air pollution from machines used along agricultural value chain?
aa. Establish input-output plans for farm energy, nutrients, and agrochemicals to ensure efficient use and safe disposal?

Waste

ab. Address waste issues related to:
- energy
- mechanization
- external inputs (e.g. fertilizers, pesticides)?

ANNEX II: A DECISION MATRIX AND THEMATIC FRAMEWORK FOR CROP-RELATED WORK PLANNING BY FAO REGIONAL/SUB-REGIONAL OFFICES

The FAO Regional and Sub-Regional Vision and Strategy frameworks generally call for *inter alia* supporting and accelerating the ongoing transformation and modernization of agriculture for development, to include its contribution to local and national food security and rural livelihoods, to national and regional economic growth and development, and to the provision and protection of ecosystem services.

The sustainable crop production intensification (SCPI) framework calls for intensification based on using an ecosystem approach, and is characterized by four dimensions: (i) increase in crop productivity (both outputs and efficiencies), (ii) supported by enhanced crop protection, and (iii) management of biodiversity and ecosystem services, and (iv) all within the context of strengthening rural livelihoods. The ecosystem approach forms a defining basis for good farming practices to be promoted within crop sector development strategies and whose principles can be adapted and integrated into local production practices to generate the desired production growth and productivity gains with sustainability.

Thus, the field-based crop-related work plans must take into account: (a) the prioritized national crop commodities and their development policies and strategies (based on the specific needs, potentials and opportunities); (b) the various national agricultural development and implementation plans and ongoing programmes and projects; (c) the Vision and Strategy frameworks of the FAO Regional and Sub-Regional Offices that define what role FAO should play to provide policy and technical support, and where does it have a high impact comparative advantage; (d) the SCPI framework for alignment with FAO's normative agenda; and (e) the need to contribute to FAO's global agenda.

The contribution of the crops sector to the above strategy is largely through increased production (total output) to meet domestic and export demand through economically and environmentally viable levels of factor productivities. While yield is the key output indicator of productivity (land productivity), economic viability, competitiveness and ecological sustainability including issues of food safety, and the development context or relevance of FAO's crop-related activities in the field will depend on a decision matrix involving *inter alia* the following two sets of strategic elements for engagement and provision of FAO support to member countries:

Set 1: The importance of priority crop commodities within the national crop sector development strategies including which crop commodities and products, what polices, investments and programmes are in place and/or planned on the different development aspects of the commodities including, and in collaboration with appropriate FAO Regional/Sub-Regional Office experts, FAO country staff, national and international stakeholders in the public, private and civil sectors, and HQ staff etc:

(i) **the nature and size of demand, both population and livestock driven non-market local/national demand as well as effective market demand** (e.g., local, non-local domestic or national, and/or regional or international -- primary commodities for bulk delivery, processed for local and distant domestic markets; bulk or processed for export, or niche markets, national and international etc);

(ii) **in which agro-ecosystems and geographical regions** (e.g., lowlands vs highlands; rainfed vs irrigated; humid, sub-humid, semi-arid or arid moisture regimes). This would involve practical level land use maps of major commodities and their possible future potentials;

(iii) **for what types of farmers and enterprises** (e.g. small scale vs large scale; fully commercial or part subsistence; whether organized into associations or not; whether within growth corridors involving contract farming or not; whether in marginal areas etc);

(iv) **for which type(s) of production system(s)** (e.g., tillage-based or conservation agriculture based crop (including pastures) systems, organic farming, agro-forestry etc); and how are they being managed and serviced (e.g., cropping system including integration with trees and livestock, types of farm power, production inputs and services etc);

(v) **for which good farming practices** (e.g. CA, IPM, IPNM either individually or in combination, and integration with livestock and agro-foresty etc) and the underpinning principles and opportunities for synergies among production chains, e.g. crops for feed to enable competitive livestock sub-sector development; with what impact on productivity, production and livelihoods (e.g., increased yields and incomes, improved factor productivities, labour and cost savings, changes in ecosystem services, climate change adaptability and mitigation, etc); and with what implications on input supply (including equipment and machinery, training, equipment manufacturing, incentives) and output value chains and services (e.g., storage, value added food processing, marketing etc)

FAO Regional/Sub-regional Offices should have the competence **to provide strategic policy and technical advisory support for correct decision-making to** member governments on all the strategic elements above through its crop related expertise as well as its collective team expertise, and facilitate effective development of policy, investments and programmes in an overall sense as well as in any of the five elements elaborated above.

Set 2: The adequacy of national capacity (public, private and civil sectors) to implement the national crop sector development strategies, and where FSE's assistance would be justified (based on the need and its comparative advantage consistent with its role and objectives) including, and in collaboration with appropriate FAO Regional/Sub-Regional Office experts, FAO country staff, national and international stakeholders in the public, private and civil sectors, and HQ staff etc:

(i) **policy, investment and development management support** (assist in implementation planning including the identification of agro-ecosystems and geographical areas of greatest potentials and impact; programme and project formulation support etc);

(ii) **development of and access to input supply markets and delivery services** (see as elaborated for Theme 3 below)

(iii) **development of and access to output value chains and delivery services**

(iv) **the strengthening of the innovation systems** as applicable to the differentiated production systems (as elaborated in (a) above) including differentiated farmer empowerment approaches and infrastructure to support ongoing and planned crop sector development including the knowledge and information, research, extension and training, and education capacity and capability for generating "proofs of concepts" for SCPI and momentum for scaling;

(v) **the development of technical capacity to identify and manage risks and mitigate new threats to development** such as those related to climate change, extreme climate events, invasive species of weeds, insect pests and diseases;

(vi) **the national capacity to meet FAO related international and global obligations** [e.g. IPPC, RC, GPA-PGRFA etc].

FAO field offices should have the competence **to provide strategic programmatic policy and technical support to member governments to strengthen national capacity** on all the six strategic elements in Set 2 above through its crop related expertise as well as its collective team expertise, and facilitate capacity building in an overall sense as well as in any of the six elements elaborated above.

<u>Possible areas for inclusion in the FAO Regional/Sub-Regional Offices' work plans on crop-related activities:</u>

The areas of immediate addition to crop work plan of FAO field offices must be defined at two levels as follows. The first level is the crop-related conceptual framework of essential and interlinked broad themes that can address the broad objectives set by the Vision and Strategy frameworks of the FAO Regional/Sub-regional Offices. The second level is the specific crop programmatic activities within each thematic area that can deliver specific objectives and take into account the elements of the decision matrix described above in (Set 1, elements i-v) and (Set 2, elements i-vi) plus other relevant elements such as what is already ongoing and in the pipeline, and what is happening in the areas that are under complex emergencies and those that are in the post-conflict or post-crisis areas where opportunities and need for rehabilitation of productivity and livelihoods are emerging and require to be supported by the FAO Regional/Sub-regional Offices in liaison and collaboration with FAO Emergency and Rehabilitation Programmes.

It is important that the crop-related conceptual programme framework is formulated by each FAO Regional/Sub-Regional Office and put in place so that the prioritized and selected crop-related activities can be justified and supported. The three essential technical thematic dimensions of the crop-related conceptual programme framework at the regional level are as follows:

Theme 1: Support to national crop sector development strategies (Productivity focus, with support from Policy and Investment focus): There will be a variety of development tracks (and emerging opportunities) in a given nation contributing to the transformation of the overall agriculture and rural sector for development. Support is needed for national policy and operational planning and implementation management across input supply-production-output value chain for niche and bulk commodities and products for domestic and export markets. The crop sector strategies will help decide the kinds of development schemes that will be involved in the short and longer term, and the various constituencies involved within the schemes or area development strategies, e.g., growth corridors, vs peri-urban development vs incremental development etc.

The focus of the crop-related activities should be the provision of support to enhance the formulation and management of national crop sector strategies for sustainable production and productivity enhancement components consistent with national development goals and opportunities, and the crop expert in the FAO regional/Sub-Regional teams must work in collaboration with policy and investment experts, and to some extent also with NRM & Capacity Building experts. Regional and Sub-Regional Offices will need to provide ongoing support at the policy and strategy level.

In this regard, (a) the contribution that can be made by good farming practices such as CA in combination with IPM and IPNM to productivity, food security, livelihoods and economic growth, ecosystem services, production and environmental cost reduction, enhancement of the land and water resource base, climate change adaptability (both adaptation and mitigation) as well as for rehabilitation of degraded and derelict lands, and (b) how CA, IPM and IPNM principles and practices can be integrated into transforming the national production systems, becomes the justification for policy and investment advocacy and resource allocation, programme and project formulations, collaboration and partnerships. These can also become the justification for integrated crop-livestock-tree development, especially for the mixed farming systems of small holders, and for growth corridor development for crop commodities that are of national priority for food security, for both import substitution and export, or for export etc.

These *national* strategies based crop-systems will form the building bocks of the development of the *regional* crop sector strategies, and will define the information and database processing needs for FAO's sub-national, national and regional programme intervention and planning, and for Vision and Strategy reviews and evolution. Set alongside similar activities in the livestock, forest & tree, fish and aquaculture sectors, and the cross-cutting NRM and Capacity Building, FAO Regional/Sub-regional offices will establish the development-oriented strategic information base for various policy and programmatic applications with member governments as well as for internal purposes. This activity would need to be developed and implemented in consultation with FAO country offices and national ministries and institutions in the countries.

New activities for the policy and investment support focus can be formulated by applying the conceptual framework comprising the six necessary elements in the decision matrix described above.

Theme 2: Integration of good farming principles and component practices such as CA, IPM or IPPM, IPNM into specific crop sector development programmes and projects for SPI, livelihoods and employment generation in prioritized farming systems (for the Productivity Pillar plus associated with Capacity Building and NRM focus).

Whether the agriculture production transformation is to occur within fast track structured situations e.g. specially designated growth corridors, irrigations development, or within peri-urban areas with reasonable growth conditions and infrastructure, or within incremental development situation with semi-subsistence small farmers or even with rangelands, the principles of conservation agriculture must for the core of FAO Regional/Sub-regional crop programme thrust to enhance productive capacity and raise production (output) and factor productivities.

For example, CA, IPM and IPNM apply to all farm size and all agro-ecological zones, and the CA practices have certain measure of built-in natural pest management elements (e.g., organic mulch and SOM to drive food webs, crop diversity for pest control) as well as integrated plant nutrient management elements (e.g., BNF, organic mulch & enhanced SOM/CEC, diversity of rooting systems, soil biota for nutrient mobilization, plus any inorganic source of nutrients). CA, IPM and IPNM practices therefore work with traditional as well as modern adapted varieties and cropping systems. This means that crop and cropping system agronomy can help harness production gains without necessarily replacing traditional varieties every time, thus helping to conserve agro-biodiversity and indigenous knowledge.

There are already successful CA and/or IPM projects in several countries across different regions. FAO Regional/Sub-regional Offices can build on these and help support the scaling process and spread, while initiating it in other areas including in the follow-up to FAO's emergency and rehabilitation programmes where CA has been shown to be a successful entry point in several countries in Africa. FAO Regional/Sub-regional Offices should organize action for advocacy of SCPI and for projects that can lead to the establishment of "proofs of concepts" in key production systems in key agro-ecologies for high impact, as well as capacity building to strengthen innovation systems that combine traditional knowledge with new approaches and information. This should involve the deployment of FFS approach and collaboration with NGOs, particularly in integrated mixed production systems where incremental changes in productivity and farm output across a large number of farmers are being sought.

The sub-activities under this major activity would be differentiated across production system types and by commodities – production systems in growth corridors including irrigation systems; peri-urban production systems; small-holder mixed systems; and rangeland systems. Organic farming and agro-forestry systems in the region/sub-region may also need to be helped to adopt CA principles and practices, particularly of minimum soil disturbance, which will improve performance and incomes, and sustainability. All the systems are important so the choice of activities would depend on which commodities contribute most to national and local food security, livelihoods and economic development. In this regard access to rural and urban markets will be increasingly important. Another deciding factor would be the geographical areas where government development agencies are active and whose capacities can be built up to accelerate the transformation elaborated above.

There is a need to include activities with the objective of integrating good farming practices of CA plus IPM and IPNM into crop sector development programmes and projects for priority crop-systems. Such activities should have clear SCPI, income and livelihood, and food security targets. In instances where FFS network approach is to be deployed, it should be linked the objectives of achieving the changes in SCPI, income and livelihood, and food security.

Theme 3: National action plans for input supplies and delivery services (including farm power, equipment and machinery) (Productivity focus, but linked to Policy & Investment focus):

Modernization and transformation based on CA principles and practices (as well as on existing practices while in transition) will require affordable sources of adapted good quality seeds, affordable mineral fertilizer, as well as farm power, equipment and machinery, and pesticides (herbicides, insecticides, fungicides etc). There will also be a need for policy planning and investment required to establish/strengthen the seed, fertilizer and farm equipment machinery sectors, as well as the pesticide sector. In particular, national action plans for input supplies and services consistent with national crop sector strategies would be essential to ensure the delivery of sector development strategy, projects and campaigns.

Activities that are defined in Theme 1 and 2 under the Productivity focus must be reflected in Theme 3 to ensure that the supporting input supplies and delivery services will be available and affordable. The thematic framework for crops (including its own set of activities dealing with policy and technical advocacy, NRM and capacity building) must link up or inter-phase with similar thematic frameworks for livestock, forestry, fisheries and their specific activities on policy and investment, NRM, and capacity building. This will facilitate the integration of crops with other sectors of the FAO Regional/Sub-Regional programmes at the policy and technical advocacy level as well as at the project level.

A process for developing a longer-term FAO Regional/Sub-Regional programme with prioritised activities on crops, and the information needs to support the crops programme and its associated policy and technical advocacy

The decision matrix of two sets of elements (Set 1, i-v; and Set 2, i-vi) described above can be applied together with additional elements to drive a work planning process 0to identify priorities and formulate action and deliverables. It can also drive the process for developing a longer-term Regional/Sub-regional programme with prioritised activities on crops.

It is important that the process for developing a longer-term Regional/Sub-Regional programme with prioritised activities on target crops must involve national and international stakeholders in the public, private and civil sectors including ministry officials, institutional leaders, business entrepreneurs, FAO country teams, etc. There should always be a close working relationship between FAO Regional/Sub-Regional Office staff and FAO country staff. Any priority setting and strategy formulation activity for programme development undertaken by Regional/Sub-regional Office staff must involve FAO in-country staff and their national collaborators and decision-makers as appropriate.

The information needs to support the crops programme and the associated policy and technical advocacy is defined by the two sets of elements in the decision matrix. In general, the quality and reliability of the crop-related information from national and international sources has improved considerably and so have the national agricultural and rural development and policy planning processes, action plans and projects etc. These are increasingly being supported by the national agricultural research, extension and education systems as well as by the specialised institutions in NRM, climate, soil, hydrology, forestry, livestock and fisheries. They all participate in national planning and development activities.

Multi-year national and sector plans as well as national investment plans and PRSP documents are important sources of information on development priorities and opportunities as well as on development investments and on capacity building. FAO Regional/Sub-regional Offices should participate in and support the national and regional policy and programme planning processes so that it is able to provide inputs and advice, and participate in project formulation work as well as in project implementation. There are also regional and sub-regional research and development agencies that are generating useful information and analysis for their own planning and programme formulation. There are also useful analysis undertaken by bilateral and multilateral development agencies and they also are a source of information for formulating longer-term crop-related priorities. There too, may be a need to facilitate dialogue with selected private sector and civil society partners and stakeholders.

The information on the actual and planned distribution of agricultural systems, on land and rural resources including infrastructure, on agro-ecological potentials, and on NRM etc is increasingly being organized by nations using GIS and digital techniques. FAO Regional/Sub-regional Offices should link up with national information systems and bureaus of statistics and develop a strategic data and information base for its own work programming and project planning, as well as for monitoring and outcome mapping and for impact analysis.