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Contents

I. Introduction

1. Farmers are faced with the multidimensional challenge of feeding world a growing world population while coping with changing weather patterns and an increasingly strained natural resource base.

2. As the world population continues to grow, food needs will increase accordingly. Transitioning to more sustainable patterns of consumption and production is at the heart of sustainable development. Farmers, farming and the environment must interact harmoniously in order to meet these challenges. Maintaining the sustainability of agriculture and the livelihoods of farmers are key to securing adequate food supplies and the sustainable management of natural resources. In fact, farmers are the custodians of much of the earth's land and freshwater resources.

3. Besides, one out of three people on this planet work in agriculture and, as a consequence, farmers are the largest ecosystem managers.

4. Agricultural development, poverty and environmental degradation are closely interrelated. It is recognized that the development of sustainable agriculture is an essential driving force for poverty reduction and food security. However, the challenges are enormous for agriculture to remain sustainable.

5. Food production would need to be increased by 70% by 2050 when the world population will reach 9 billion. Food security has to be integrated in a shared vision for long term action, in order to open the door to sustainability for the agricultural sector as a whole. Food security underpins human life and consequently the role of agriculture in providing staples and stability while preserving the environment should be fully recognized.

6. Farmers should be key partners when it comes to implementing sustainable production and consumption patterns. They have the capacity to provide solutions through appropriate existing and new agricultural practices. These include conservation agriculture, the sustainable management of water, the production of renewable energies (e.g. biogas), sustainable livestock and appropriate manure management. Sustainable land management practices are already available and methods to measure and monitor them have been developed in several parts of the world.

7. It is crucial to implement a new agricultural model in which farmers contribute as real entrepreneurs, through the development of more sustainable agricultural practices, the management of water in an efficient way, the use of sustainable land management (SLM) techniques, and by getting organised in the market place and developing high quality products in order to respond to increasing consumers' demands.

8. This document presents an analysis of current trends, policy options and practical farmers' solutions that foster the transition to more sustainable patterns of production and consumption.

II. Challenges and Main Issues for Farmers

9. One of the biggest challenges for sustainable agriculture is the setting-up of a farming approach which encompasses environmental sustainability, food security and includes improved yields, better farmer incomes and reduced costs of production.

10. The balance between environmental, economic and social development, namely the three pillars of sustainability is thus critical to reduce poverty and hunger. The following paragraphs are an attempt to describe the main challenges that farmers have to overcome to implement sustainable production systems and to deal with the problems and opportunities that arise from the use of chemicals and the management of agricultural waste.

A. SUSTAINABLE CONSUMPTION & PRODUCTION PATTERNS

(a) Deteriorated natural resources hinder sustainable development

11. Farmers rely on natural resources to carry out their activities. Soil erosion, water logging and salinity all contribute to land degradation and desertification, leading to the over-exploitation of the land.

12. Combating desertification and land degradation is one of the most important challenges to ensure food security and sustainable development. Farmers are among the first victims of the phenomenon of desertification as natural resources such as fertile topsoil, organic matter, plant cover and healthy crops are the most severely affected by desertification. Without fertile soil and without the right tools for sustainable land management, people living in the regions affected by land degradation are unable to break out of the poverty cycle.

13. All over the world, climate variability associated with climate change is leading to an increase in the frequency and intensity of floods, droughts and desertification. Climate variability brings widespread weather events that affect entire communities.

14. Diminished biodiversity, due to habitat encroachment, fragmentation and pesticide misuse, lead farmers to rely on chemical inputs to increase their yields. Because decreased biodiversity results in less resistant crops and loss of ecosystem services, pest infestations and weather variability increase agricultural stresses. Producing substantial crop yields without chemical inputs or intensive fossil fuel use is becoming a real challenge.

15. Pressures on water resources due to increased crop intensity bring about increased water resource competition in areas where water resources are scarce. Therefore, this situation may lead to conflicts. Unfortunately, the decreased water resource base is a reality that must be addressed in a long-term perspective. Without access to uncontaminated water, fertile land, and healthy biological ecosystems, farmers' livelihoods are in danger.

(b) Without rewards farmers are unable to implement sustainable production patterns

16. Efficient and sustainable production and consumption patterns must ensure fair incomes, profitability of agriculture and decent opportunities for farmers to help alleviate poverty, reduce imbalances and enhance food security. In particular, farmers need to be able to get their products to the market and receive equitable price treatment.

17. Farmers' efforts tend to face two challenges. First, many policies related to the institutional environment for farmers to access agricultural markets are generic and do not consider the specific features of smallholder farming and their forms of economic organisation. These adapted policies do not include, competition policy, taxation policy and risk mitigation mechanisms. Policies are often inadequate to develop well functioning markets through transparent information, access to up-to-date market

pricing information, provision of fair prices, sound infrastructure and regulated speculation. Secondly, marketing strategies developed by farmers to cope with these challenges in the market are often not feasible within the existing institutional environment.

18. Smallholder farmers face an even more difficult situation, especially those located in developing countries. Often, in most of these countries, smallholder farming is crucial for poverty reduction, food security and the rural economy as a whole. The importance of small farmers in a country is dependent on their number, their role in the agricultural and economic development and their concentration in rural areas. Most smallholders are vulnerable to economic and climatic shocks. They spread their risk by diversifying their sources of livelihood, which often include significant off-farm income. Self-sufficiency rarely exists as there is often some form of local market in which smallholders trade their surplus. But these markets are not very remunerative and offer limited opportunities for price negotiation. Finding and entering markets with better prospects is challenging.

(c) Sustainable bioenergy production: opportunities and challenges

19. Increased utilization of renewable energy has a significant impact on agriculture in both the short and the long term. Agricultural sources of energy are becoming the new

paradigm for the food and energy business. For farmers, bioenergy represents a new market and a way to diversify risk. Many hope that these products will become income and export opportunities. Both developing and developed countries see them as an opportunity to keep expenditures on energy within the domestic economy. Bioenergy also plays an important role for households in terms of local energy use, in particular in many developing countries. Therefore, these populations become less exposed to increased energy prices.

20. In spite of this potential, at the global level, sustainable energy has low penetration in the agricultural sector, and faces many challenges. These include: early adaptation of technologies, geographic location, high capital costs, and cost competitiveness with traditional sources of energy. Most farmers in the world have little ability to make large capital investments in infrastructure to consider alternatives such as renewable energy. However, in many regions of the world, bioenergies represent a positive alternative source of energy for farmers and rural development.

21. Even though bioenergy has multiple benefits, which contribute to address at the same time energy supply constraints, climate change, national security, and economic development issues, there are still questions on issues related to food security, economic and environmental sustainability and trade. There is indeed a need to weigh prospects of bioenergy against their costs.

22. The policy mechanisms implemented will not be identical for developed and developing countries. However, bioenergy can provide growth opportunities for both types of economies. Increasing the use of bioenergy is largely an issue of policies by governments, institutions, and organisations to create strong, stable investment environment to develop this potential in a sustainable way.

(d) Lack of resources is a barrier to sustainable production

23. In many developing countries, the lack of financial resources and infrastructure makes the adoption of sustainable practices difficult to implement. In many rural areas, infrastructure such as water and irrigation systems, energy supply, roads, storage facilities, telecommunications are either missing or outdated. Also, there is a general lack of services, hindering access to knowledge and appropriate technologies. Farmers become increasingly vulnerable without sufficient infrastructure. In many developing countries required infrastructure and services remain insufficient and this represents a major constraint to competitiveness and profitability of the agricultural sector. Support from developed countries is essential especially in terms of knowledge sharing and technology transfer.

B. CHEMICALS

(a) Benefits and challenges arising from the use of agrochemicals

24. In most regions of the world, the agricultural sector widely relies on synthetic chemicals which are used as fertilizers, crop protection and plant growth regulator products. Agrochemicals are utilized in both crop and animal production to increase yields, influence food quality and control insects, weeds, plant diseases and other pests.

25. Undoubtedly, several are the advantages of their use in industrialized countries in terms of economic returns. They guarantee abundant supply of food, quality standards and reasonable food prices. These advantages have led to the rapid adoption of agricultural production systems based on chemical inputs in several regions of the world. In less industrialized countries, the use of chemicals is still limited as these products are often too expensive for resource poor farmers.

26. However, the use of chemicals in agriculture is not free from concerns as they present potential problems and risks both for farmers and the environment. The undesirable side effects are a consequence of the indiscriminate and overuse of agro-chemical products. They often originate from a lack of understanding of the impacts of these products on human health and on the environment. In particular, many developing countries lack the resources, the expertise as well as the awareness necessary for an appropriate and sustainable use of chemicals.

27. Over the past decades, the expansion of agricultural land and the injudicious use of chemical products such as pesticides, herbicides and fertilizers have seriously deteriorated the natural resource base, including water and land, in numerous rural areas.

(b) The application of integrated farming practices is still a challenge

28. Integrated agriculture based on the appropriate use of chemicals (such as fertilizers and crop protection products) as well as sustainable agricultural practices can ensure farm production in a sustainable way. Integrated management techniques can be seen as a fundamental component of responsible farm management, providing the conditions for economic stability and respect of the environment and natural resources.

29. Sustainable agricultural practices include integrated crop, pest, plant nutrition and soil fertility management as well as sustainable fertilizer management practices. These are practices that promote the responsible use of agricultural inputs in a more efficient and cost-effective way for farmers and for the environment.

30. The role of farmers as guardians of ecosystems is not always fully recognized. There is a need for a shift in thinking which would place farmers at the centre of sustainable agricultural practices. Incentive mechanisms for farmers to promote the development of a sustainable agriculture are missing in many countries and in particular in developing countries. Because of the lack of resources and knowledge, farmers are

often not in a position of choosing the most appropriate integrated farming systems. The stakeholders involved in agriculture are also not in a good position to offer farmers the best technologies to use. Knowledge sharing, adequate tools and technologies on the sustainable use of chemicals are not yet accessible to all farmers.

(c) The social and safety dimension of farmers using dangerous chemicals

31. Agriculture is a high risk activity as farmers handle potentially dangerous agrochemicals. In certain regions of the world, especially developing countries, farmers are often exposed to dangerous substance with little regulation and education, facing great health and safety risks. This is due to a lack of resources, weakness in basic infrastructures, absence of appropriate regulations, inadequate education and inefficient, or inexistent, social security or insurance systems. The promotion of socially, environmentally and economically sustainable practices in the use of chemicals in agriculture is often weak or inexistent. Too often, this is not included in a broad strategy to improve agricultural working conditions and incomes encouraging, at the same time, the use of safer and sustainable practices. Information campaigns, specific training and education are decisive to raising awareness among farmers on the danger of using chemicals and the lack of respect of safety measures.

C. WASTE MANAGEMENT

32. Models for sustainable agricultural development must include proper management of waste from farming operations. This comprises minimizing agricultural wastes and, on the other hand, maximizing environmentally sound waste reuse and recycling.

33. Waste management in agriculture helps reduce the need for fertilizers and other inputs such as water and fossil fuel based energy. Cultivating crops, breeding animals and decreasing -at the same time- waste, losses and inputs can significantly mitigate the negative effects of the environment, thereby, enhancing sustainable development.

(a) Handling agriculture production losses is crucial to minimize waste

34. Taking into account production and food losses is key for sustainable development as it has a strong impact on environmental degradation. Resources such as land and water, human labour as well as non-renewable resources such as chemicals and energy are used to produce, process and transport food products that are not consumed.

35. In many developing countries, significant amount of crop yields is lost because of inadequate pre- and post-harvest support. This is caused by incorrect harvesting techniques, spillage, exposure to adverse weather conditions or extreme temperatures, contamination by micro-organisms, pests and physical damage caused by inappropriate tools, chemical contamination and improper handling during transport.

36. The main barriers that farmers around the world have to face are related to the difficulties in building local storage facilities and adequate transportation mechanisms, including cold chain storage for food preservation. This is due to a lack of resources, awareness, knowledge and information that would allow the identification of appropriate techniques and management procedures.

37. In addition to production losses, in most countries of the world, large quantities of food are wasted during the production and consumption phases. This includes products that are not accepted by consumers in industrialized countries due to non-conformity to trade, commercial and quality standards. These products are, in most of the cases, wasted. Better information and education on sustainable consumption and production and on the need to reduce food waste are needed to change behaviors of food chain actors including consumers.

(b) Upgrading efficiency to minimize water waste and secure water quality

38. Water is one of the main inputs for agriculture and it is a public good necessary to ensure the health and livelihoods of millions of farmers. Water security and efficiency in its use should be recognised as key to poverty alleviation. Farmers and the rural population are the first victims of water problems in terms of quantity and quality.

39. Lacking drainage infrastructure, poorly maintained drainage and irrigation systems are one of the causes of water waste in many countries. The inefficient use of the water resource is often a consequence of weak infrastructure, lack of a good functioning water authority with the right competencies, lack of incentives for an efficient use of fresh water resources and, finally, the use of unsuitable crops.

40. Maximizing irrigation efficiency is a challenge for many farmers. It is crucial for them to seek an optimal combination of all water uses. This might be done through infrastructure planning, provision of cattle wallows or laundry areas in or adjoining canals or making sure that irrigation is also available for non-agricultural uses. Increasing the combined value of all water uses is strictly linked to water quality, rather than just quantity issues. The protection of the quality of water represents a prerequisite for sustainable development. In this view, waste disposal becomes critical to sharing water among different uses. The approach to water waste disposal should be multi-sectorial.

(c) The exploitation of animal waste for biogas is still a challenge for most farmers

41. The agricultural sector produces millions of tonnes per year of agricultural organic waste such as manure and slurry that could be used to produce biogas. Emissions of methane from the breakdown of organic feedstocks may be captured

within an anaerobic digestion plant, instead of being released into the atmosphere from conventional manure storage systems or landfill sites. Biogas is a combustible gas derived from decomposing biological waste and it normally consists of 50 to 60% of methane.

42. Biogas production from animal manure standardises and improves the agronomic value of agricultural and other residues and is beneficial for the environment. Well-managed biogas supply chains contribute to reducing odour and leaching of nitrates from agriculture while at the same time delivering renewable energy and allowing the substitution of fossil fuels. The reduction of methane emissions from manure helps mitigate climate change as methane is about 26 times stronger as a greenhouse gas than Carbon Dioxide.

43. The establishment of biogas systems remains a challenge for most farmers in the world. This is mainly due to the relatively high costs of the initial set up, the maintenance of the plant and the labour involved. The potential lack of regular supply of organic material may also be a major constraint for certain farmers which do not have access to a relatively large number of cattle. Furthermore, connecting the electrical generating plants to rural grid networks is still a complex and expensive issue. Finally, the logistic and economics of transport, beyond its local production area, limit the market potential of digestate (the solid material remaining after the anaerobic digestion of a biodegradable feedstock).

III. Review of Implementation: Analysis of Progress and Successful Experiences

44. Farmers render a wide array of solutions to provide models for sustainable production systems, the management of chemicals and waste

A. SUSTAINABLE CONSUMPTION & PRODUCTION PATTENS

(a) Sustainable agricultural practices in coffee production in Peru: soil conservation and reforestation

45. Farmer members of the National Coffee Board (*Junta Nacional del Café*) of Peru are currently working on the implementation of sustainable agricultural practices. These are put in place in 30% of the total area under coffee managed by the Board and include: the implementation of soil conservation practices and reforestation projects that increase productivity and reduce pressure on forests.

46. With the aim of ensuring environmental sustainability, the JNC is working to encourage public policies to support reforestation by promoting, in particular, the shade coffee plantations (i.e. the cultivation of coffee under a shading canopy of natural forest or planted shading trees). Diversified shading canopies in coffee plantations, made by trees for timber or other uses, play an important role in protecting biodiversity and

natural resources. The JNC is working on generating feasible technical proposals including technical assistance for farmers and providing adequate tools and inputs to promote sustainable agriculture.

47. With the aim of ensuring social and political sustainability, the JNC is working on organizing farmers into cooperatives, associations, certification groups, to improve farmers' self-management capacity. The JNC is leading initiatives to strengthen producers' representation in policy processes, to support improvements in road infrastructure and quality of basic services such as education and health facilities in the coffee areas. Finally, the JNC is working to increase tax incentives for farmers engaged in sustainable agriculture in Peru.

48. With the aim of ensuring economic sustainability, the JNC is working for greater diversification of coffee niche markets which allow better direct marketing, reducing dependence on retailers. The JNC is working to improve funding and to encourage the creation of incentive schemes for sustainable agriculture.

(b) Anti-soil erosion practices in Albania to prevent land degradation

49. In Albania, the progressive deterioration of natural habitats and land threatens the country's biodiversity as well as family farmers' livelihood who widely cultivate on small parcels. The reduction of soil fertility, desertification and impoverishment of the

soil from degradation has intensified over the past decade. Besides, salinisation, water logging and inappropriate land management are accelerating soil degradation. This progressive loss of land's fertility decreases productivity and worsens the vulnerable economic conditions of family farmers. Land degradation is caused by an array of interrelated factors such as deforestation, overgrazing, illegal logging, low investments etc…

50. In the face of severe erosion threats, Albanian farmers have identified and implemented good agricultural practices to maintain soil productivity conserve water and lower production costs. These practices include adequate crop rotation, intercropping, zero or minimum tillage, mulching, effective irrigation systems and rain collection systems, selection of resistant varieties, composting and biological pest and disease control. In order to stop further land degradation, the development of in agricultural good practices include afforestation, the setting up of barriers to protect the arable land and the improvement of irrigation systems.

(c) Farmers' in Colombia propose solutions to mitigate climate change through changes in farm practices and production systems

51. In Colombia, the dairy and beef cattle is the main contributor to emissions from enteric fermentation and from manure. The utilized fertilizers are also responsible for the Nitrous Oxyde (N_2O) emitted by the agricultural sector. Changes in agricultural soil

management practices have been envisaged by farmers. These include practices to reduce soil erosion, use of manure, appropriate crop rotation and minimum tillage. These practices lead not only to reducing or eliminating the carbon release due to the loss of fertility and organic matter in the first centimetres of soil, but also to sequestrating carbon through increased organic matter levels. And, finally, they lead to encouraging the rational use of fertilizer in order to reduce production costs and emissions of nitrogen oxides. The development of conservation farming practices in crops such as grains and oilseeds improves the net carbon stock in soil.

52. The cultivation of cassava for industrial uses such as biofuel production presents opportunities for sustainable production through appropriate agricultural practices. About 135,000 small farmers derive their income from cultivation of cassava in the Caribbean coast of Colombia. This crop can in fact be cultivated with rational and efficient use of fertilizers, maintaining the nutritional status of the soil and thus reducing N2O emissions. Cassava can be naturally desiccated by solar radiation and this avoids the energy intensive artificial drying practices, which use a technology not adapted to the Colombian conditions.

53. In recent years, the cassava industry has gained importance not only for the feeding industry and starch but also for the production of biofuels. Currently, industrial cassava is the third crop with higher yield (4,500 liters / ha year) in biofuel production after sugar cane and sugar beets. In Colombia a large area is planted by small farmers,

with a potential production of cassava of 140 000 hectares that can be dedicated to ethanol production.

(d) Optimization of water resources use in Palestine supports sustainable productivity gains

54. With the aim of optimizing the use of water and fighting water shortages, Palestinian farmers are encouraged to adopt innovative approaches. The *Palestinian Farmers Union* (PFU) supports farmers in optimizing their on-farm irrigation networks as well as in guaranteeing a fair access to irrigation water and, as a result, reducing the risks of negative impacts on farmers' livelihoods. The PFU's water optimization projects in the Jordan Valley provide farmers with on-farm optimized irrigation systems and training on the practical use of such systems. The two-year water optimization project led to significant results: 30% water savings, 25% input savings and 15% yield increase. The reduction of inputs corresponds to an increase of 15 to 25% of farmers' income.

55. In particular, the project of PFU demonstrated that simple improvements and the right application of minimum water bring the same or higher productivity levels. Water savings can help increase irrigated area. Through the PFU project, about 80 farmers benefited from new irrigation equipments to irrigate more than 50 ha of agricultural land. Farmers trained to the optimization of irrigation systems contributed to the diffusion of the good practices of water savings to a larger number of beneficiaries.

(d) The French plan of energy performance for an ecological and productive agriculture

56. Improving the energy performance of French farms is a key issue both from the economical and the environmental point of view. For certain agricultural activities in France, such as vegetable production and horticulture under glass, the energy bill is often a real burden. Therefore, farmers are engaged in efforts to improve the energy efficiency of farms in an environmentally friendly way. The energy performance plan (EPP) developed by the Ministry of Agriculture and Fisheries is an opportunity for farmers to engage in good practices and it particularly refers to energy savings. The target set by the EPP is to increase the control of energy to achieve, by 2013, a rate of 30% of farms with low dependence and consumption of energy.

57. In France, some energy suppliers are obliged to undertake a minimum amount of energy savings and this can be justified through the so-called Energy Savings Certificates (ESC). Suppliers can obtain these certificates by directly contributing to energy savings or by purchasing them from other actors, including farmers, who make energy savings. A real market for ESC now exists with an ESC price following the supply and demand rules.

58. A correct diagnosis of energy performance is the first step to be carried out at the farm level. Farmers must make an inventory of the direct and indirect energy uses. The

diagnosis identifies energy improvement possibilities and actions that farmers can carry out to enhance their energy efficiency through their farming practices, their equipment and their buildings. Improvement actions often include: the adoption of more energy efficient practices (e.g. modifying the use of agricultural machinery, choosing crops that consume less energy and nitrogen fertilizers etc…), the choice of appropriate equipment (machinery and buildings) that are less energy consuming and, finally, the opportunity of producing on-farm renewable energies.

(f) The Climate labelling system in Sweden to inform consumers on climate friendly products

59. Thanks to a recently established “climate-certified” label system, consumers in Sweden are the first in Europe to easily identify climate-friendly food products. They are able to choose foods according to the impact that production and transport have on climate. Consumers have the potential to actively select foods having a lower climate impact. Through the labelling systems, consumers are informed that climate certified food is produced using best available techniques that include, for instance, the use of renewable fuels for heating greenhouses, the use of mineral fertilisers with low emissions of nitrous oxide, a limited use of soy beans coming from high value conservation areas, etc.

60. The *Federation of Swedish Farmers* (LRF) is involved in the development of climate labels in order to help consumers make climate smart choices while increasing the competitiveness of farmers by being more climate-friendly. The corresponding guidelines cover meat, fish, fruits and berries, vegetables and leguminous plants, potatoes and cereals. These standard guidelines were drawn up in partnerships with the Swedish Board of Agriculture and local researchers.

61. The project also includes monitoring systems for energy use at different levels in order to measure and follow-up the achievements. Each product is independently certified by a third party certification body ensuring that farmers and the food industry comply with climate mitigation measures.

62. The climate-certified labelling system put in place in Sweden corresponds to a reduction in emissions estimated between 5 to 80% throughout the whole supply food chain. Besides reducing the negative climate effects in food production through consumers' informed choices, the labelling system also strengthens the competitiveness for the food businesses. The climate-friendly label covers the entire production chain with measures taken to decrease climatic impact and it covers both Swedish and imported products. The system can be considered as an additional labelling to be used along with other certifications related to sustainable development productions.

B. CHEMICALS

(a) Crop rotation in Madagascar to limit fertilizer use and preserve natural resources

63. Agriculture in Madagascar is dominated by intensive farming and livestock breeding. Unsustainable crop and agro pastoral practices are widespread and are due to the lack of farmers' capacity and awareness on the use of chemicals as well as missing infrastructure.

64. As far as crop production is concerned, the use of appropriate crop rotation has been identified in Madagascar as an effective farming practice to limit fertilizer use and preserve natural resources. Rotation is the practice of growing different types of crops in the same area in sequential seasons according to their nutritional needs. Crop rotation seeks to balance the fertility demands of various crops to avoid excessive depletion of soil nutrients. In fact, the practice of growing the same crop repeatedly over several years on the same parcel depletes soil and leads to a gradual deterioration of fertility. Crop rotation is a simple and accessible practice that allows farmers to regenerate the soil organic matter, water and nutrients. This regeneration of the soil provides plentiful production while preserving the structure and texture of the soil. Rotation is a solution easy to apply for farmers and it can be associated to other sustainable practices for soil fertilization such as the use of manure and compost.

(b) Practices used by farmers in El Salvador to use cattle manure as natural fertilizer for fodder crops

65. In El Salvador there is more than a million heads of cattle. The main problem for livestock breeders is the accumulation of large quantities of cattle manure per day and its redistribution results often difficult. The accumulation of manure generates bad smell and proliferation of disease-carrying pests.

66. The cooperatives that make up the *Central Cooperativa Agropecuaria* (CCA) have developed solutions to reduce the accumulation of manure and exploit, at the same time, the nutrient value of this important by-product from livestock production systems. Manure is a fertilizer containing nitrogen, phosphorus, potassium and other nutrients. It also adds organic matter to the soil which improves soil structure, aeration, soil moisture-holding capacity and water infiltration.

67. Each cooperative member of CCA has built an area with concrete floor for collection of manure which can be later loaded in a manure spreader. This machine is driven by a tractor to spread manure in pastures for forage production for cattle herd. This operation can be carried out in both dry and rainy seasons. However, t most commonly, many farmers collect manure during the rainy season to spread it later during the dry season.

68. Several are the benefits of this practice. Firstly, the use of cattle manure as a fertilizer for fodder crops, delivers better profitability in cattle breeding as it decreases the input costs of chemical fertilizers and provides satisfactory fodder yields. It also permits the reduction of pollution from chemical fertilizers in the medium and long term. It helps improving the soil texture and structure increasing the micro-flora and micro-fauna. Finally, this practice eliminates the sources of odours and pests.

69. With this simple practice recently implemented, farmers within CCA feel that they have taken a step forward in putting in place a cattle production system that results economically and environmentally sustainable. A weak point of the system remains the cost of acquisition and maintenance of the equipment which is not easily available in the domestic market.

(c) Natural pesticides: a simple and sustainable solution to limit negative effects in Rwanda

70. The vulnerability of agriculture in Rwanda is exacerbated by soil erosion, landslides and mudslides caused by rugged terrain and dependence from non-irrigated agriculture, deforestation and unsustainable agricultural practices. The high population density and poverty leads to the overexploitation of agricultural land that severely alters natural resources.

71. In order to limit the negative effects of pests on crops and to find an affordable solution for the protection of crops, a number of farmer members of the *Ingabo Livestock Breeders' Union* of Rwanda apply natural pesticides. This technique is used in association with other simple and sustainable practices such as the use of improved seeds, appropriate crop rotation, the removal of plants affected by viral diseases and, finally, the respect of the growing seasons.

72. Among farmers in the Ingabo Union, the use of natural pesticides is preferred and encouraged also because it protects crops at a minimal cost. Over 10 species of plants are used in the production of natural pesticides. These include pepper, onions, leeks, tobacco, tomato leaves that grow naturally in the country and are useful to control flies, termites, caterpillars and other insects harmful to crops. Also, other natural products such as dung and wood ash are employed. The use of these products is linked to traditional medicine that has long been applied by farmers in Rwanda.

73. On the other hand, chemical pesticides are scarce in Rwanda. They are expensive and pose a danger to human health if used in excess. Besides, the overuse of pesticides may create unbalanced ecosystems. And yet, only few farmers have pumps to spray pesticides on crops and few are trained to use chemicals properly according to the doses prescribed.

74. The use of natural pesticides started as an initiative supported by some farmers and gradually developed into a stable and wider program within the Ingabo Union. Each member of the Union owns a small kitchen garden that is vital for its subsistence and it is where the use of natural pesticides is particularly important.

(d) Fertigation in greenhouses in the Seychelles allows an optimal application of chemicals

75. The Seychelles is a characteristic SIDS (Small Island Developing States) with geographical dislocation, very limited natural resources, proneness to natural hazards and to external shocks, highly exposed population and infrastructure, limited adaptive capacity and very fragile ecosystems.

76. In the face of forecasted prolonged drought, the greenhouse technology and associated irrigation system of low volume water applicators such as, drip, mister and mini-sprinklers are viable and sustainable solutions. An effective irrigation system using low volume irrigation water applicators (misters and drips) combined with a fertigation system allows the optimal application of water and chemicals such as fertilisers and pesticides.

77. In the Seychelles, the promotion of greenhouses in tropical regions is considered as a component of a broader approach for integrated production and protection

management. In the Seychelles, greenhouses currently represent only about 5% of the total area under intensive cultivation and it is practiced to ensure the production of vegetables during the rainy months of November to April. The objective is to reach at least 25% of the area under intensive production. Presently about 10% of crop growers have adopted the system of fertigation. The import of construction materials such as ultraviolet resistant plastic sheath, galvanised steel pipes, and the supply of fertigation fertilizers is, however, still a big challenge for farmers in the Seychelles.

C. WASTE MANAGEMENT

(a) Recycling in Uganda: charcoal briquettes transform agricultural waste into energy source

78. The basic source of cooking fuel in Uganda is wood in the form of wood charcoal or firewood. Urban populations commonly use the wood charcoal while farmers in rural areas exclusively use firewood. This dependence on traditional charcoal and firewood is responsible for the prevailing deforestation and soil degradation which have impacted the environment adversely. The effects are manifested in phenomena such as irregular rainfall, floods and violent storms. The major cause of this is lack of affordable and reliable alternative sources of energy. Moreover, even in cases where alternative sources such as hydro-electric power, kerosene and gas do exist, the majority of farmers are too poor to afford to get them, hence the continuing dependence on charcoal and firewood. To save the forest, recycling agricultural waste to manufacture charcoal briquettes is a

simple, low cost and reliable technology. Charcoal briquettes are an affordable source of energy and can be used in cooking instead of the traditional charcoal and firewood.

79. The first step consists in the fabrication of charring drums and “kilns” (1-2 days). Kilns are thermally insulated chambers, or ovens, in which controlled temperature regimes are produced. They are used to harden, burn or dry materials. The second phase is the “Charring” (1 to 2 hours). The charring is a chemical process of incomplete combustion of a solid when subjected to heat. By the action of heat, charring removes hydrogen and oxygen from the solid, so that char is composed primarily of carbon. This phase is followed by the “Pyrolysation” process (1 hour). Pyrolysis is the decomposition or transformation of a chemical compound caused by heat. The final step is the “briquetting” the creation of charcoal briquettes.

80. Several are the benefits of this recycling system. From the environmental point of view, these benefits include: provision of energy without the use of fossil fuels; a wide range of biomass can be used as raw material; further deterioration of the forest and deforestation is limited; training increase farmers knowledge on alternative sources of energy to wood charcoal.

81. From the social point of view, these benefits include: increased awareness of the farmers on the need for good environmental management; participation of women in the

making and management of the kiln; practical “hands-on” training in several districts in making charcoal briquettes from agricultural waste.

82. From the economic point of view: the technique is easy to replicate and affordable, it constitutes a readily accessible energy source for the farmers’ households and, finally, it incorporates social learning and practical skills development for long-term sustainability of conservation agricultural practices.

(b) On-farm Biogas: capturing methane emissions to produce clean energy

i The experience in the United Kingdom and Denmark

83. The production of biogas plants provides multiple environmental and economic benefits. It reduces the impact of agriculture on the environment while at the same time delivering renewable energy and substituting fossil fuels. Biogas plants convert manure, energy crops and organic solid waste into clean energy and efficient fertiliser. Biogas improves security for meeting energy supply requirements and, at the same time, enables synergy effects between farming, energy production and the environment. Biogas plants are a multifunctional tool for sustainable development in agriculture, the energy sector and rural areas in general.

84. Biogas can be used as a substitute for fossil fuels on the farm or sold to off-farm energy to other users. It is most commonly turned into electricity and heat by on-site co-generation. The organic material comes from farming operations and is collected and stored in a closed air-less container that acts as the ‘digester’. After 20 to 60 days (depending on the internal temperature of the digester), the organic matter is broken down by bacteria in the absence of oxygen to produce a methane-rich biogas. The remaining material, called digestate, can be recycled as a valuable nutrient source and soil conditioner. As the nutrient proprieties of the digestate are better characterised than unprocessed manures, it may be matched more closely to the nutrients requirements of crops. Digestate must be well managed and applied in accordance with best practice guidelines to reduce risks of diffuse nutrient pollution and habitat damage.

85. Anaerobic digestion (AD) systems located either on farm or at a larger centralized management facility, offer a well proven and established technology which is increasingly commercially available to agriculture in countries such as the United Kingdom and Denmark.

86. A number of dairy farmers in the United Kingdom have been producing biogas using an on-farm AD system since the recent years. Biogas and dairy production can be considered as an effective partnership.. Every dairy farmer can be, in principle, a producer of biogas. Both activities are production industries and dairy farmers can use all their own resources, assets and skills for the production of biogas.

87. Biogas plants are tools that reduce leaching of nitrates but are also one of the most promising mitigation options for reducing Green House Gas (GHG) emissions from animal manure and slurries. Biogas burns indeed more cleanly than fossil fuels such as oil and coal, and emits much less carbon dioxide per unit of electricity and heat produced. By using biogas for combined heat and power production, the emission of GHGs is reduced by more than 200 %. When used as a transportation fuel, manure-based biogas can reduce GHGs emissions by more than 160 %. These high reduction potentials are due to the dual effect of substitution of fossil fuels and reduced emissions of GHGs methane and nitrous oxides from livestock manure.

88. Biogas production delivers also numerous advantages to farmers. It improves the nutrient value of livestock manure as nitrogen becomes available for arable crops and it is an alternative to slurry soil injection equipment, which is energy consuming, slow and expensive. Biogas plants minimise the odours associated with conventional manure management, protect the aquatic environment as well as enhance employment opportunities in rural areas and, thereby, promote sustainable development in rural areas.

89. Benefits of Biogas production systems comprise an increase in farm business profit by using or selling the energy produced by the digester and replacing manufactured fertiliser requirement with digestate.

ii. Biogas for rural households: on-farm production and use in Vietnam

90. Vietnam has become a major producer of biogas in Asia due to its effective animal, vegetable and human waste management. The significant production of biogas in recent years is due partly to the creation of the program: “Biogas for the Animal Husbandry Sector”. This program is part of a rural development policy framework that encourages favourable conditions at the household level to develop the farming economy and expand livestock production.

91. The Biogas Program is a joint collaboration between the Ministry of Natural Resources & the Environment and the *Vietnam Cooperative Alliance* (VCA). It aims at managing animal waste in a sustainable way, while at the same time producing clean and affordable energy to rural households.

92. Biogas program in the animal husbandry sector aims at exploiting effectively biogas technology, contributing to rural development and environmental protection, improving community‘s sanitation and rural people‘s health, improving the livelihood and quality of life of rural farmers by exploiting the economic and non-economic benefits of domestic biogas and, finally, developing a commercially viable domestic biogas sector.

93. Biogas plants represent a concrete solution to improve livelihoods in remote rural areas. Indeed, in the long-term, the use and production of biogas can significantly improve the quality of life of rural farmers. The energy return of the system is high. It is estimated that the Biogas Program in Vietnam provides clean and cheap energy enough to replace the usual sources of energy such as firewood, agricultural waste, charcoal, kerosene and liquefied petroleum gas (LPG).

94. The objectives of the programs are to provide a clean and affordable energy source for local people (for cooking and lighting) and thus improve the livelihoods of rural farmers. Secondly, the program prevents and diminishes the environment pollution caused by livestock waste. It protects forests by reducing the use of fossil fuels thus minimizing greenhouse gas emissions. The program also supports the socio-economic establishment of organizations and enterprises related to biogas production and services. Finally, it provides bio slurry (by-product of biogas production) as a soil fertilizer for fodder crop cultivation.

95. The Biogas Program in Vietnam has enabled, besides the high amount of valuable energy provided, the construction of over 56 000 biogas plants, the training of more than 500 provincial and district technicians and, finally, the promotion of biogas to rural population through informative workshops. Using biogas instead of firewood means a reduction of costs for family farmers, a relief for women and children to collect firewood and a significant reduction of deforestation.

IV. LESSONS LEARNED, NEW OPPORTUNITIES TO EXPEDITE IMPLEMENTATION

96. An official recognition of agriculture as a sector with a huge potential to provide solutions for sustainable development and consumption is crucial.

97. Numerous strategies are already available but these are not yet fully appreciated by policy-makers and the general public. There is a need to recognize that sustainable management practices already exist and methods to measure and monitor have been developed in some parts of the world. Increased and coordinated actions are necessary to raise awareness in this regard

98. Nevertheless, farmers and agriculture are faced with several challenges which urgently need to be overcome. It is recognized that agriculture must nearly double food production to meet the demands of a growing population expected to reach 9 billion by mid-century while minimizing the impact on the environment. Farmers are increasingly being asked to not only produce food, but to providing a wide range of ecological services to society, such as the protection of landscapes and wildlife habitats, integrated water resource management and conservation of local products.

99. The agricultural community is committed to playing an active role in creating sustainable production and consumption systems while increasing the productivity of

agriculture however this enormous task needs the commitment of the international community to facilitate the needs in the agriculture sector.

100. A commitment for a substantial increase in investments in and support for agriculture is essential. The sector must be prioritized in international and national strategies as well as in budgets in order to increase agriculture's role in boosting economic growth.

101. Investment must be focused on infrastructure, especially roads, drip irrigation, storage and processing facilities to reduce post-harvest losses, market information systems, extension services, credit and insurance and access to inputs. Finally, national governments should invest in improving the livelihoods of farm families through returns from the market and through rewarding them for the services rendered to nature, the so-called ecosystem services.

102. Significant financial resources and political will are needed to better address food security, and sustainable patterns in production and consumption. These resources must be accessible to all stakeholders that include researchers -necessary to underpin needed advances in the effectiveness, efficiency and equity of agriculture approaches- but also civil society and, especially, farmers and their associations.

103. Recognition of Farmers' Organizations as partners, and as the link between farming communities, national government and the international institutions is crucial. The road to sustainable agriculture and sound implementation strategies around the world needs to encompass participatory approaches. A farmer-centred approach to agriculture and rural development should prevail.

104. Policy processes need to be empowering and adaptive to respond to the needs of farming local communities. They also need to ensure good governance. In particular, increased recognition should be given to the development of smallholder and family agriculture with the development of local food markets. The rights and roles of indigenous and local farming communities especially women and young farmers must also be recognized in developing national strategies for sustainable patterns.