CONTRIBUTION OF AFRICAN AGRICULTURE TO CLIMATE CHANGE

AND MITIGATION POTENTIAL

PRACTICAL ACTION

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Summary

The contribution of African countries to Green House Gases emission is insignificant as compared to large emitters. The continent contributes to 20% of emissions related to land use changes (17% of total GHG and 25% of anthropogenic emissions). Africa provides 50% of the annual carbon release from burning natural vegetation. Biomass burning and wind born dust increased by desertification and soil degradation produce large quantities of aerosols which partially add to the GHG effect on warming; great Sahara dust storms are by far the largest source of dust. Deforestation is kept at high annual rate (4 million ha). The use of fuel-wood per capita is the world highest (0.63 m3).Sub-Saharan Africa will have a high share of Climate Change impact on productivity on agriculture for the next 100 years if actual production systems prevail. Western and Southern Africa will face 15 to 40 % reduction in productivity. Warmer temperatures will increase evaporation; drier conditions will prevail but East Africa will have more rains; more floods are expected in some regions and more intense cyclones. Sea level will be higher, destroying most coastal lowlands. Climate variability will increase, both inter-annual and annual with less rains and increased intensity of rainfall.

Climate Change will generate changes that have not been experienced for temperatures, rainfall pattern, the distribution of living species and relationships between land and water. A new set of conditions and risks for agriculture will rapidly be imposed to farmers. The adaptation process will result from long term adaptation strategies. Mitigation measures in agriculture should reduce factors inducing climate change: forests development, cropland and grassland management, livestock management, restoration of degraded land and improved wastes management. Adaptation and mitigation should be combined limiting conflicts between the development of agriculture and forest development and restoration of degraded land. Win- win situations should be looked for in

agriculture combining the raising of carbon capital and the intensification of production systems. Promoting development will give more resilience to societies and more capacity for organizing adaptation. Addressing risks management is possibly the most important task. It cannot only be based on technology, but encompasses social capital, institutions and compensation systems. Mitigation cannot succeed in Africa if it does not contribute to development and to provide resilience, in particular through poverty alleviation and the reduction of vulnerability. Mitigation in Africa will not help for adaptation if it does not contribute to risks management. A failure in adaptation would jeopardize efforts for mitigation. Water management is the key issue for facing changes in rainfall patterns and increased evaporation. In Africa, surface water is unevenly distributed and the ratio to rainfall is poor (20%). Potentials for irrigation will be seriously affected by reduced rainfall, especially in dry regions. The present rate of development of irrigation is grossly insufficient (40,000ha/y). A wide and integrated action plan for water management is needed, with emphasis on private and small scale scheme. Water storage cannot be considered only in lowlands and water harvesting should be developed.

For the last 25 years, the total population in SSA increased by 93%; it will increase by 100% in 20 years and generate a huge need for food and other commodities. The agricultural population increases less than the total population and labor intensification is necessary. For the last 25 years, the cropped area increased by 69%; it will double if land productivity does not improve for the coming 20years, destroying one third of forests and woodlands (200 million ha). Options for adaptation and mitigation in agriculture strongly depend on intensification while actual crop yield increase rates cannot meet production requirements for the next 20 years.

The proposed actions for intensification, adaptation and mitigation of climate change are operating on the three issues. Priority is to the development of agricultural markets, through policies for reducing GHG emissions from farming and conserving biodiversity. The role of trees should be rehabilitated in cropping systems and watersheds for generating shade and windscreens and for controlling water run-off within a land use policy reducing encroachment on new land at community level and the support of REDD+ funds. The use of agricultural inputs, mechanization and motorization should be supported to generate land productivity and labor intensification, thus limiting encroachment on new land, within policies for the development of production to consumption chains fairly redistributing added values to stakeholders. The recycling of organic wastes in agriculture should be promoted and facilitated by mechanization. Water harvesting should be actively promoted for complementary irrigation and diversification. Energy production from renewable resource should be widely developed in rural areas (Solar power, biogas, bio-fuels for local use, carbonization and the production of bio-char). Rural infrastructures should facilitate marketing for inputs and outputs, harness natural resources for development, empower people and drive social organization, monitor and mitigate risks. The intensification and equipment efforts should be supported by funding proposed in the L'Aquila Declaration of G8. Access of farmers to credit systems for inputs and machines should be facilitated and crop and livestock insurances developed in order to safeguard investments and shield credit. Social risks management should encompass further development of decentralized food stock systems and social nets alleviating vulnerability. Adaptation and mitigation should generate employment for the vulnerable. Thus climate change is making more urgent the complex tasks for rural development and agricultural intensification which should be supported by adaptation and mitigation altogether.

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1. Contribution of African Agriculture to Climate Change

1.1 Limited contribution of African countries to the load of climate warming agents

Sub- Saharan Africa has a limited contribution to the overall load of CO2 and other Greenhouse Gases to the atmosphere (GHG). The contribution per capita to this load is insignificant as compared to large emitters as indicated through the table below (data from 1997) presenter selected contributions to the load of GHG in CO2 equivalent terms.

Emitter	tCO2/capita/y	Emitter	tCO2/capita/y	Emitter	tCO2/capita/y
USA	22	Gabon	2.9	Kenya	0.3
UK	8.9	China	2.8	Tanzania	0.2
South Africa	8.3	Zimbabwe	2.6	Burkina Faso	0.1
Libya	8.0	Nigeria	1.6		

However, it can be seen that South Africa contributes to some 350 million t CO2/year, Nigeria to some 160 million t, while the total annual load from Zimbabwe is limited to some 30 million t and the annual load from all other sub-Saharan African countries is less than 10 million t. This is very far from the annual load from the USA which was close to 10 billion t in 1997.

It should be anyway considered that the contribution of Africa to the GHG global load is significant when considering those emissions related to land use changes. Virtually all of the carbon released to the atmosphere from land use changes (17% of the total GHG emissions and 25% of anthropogenic emissions) now comes from the tropics. This is equivalent to 8.5 Giga tons of CO2 equivalent every year. Africa now contributes to some 20% of this load (2.1 billion t of CO2 per year). 50% of the annual global carbon released from burning natural vegetation comes from Africa. Biomass burning also produces a large quantity of aerosols (extremely thin particles in the air) which partially add to the GHG effect on Global Warming.

Wind born dust also generates loads of particles in the atmosphere which partially contribute to global warming. The great Sahara dust storms are by far the largest source of dust on the planet but people have little responsibility for that. In contrary, the recurrent very large scale dust bowls generated in the dry lands of Africa by winds taking soil particles from degraded land are human made are may reach Europe and even the USA.

1.2 Specific problems related to deforestation in Africa

Deforestation in Africa keeps a steep pace, which is alarming for the conservation of natural resource and counterproductive for the needs for carbon sequestration. The corresponding dynamics are generated by the convergence of two practices: land clearing for the needs of cultivation (combining the re-opening for cultivation of land left under long term fallow and the net opening of new land) and forest degradation for logging and for the production of fuel wood and charcoal for domestic consumption by rural and urban people. The next table shows that deforestation kept high for the last 20 years. By comparison, reforestation has kept very slow, with less than 2% average of the deforested area. Reducing deforestation trend is urgently needed through appropriate public action and change in practice from local communities and entrepreneurs, which is not an easy task. The second next table shows the importance of fuel wood consumption per capita in Africa as compared to other parts of the developing world. Public policies for diversifying energy source for domestic needs had not the necessary impact for reducing deforestation, in particular for the poorest sections of the population.

Forests and deforestation in Africa

Region in Africa	Forest area million ha	% of land area	% deforestation 1990 – 2000	% deforestation 2000 – 2005	Deforestation/year Actual -Million ha
Eastern + Southern	226.50	27.8	0.71	0.74	1.7
Western + Central	277.83	44.1	0.56	0.48	1.4
Northern	131.05	8.6	0.72	0.73	1.0
TOTAL	635.38	21.4	0.64	0.62	4.0

Source = FAO Statistics

Use of fuel wood in the developing world

2005	Africa	South America	Asia
Population - Millions	868	365	3,838
Consumption – Millions m3	546	192	546
Consumption/capita - m3/head	0.63	0.53	0.20

Source = FAO Statistics

Therefore, concerted action should address three main issues:

- Reducing the encroachment of agriculture into the forests through sustainable intensification of the already cropped area and short term fallow lands;
- Reducing the use of fuel-wood and charcoal through the significant development of sources of domestic energy for the poor and enforced regulations;
- Reducing land degradation and wind erosion to cropped and degraded land through more appropriate land use systems and assistance to the improvement of vegetation cover of soils.

In spite of warning from scientists and development agents on those issues for at least the last 50 years, no significant action has been taken in most countries. This situation underlines how complex are regulations and enforcements in those domains and the difficulties for establishing adequate and effective institutions for dealing with the issues at decentralized and central level.

2. Estimated impact of Climate Change in Agriculture in Sub- Saharan Africa

2.1 Actual raw estimate of long term climate change

Sub Saharan Africa will have a high share of Climate Change Impact on productivity in agriculture in the next 100 years if actual production systems prevail. Available models predicting the range of change in climatic parameters for sub-regions in Africa still lack precision and are even affected by significant uncertainties. However, international experts agreed about the estimated impact range quoted in the following table.

Areas in SSA	Average annual temperature increase °C	Change in useful rainfall %	Change in crop productivity
West	2.5 to 3.5	0 to – 10	- 15 to - 50
Western Central	2.5 to 4	- 5 to – 5	- 15 to - 20
Eastern Central	1.5 to 3	+ 5 to + 15	0 to - 15
North Eastern	3 to 3.5	+ 5 to + 20	- 30 to + 15
Western South	3 to 4	- 5 to - 10	- 30 to - 40
Eastern South	1 to 3.5	-5 to - 20	- 30 to -40

Extracted from publications by Imperial College of London and GFAR

Indeed this estimate should be further developed in order to better describe changes that may occur during the rainy season as far as temperature is concerned, as well as in relation to the duration of the rainy season and the occurrence of drought spells within the season which may more affect the crop yields than the change in total rainfall. The already very dry regions of Southern Africa will be particularly affected by rather limited changes in the rainfall pattern. Local conditions (altitude, exposition and vicinity of large water bodies) may significantly affect the forecasted changes. Thus, such information should not be considered as applicable to a particular detailed site. Magnitude has here more importance than detailed figures. The forecasted changes in the time span of 100 years do not mean that change will be regular. It may well be that to begin with a wetter climate may prevail in a particular region before a massive drying up would finally occur and vice versa. Some other models for shorter term thus describe a wetter development of climate change in Western Africa and Central Africa in the coming twenty years. Therefore, the detailed description of the phasing of the possible changes in climatic conditions is not available to date.

2.2 What climate change practical means for Africa

It is however important to stress what changes in climatic conditions will mean for agriculture in Africa. In average, temperatures will be higher, especially in the dryer tropical and sub-tropical regions. This means that the evaporation-transpiration of water by crops will be much higher than today. Some crops may not afford the demand for evaporation and will stop growing and even wilt. This is how the main impact on crop yields will occur. This is somewhat different from the simple effect of a limited decrease on rainfall has it already happened many times in the recent past in most regions. Already some places in the Sahel regions have been hit by limited heat waves. The impact of such changes in temperatures, when fully developed, will redesign the geographic distribution of some crops like coffee. For sure, this change in temperature will affect the strength of winds, as far as the difference in temperature between areas and the difference in air pressure will change, in particular between the land mass and the sea. The increase in wind

speed will add to the water demand for evaporation and to the stress of crops. The wind erosion should tremendously increase. An increase in temperature by 4 degrees in the very dry and already very hot areas will bring the conditions for cropping close to those prevailing in an oasis.

In the drier conditions and in particular in Northern and Southern Africa, the rainfall will drop by up to 15%, which will have tremendous impact on crop development in particular if the evaporation largely increases. This may not have a relationship with the duration of the rainy season as it happened during the previous changes in the rainfall pattern in Western Africa in the seventies. However, it should be stressed that there are still large uncertainties about changes in the rainfall patterns and amount in most Sub Saharan Africa. More rains are expected in East Africa (including the Horn of Africa) through sharp changes in the pattern of the Indian Monsoon.

There will be more floods in some regions. It is possible that the unusual flooding events experienced for the last three to four years at the end of the rainy season in the Sahel zone in West Africa are part of this trend. However, as climate change is only initiated for some ten to twenty years there, much larger flooding events may be expected in the coming decades. This brings to the results of analysis developed in the Sahel and Sudan zones by geo-morphologists for already more than 30 years. Sand dunes fields developed during the last arid period (15,000 to 30,000 years BC) indicate tracks of wide alluvial deposits removing the sand from the dunes generated by massive flooding events (CAYOR in Senegal, Internal Delta of Niger River in Mali). As those deposits are well layered, those events have been receding many times there, but did not generated huge transfers of soils. The long and gently concave slopes with large alluvial deposits that prevail south from those sand dune fields are the track of former drier climatic conditions. During the last very dry period, considerable run-off occurred as far as drought did not allow for dense vegetation cover and large flooding events occurred under isolated large rains in the lowlands (Silty deposits of Sine Saloum in Senegal, of Central Mali, of Central Burkina Faso and Southern Niger correlated with terraces of Chari River and Lake Chad in Chad). However, the layers of such deposits have one to ten meters thickness and are coarse, which indicates rather rare but extremely powerful transfers of material from slopes to lowlands. The deposit ends with a thick non layered raw silt deposit possibly generated through the combined action of wind and local gentle but continuing run-off through a vegetation cover unable to maintain the soils. Further drying of the climate has generated the carving of the actual drainage network in those deposits before the climate came back to more favorable conditions to the vegetation which fossilized the landscape. Large showers on poorly covered landscape generated concentrated flows of water which dug out down to the layered deposits.

Therefore a drying climate in those environments, dislocating the vegetation cover and concentrating rains, may generate huge floods and the further transfer of considerable colluviums from the slopes to the low lands. If such dynamics of soil materials would be re-activated through climate change, it would have a rather rapid and tremendous impact on the fate of lowlands in this region, reshaping superficial deposits and washing away all investments made since Independence times for giving value to those lands (gardens, rice fields, small dams and irrigated paddies). Land and water are intricately related in the shape of landscapes through extremely fragile equilibriums and soils are an extremely thin skin of material very easily removed through land reshaping related to climate change in such environments.

It is certain that there will be more and more intense tropical cyclones, a basic mechanism for evacuating the heat from the low tropical latitudes to higher latitudes. While the Isles in the Western Indian Ocean have been experiencing one cyclone every 6 to ten years during the last century, in 2008 MADAGASCAR faced 4 cyclones. Since, tropical gales have been in number, which are degenerated cyclones. The same trend is hitting the Philippines, Japan and Southern China since a decade now. Geo-morphologists have identified the scars of previous cyclonic prone periods on the landscape. Those events have carved the actual shape of the islands in the Indian Ocean with immense ravines and cones of debris and have a share into the intense carving of landscape in Madagascar. They have contributed to shape the flood plains in Mozambique. Thus, intense geomorphic actions are expected from cyclones in these places.

The unavoidable rise in sea level will bring destruction in most mangroves in Africa and the corresponding abandonment of mangrove rice, as far as the river deposits will not compensate the rate of sea rising. This will have a tremendous impact on rice production in Guinea Bissau, Guinea, Sierra Leone and Liberia. Considerable areas of marine sand deposits on the Senegal and Mauritania sea coast will be swept away, destroying valuable humid lands used for horticulture. Marine sand deposits supporting coconut groves and lagoons will be destroyed all along the gulf of Guinea. Coral reefs will be destroyed from Mozambique to Somalia and the sand deposits bearing the coconut groves related to those reefs will be removed, in particular through many storm surges pushing high waters ahead in the land. The corresponding massive shift of marine alluviums will deeply affect the shores and in particular the river deltas. The actual questions raised by scientists about the fate of the delta of the Nile River will apply to all deltas in Africa.

The increased variability of rainfall will be annual and inter- annual. This will destabilize the actual food production systems in most semi-arid regions. The northern regions will thus be plagued by a combination of droughts and floods, while positioning planting time and harvest time would become more risky for farmers. The decrease in the number of rain days and the greater intensity of rainfall will generate more run-off and loss of water for farming if water management on slopes is not properly tailored through adequate land use.

The changes in the climatic conditions will induce swift changes in the geographic distribution of living organisms. Already one can see the shift of marine species related to tiny changes in sea temperatures and currents. Insects react fast and carry with them viruses and bacteria, including those generating diseases. The redistribution of pests and diseases for plants animals and humans will be abrupt and wide spread. This is certainly the most acute impact of climate change on agriculture and is actually poorly documented. However, for the last ten years, Leshmaniosis has moved from dry tropical areas to Mediterranean areas. The Nile fever has reached Southern Europe, malaria has progressed in altitude and northward; the Dengue fever has tremendously developed. The wheat rust has exploded on tolerant cultivars in the Near East and South Asia. Bugs have destroyed large areas of the boreal forest in Canada.

The induced effects of climate change on the distribution of living organisms is certainly the most short term and insidious impact from climate change. While corresponding changes for human health are seriously considered, the corresponding changes for agriculture are presently poorly explored, which is not supportive for preparing adapted responses. It may well be that the present delays required for identification, solutions design and application would be too long.

3. Facing Climate Change = short term and medium term impacts in agriculture

3.1 Coping strategies and strategies for facing climate change

Farmers have developed from long COPING STRATEGIES that have evolved overtime through people's long experience in dealing with the known and understood natural variation that they expect in seasons, combined with their specific responses to the season as it unfolds. The mobilization of this valuable indigenous knowledge is the actual basis for early response to the initiated climate change. Modern forecasting methods for weather, even short of capacity for the detailed meteorological events at specific locations, are contributing to decision making by farmers. So far the response is composed of cropping practices and possibly more accurate choice of cultivars in relation to the initial phase of the cropping season.

Scientists and all stakeholders in agriculture should bear in mind that Climate Change may well generate climatic conditions that have not been experienced before. Changes in temperature and rainfall patterns, related changes in the geographic distribution of living species, changes in relationships between land and water have been evocated above. Therefore, a new set of conditions and risks for agriculture will be rapidly imposed to farmers. Climate Change is a process. Thus the response may not be a new set of technologies and practices, but the capacity to adapt by steps to the on-going change, while such change may hardly be fully anticipated.

3.2 Rationale for combining mitigation and adaptation

Two different categories of actions are necessary: ADAPTATION and MITIGATION.

Adaptation is the long term adaptive strategies needed for people to respond to a new set of evolving conditions that they have not previously experienced. As the shift in climatic conditions will be continuing for some times, adaptation is a process and strategies should allow for monitoring this process. Adaptation will have a cost as it will require additional resource for the generation of innovation and the development of those innovations. It comes in addition to the budget requirements for financing the required innovation process for development and improved equity. As shocks for local economies and communities will increase, social nets for protecting the weakest and the vulnerable should be actively developed and are part of the adaptation process.

Mitigation is made of a set of measures reducing factors that induce climate change. In agriculture, mitigation encompasses forests development, cropland management, improved grasslands management, livestock management, restoration of degraded land, improved wastes management. Mitigation is a global deal. There would be a limited impact of mitigation through agriculture if the other factors generating climate change are not harnessed and in particular GHG emissions from the industry, from transport and from domestic behaviors. If agriculture was reducing its contribution by a quarter, it would only compensate for one tenth the other human made emissions. Mitigation will be necessarily rather modest to begin with and may first of all be an attempt to curb down the alarming progress of GHG emissions from agriculture. However, in the medium to long term, mitigation should decrease the load of GHG that will be in the atmosphere in the next twenty years if catastrophic scenarios could be avoided. Therefore, the

key word for mitigation is investment. The financial source of such investment is a corner stone of the mitigation strategy.

While for the sake of identification and mobilization of partnerships and financial mechanisms Adaptation and Mitigation are designed separately so far, **there are implicit rationales for adequately combining Adaptation and Mitigation**. The production losses resulting from the climatic events and from difficulties met for coping with new production conditions that were hardly predictable will drive increased encroachment on forests and savannahs by farmers if innovative and effective production systems are not developed and adopted. Natural disasters will increase poverty and vulnerability and drive further degradation of natural resources if social nets and insurance systems are not brought into effective development. There will thus be a conflict between social needs and forest development and the restoration of degraded land required for mitigation if adaptation is not effective and does not provide for equity. In the other hand, adaptation may very much contribute to mitigation. Limiting temperature rise for crops implies better integration of trees in production systems, through the provision of shelter and wind screens. Improved water management is a key to carbon sequestration by crops and pastures. It requires land use planning and land development, which are critical components for LULUCF (Land Use, Land Use Changes and Forestry). Improved water management will help facing increased water demand from crops and facing drought spells during the cropping seasons. It may help in the regulation of water regimes in the drainage system, protecting investments and insuring water supply for irrigation in the lowlands. Improved livestock development requires improved feed production and use within a new climatic environment. The management of fodder and fodder providing trees is an important asset for providing proper soil cover in the range lands and pastures this limiting wind and water erosion and regulating water flows to the lowlands and to the aquifers. Accordingly, investments for the sake of mitigation of climate change would generate favorable conditions for the deployment of adaptation to changing conditions. Organic wastes management should contribute to the intensification of farming and to increase carbon stocks in soils. Energy development in rural areas should reduce carbon foot prints while providing an important lever for economic development and the alleviation of poverty, the reduction of vulnerability.

Therefore, while combining mitigation and adaptation, win- win solutions mobilizing stakeholders and supported by adequate institutional development should be looked for, combining the abandonment of the carbon based energy sources, the economic development and improvement of equity and the intensification of production systems in agriculture related to the accumulation of carbon in the resource base.

3.3 Development, resilience and climate change – risks management

Promoting development gives more resilience to societies. Such resilience is important for developing more capacity for organizing adaptation. Rural development in Africa is definitely based on the development of institutions monitored by relevant stakeholders for ensuring the satisfaction of their needs, the negotiation with other stakeholders and the fair retribution for contribution to added values and production. While those local institutions have been so far mostly oriented for the promotion of income generation and security for basic needs, there is a need to insert issues related to resilience and capital raising in their management, in particular in

relation to climate change. The crucial relationships between development and the rehabilitation of natural resource should be underlined so that capitalization processes and the related social appropriation of resources would be basic part of the mindsets. This brings to a revision of the regulations related to property rights and to the management of the commons by communities, to a revision of the state property of natural resource which has been an open door for the spoliation of rural communities in so many situations. However, local groups of operators should not be entitled to confiscate public goods; a set of user rules should be urgently designed with enforcement methods and compensation measures in case the rules will not be respected by individuals and communities. This considerable agenda requires juridical action and contribution from specialized skills.

The actual state of development of social capital, local institutions for the monitoring of the use of natural resource and for the promotion of sustainable production chains is very unequal from one state to another. This results from the historical development of the organization of the society and from political conditions. Cooperation between organized structures of the civil society would be a lever for promoting changes in the countries where such development is so far limited in order to achieve socially acceptable combinations of adaptation and mitigation.

Addressing risks management is possibly the most important task. It cannot be based only on technology, but encompasses social capital, institutions and compensation systems. Storing food for facing shortages is already organized from community level to national level and trade arrangements may bring the corresponding logistics to sub-regional level. Developing food production alternatives may also mitigate risks for food production. Financial stocks are already under development for purchasing imported food if the need may be. However, the distribution of food aid had always a number of distorting effects on local and national economies. Safeguarding the food purchasing capacity of consumers is essential so that markets would play their role for regulating food supply. As far as most of the rural population produces food for self consumption in Africa and even a part of the urban dwellers relay on food transfer from their relatives in rural areas, the disruption of food production through poor climatic production is an immediate and massive cause of shortage of income for rural people and their relatives in urban areas. Diversification of production is an essential asset in such systems in order to improve the management of risks. Farmers have already developed strategies for facing such risks; a largely developed strategy in the semi-arid tropics is the raising of extensive livestock which is mobilized in case of short terms difficulties. However, livestock markets generally cannot face massive destocking of herds and prices collapse when farmers are affected by risks and sell their animals. In case of drought, the quality of livestock products decreases rapidly and farmers get very little from their sales. This risk management strategy is not fitting with the risks management needed in relation to the development of climate change.

The development of value chains for wood products, in particular for the generation of energy through carbonization may provide a new route for income in case of droughts. Farmers may then sell to relevant energy production chains and wood products production chains some trees “on feet” from their plantation against immediate fund release while the industry may use those trees according to their need at a later stage. Such development would participate to mitigation if the necessary local institutions would provide guaranty that the corresponding wood products would not be consumed for fuel-wood or charcoal or destroyed through bush fires while already

sold to the industry. The development of fodder reserves, in particular from bush trees, may provide another source of income for farmers in case of drought through the selling of this fodder to herders in need for sustaining their livestock. Accurate organization for production and delivery and the corresponding organization of herders may assist in generating complementary income and regulating the sales of livestock resulting from destocking in case of drought. From those two examples, it is proposed that new production chains based on service and trade and social capital development at community level would facilitate facing climatic shocks and also would contribute to the recapitalization of carbon stocks in the watersheds.

Crop insurances and livestock insurances are useful developments. However, regulations are needed in order to protect farmers against crooks and initiatives not properly backed by competences and the necessary re- insurance networks. It is particularly necessary to design by law when the risk is no more a matter of insurance but a natural disaster that will be taken charge of by the state. All insurances related to climatic conditions should refer to documented "climatic norms" and identified deviances from the norms that insurance would consider for compensation. Compensation is mutual by nature within an insurance system: the payment for insurance from those not affected supports the compensation for those affected by a risk. If all subscribers are affected together by the same risk at the same time, which is often the case with climatic events, the insurance systems should redistribute the gains from favorable years to risk prone years. Therefore, crop insurances related to multi- annual management and large areas may hardly be developed by small scale financial organizations. State regulation is needed to ensure that subscribers are protected through re- insurance systems and a proper identification of the cost of insurance in proportion to the proposed compensation.

Mitigation in Africa may hardly succeed if it does not contribute to development and does not provide for resilience. Forest re-plantation cannot be sustained if poverty is not alleviated in rural areas, as far as people will smuggle the corresponding wood products to generate income. Forest plantations cannot be sustained and land rehabilitation cannot succeed if farmers continue to look for new land in order to develop extensive farming or to face the degradation of their own land. Land rehabilitation cannot happen if people are still mostly depending on wood based energy in rural areas and in most cities. Land rehabilitation cannot happen if the livestock population continues to increase while pastures are invaded by croppers and the herding practices are still mostly based on the harvest of natural fodder. Land rehabilitation and reforestation cannot happen if bushfires are not put under social control. Thus mitigation depends on the emergence of land use rules and the enforcement of those rules through the promotion of social capital and the development of accurate decentralized institutions in the wake of adopted and decentralized development programs engaging all local stakeholders with a shared vision. Mitigation requires in most countries a sharp modification of regulations and of the methodologies and budget for enforcement.

The products from mitigation: wood products and non wood products from forests and bush lands, environmental services, alternative generation of energy should visibly contribute to local development, engage stakeholders in decisions, provide employment and incomes, contribute to poverty alleviation and provide for the reduction of vulnerability. Thus mitigation programs should be anchored into both the development of innovative value chains and the

empowerment of locally organized people. Such development requires investments, capacity building, institutional development, policy development and regulations.

Mitigation in Africa will not help for adaptation as it should do if it does not contribute to risks management. Mitigation should provide for alternative financial resource in case of disruption of income source through climatic events as already suggested. Mitigation should help in limiting the impact of temperature increase, heat waves and increased winds. Mitigation should help in restoring the carbon stocks in farming, thus improving the capacity of soils to hold moisture and nutrients. Mitigation should help in capturing and keeping water in watersheds. It should restore biodiversity so that people could find alternatives for income in case of crop failure or accidents for their livestock. Mitigation should provide for the necessary ecological services in order to limit the impact of outbreaks of pests resulting from the shift of living species induced by new climatic conditions. For all those reasons, mitigation should be decentralized, owned by organized local people, protected by accurate national and local regulations and enforced by relevant institutions, supported by accurate capacity building and monitored by competent institutions providing local advisory services. As already proposed, the accumulation of capital generated through mitigation enforcement may contribute to risks management through accurate development of value chains and institutions.

A failure in adaptation of agriculture to climate change will jeopardize efforts for mitigation. Mitigation efforts should support adaptation, providing contribution to innovative production and income generation systems, harnessing risks and providing for insurance. Mitigation programs should contribute to develop the social capital necessary for the success of adaptation programs. Mitigation programs should provide venues for capital raising for farmers, herders and rural communities through a contractual approach for development.

3.4 Water management, adaptation and mitigation

Water management is the key issue for facing changes in rainfall pattern and increased evaporation related to hikes in temperature. Thus leakages in the water supply system to crops should be put under control. Evaporation and impact of heat waves and wind should be limited by shade and wind screens which is related to tree plantation or protection. Run-off water should be collected and redistributed to crops. Water infiltration to ground waters should be facilitated. Water in the drainage system should be collected and protected from evaporation. Lowlands should be protected from flooding by dykes and those dykes protected through trees plantation. The rehabilitation of degraded land should contribute to regulate the water regimes of drainage systems, thus facilitating water use. Such rehabilitation may provide venue for harvesting rainwater in support to agricultural production.

There are specificities of water regimes in Africa, as compared to other continents. Firstly, surface water is very unevenly distributed and the ratio of surface water to rainfall is poor. Secondly, the amount of surface water will be seriously affected by reduced rainfall through climate change, which will affect the potentials for irrigation development.

Africa has 36 international river basins spanning 64% of the continent and holding 90% of all surface water resources. In relation with a dominant rather flat landscape, only some 20% of rainfall is converted into run-off water in Africa against 40% in Asia and in South America.

Considerable areas have no organized drainage (endoreism) and water in excess to evaporation if providing ground waters. In the sudanian - sahelian and southern regions run-off water is respectively 6% and 9% of rainfall. All of the large lakes in Eastern and Southern Africa show a less than 10% run-off to rainfall ratio. For such reasons, water development in Africa may hardly consider development schemes used in the other continents and should develop genuine approaches. Water development schemes settled in central parts of India may be usefully considered, which are based for millennia on watershed management and local water harvesting. New small scale and flexible water storing technologies could be tested at large scale.

The effect from a 10% drop in rainfall on perennial drainage density is important in Africa. A recent aggregation of available hydrological data by the Imperial College of London concludes on what such reduction would imply for different amounts of annual rainfall:

- For less than 400 mm, there will be no more perennial drainage of importance;
- For 400 to 600 mm, the actual drainage would decrease from 100% to 60%;
- For 600 to 800 mm, the actual drainage would decrease from 30% to 5%;
- For 800 to 1200 mm, the loss of drainage would be from 5% to nil;
- For more than 1200 mm, there will be a slight increase in drainage.

This kind of change would have a tremendous impact on the main water basins, especially for rivers supplying water to very large dry areas. Already, the ZAMBEZI River would have lost 1/3 of its annual water flow. While the NILE River mostly fed by humid highlands would not be much affected, Rivers SENEGAL, GAMBIA, NIGER, VOLTA, KUNENE, OKAVANGO, ORANGE and LIMPOPO will be badly affected. More hydrological modeling is needed to describe the fate of water availability in those basins. Massive change of water harvesting in the upper basins of those rivers will also significantly modify the downstream.

In Sub Saharan Africa, water withdrawals for agriculture amount only 3% of its total renewable water resources despite the highly spatial and temporal variability of rainfall and resultant low land productivity and crop failure. Irrigated areas progressed from some 2.2 million ha to 3 million ha between 1985 and 2000. However, as the cropped area has tremendously progressed during the period, the ratio of irrigated areas in the cropped area decreased from 2% to 1.8%. The role of irrigation in the total crop production thus remains very low. In average, 46,000 ha are brought under irrigation every year since 2000. 1 million additional ha could be irrigated by 2025. This will not significantly improve the irrigated area to cropped area ratio for the sub-continent. It is important to know that some 2 million ha prepared for irrigation are not in use and degraded, which is a considerable wastage of resource. It is now documented that private and small scale irrigation systems managed by local farmers' associations are more effective and have a longer life span than large scale and public irrigation schemes. Strategies for developing irrigation should change in the continent, which is part of the mitigation and adaptation strategy to Climate Change.

A wide and integrated action plan for water management is needed. It should encompass watershed management with the necessary modification of land management and vegetation cover necessary for charging ground waters and for regulating surface water flows. Local water storage providing for securing rain fed crops should have particular attention. Water storage cannot anymore be considered only on lowlands. Considerable efforts and investments are

required for harnessing floods through dykes and dams. Cropping on land released by receding flooding should be organized at large scale. Public and private investments should be combined and transfer of capacity from the central level to the decentralized local authorities is necessary and should be associated with the provision of adequate technical assistance to those local authorities. Local entrepreneurs should be encouraged for delivering the corresponding works and trained in order to insert sustainability issues in the concept and building of local infrastructure. Local institutions are required for proper insertion of water works into an integrated management of recapitalized watersheds through mitigation measures.

3.5 – Short terms and long terms impacts in agriculture from climate change and corresponding objectives for mitigation and adaptation

In conclusion, climate change will have short term impacts on farming and short term impacts on water availability. It will have medium term impacts on vegetation cover. It will have short and medium term impacts on pests and diseases distribution and outbreaks. Climate Change will generate important human health issues. Those impacts of Climate Change on agriculture will have effects on food availability in Africa and globally and thus will affect local food security and local and international food prices.

Corresponding objectives have been identified for integrated mitigation and adaptation:

- Massive support to investments and promotion of conducive social and economic environments through regulations and public programs and expenditures;
- Large scale development of infrastructures in combination with support to decentralized initiatives for changing watersheds management through land rehabilitation and development based on local institutions for land use planning and a new approach of social access to natural resource;
- Pro-active public support to private initiatives for risks mitigating systems and corresponding institutions; design of public measures for natural disasters management;
- Development of innovative rural development policies.

4. Climate change has already been initiated while considerable changes have happened

4.1 The population has largely increased and migrations have taken place

For the last 25 years, the total population in Sub Saharan Africa increased by 93%. It will increase by more than 100% in the coming 20 years. This development, combined with the need for improvement of the availability of goods for consumption, represent a need for a huge increase in the production of food, fiber and other commodities. For the last 25 years, the agricultural population in Sub Saharan Africa increased by 58%. It will increase only by 31% in the coming 20 years. The difference in growth rate between the rural population and the total population has serious implications for farming. One rural person was producing agricultural commodities for 1.48 people in Sub Saharan Africa in 1985 (not considering production for exports). In 2010, this ratio is by

1.73 and in 2030 this ratio will be by 2.1 persons. Therefore, most farmers should shift from production schemes firstly addressing self consumption to production for marketing. Labor intensification is necessary. However, this ratio of producers to consumers is still quite low as compared to the prevailing situation in other continents, which generates limitations to such intensification.

Urban people are shifting more and more to food consumption patterns quite different from traditional ones in rural areas. The role of rice and wheat are increasing in the diet, as well as the share of fats and animal products; the consumption of vegetables and fruits is emerging. Most farmers are still concentrating on traditional crops and animal products and thus cannot supply the emerging markets. The lack of processing of traditional products, related to the general absence of standards in production, is jeopardizing the development of the use of traditional products by urban consumers. Food imports are not only compensating for food production deficits but generate new food habits which are barriers to the progress of domestic agriculture.

In addition to internal migrations from rural areas to cities, there is a constant migration from landlocked areas to coastal areas where urbanization goes particularly fast. This movement of people in Africa should accelerate as it does in Asia. Most coastal areas are more humid than landlocked areas with the exception of the western side of the Sahelian and Sudanian zone and of East Africa. Such migration, if politically feasible, is a solution to the food equation problems of several dry and landlocked countries. It will transfer the needs for food production increase from the dry lands to more humid lands.

The adaptation to climate change should provide venue for increased productivity by farmers in relation with the emerging markets demand, which presently will require the mobilization of more water for agriculture. Action on patterns of food diets is necessary from governments and from consumers' associations and farmers' associations. Farmers should tend to produce what people consume and people should tend to consume what their farmers produce, limiting the cost for transportation in food supply schemes. Public action for stimulating the development of private initiatives for processing food production is necessary so that local food products would be competitive with imported products and would be more attractive to consumers than imported products. The role of multi-national food industry firms on food markets should be negotiated so that they would contribute to mitigation and adaptation and may develop their business while contributing to the development of local small scale farmers.

4.2 The cropped area has tremendously increased

For the last 25 years, the cropped area in Sub- Saharan Africa increased by 69%. It should be underlined that the cropped area doubled in West Africa, while it decreased in Southern Africa. The actual cropped area is estimated to 182 million ha. If the productivity of the land does not significantly improve from 2010 levels, the cropped area in the sub-continent should double in the coming 20 years. If crop yields are severely affected by climate change, the expansion of the cropped area may eventually be higher. The corresponding encroachment on new land resulting from a continuing development of the cropped area as per the last 25 years would take out from natural vegetation the equivalent to 1/3 of the actual woodland and forest areas. Such development would completely overwhelm any large scale development of forest plantations on degraded land, dwarfing

any program for mitigation through trees plantation. This underlines again the crucial need for supporting the intensification of farming systems through the development of adaptation and mitigation to climate change.

4.3 Crop intensification has been very far from matching population growth rates

Actual crop yield increase rates for the last 25 years cannot meet production requirements for the next 20years. There is a need for structural change in agriculture which will support a new deal for development of intensification. As far as climate change will impose new constraints to farming and to crop yields improvements, this structural change should be particularly effective on farmers' adoption of innovative technologies increasing their productivity.

From FAO statistics, the crop yield increase index for aggregated countries has been somewhat different according to groups of crops. As far as cereals are concerned, progress has only be steady for maize in Southern and Western Africa and for sorghum in Southern Africa. As far as leguminous grains are concerned, progress has happened only in West Africa, with some breakthrough for pulses and groundnuts in Southern Africa. As far as root and tubers are concerned, only the production of Irish Potatoes progressed quicker than the population.

Crop	Eastern Africa	Middle Africa	Southern Africa	Western Africa	Crop	Eastern Africa	Middle Africa	Southern Africa	Western Africa
Rice	1.18	0.97	0.66	1.12	Groundnuts	1.12	1.14	1.70	1.31
Wheat	1.27	1.98	3.51	0.85	Seed cotton	1.31	1.08	1.13	1.18
Maize	0.92	1.15	2.07	1.66	Soybeans	0.66	0.71	1.07	3.10
Sorghum	1.24	1.11	1.43	1.13	Cassava	1.24	1.16	-	1.19
Millet	1.04	0.93	0.82	1.17	Sweet potatoes	1.10	0.79	0.79	0.62
Beans dry	0.83	1.03	0.89	1.96	Irish potatoes	1.32	1.46	2.08	0.67
Pulses	1.39	1.08	1.42	1.09	Bananas	1.22	0.87	3.42	1.26
Cowpeas	1.16	1.19	0.88	1.64	Plantains	0.99	1.22	-	1.34
Population	**1.82**	**1.95**	**1.52**	**1.82**					

Source: FAO Statistics

4.4 Adaptation and mitigation while changes in farming and food demand will continue

It can be seen that a supportive action plan for intensification is urgently needed and should not be disconnected from plans for adaptation and mitigation. Funding for investment in agriculture is scarce and funding needs are huge for Sub- Saharan Africa. Therefore, win- win situations for addressing intensification and for facing climate change should mobilize most of the available funding. The necessary intensification of farming should take the utmost care of the on-going change in food demand in quantity, quality and nature. Joint action by the governments and by the Civil Society is required. Sources of funding should be shared by those two major stakeholders of development and conservation of natural resource. Joint action from Governments and the Civil Society should orient the choice of consumers, orient the selection of production options by farmers and herders, facilitate decentralized action for investment, land use planning and development and the emergence of necessary institutions, regulations and enforcement methods. Governments have a particular role for public investments and for providing incentives for the right choices and for taxing activities detrimental to the environment and natural resources.

5. Proposed actions for intensification, adaptation and mitigation of climate change

5.1 The domain of proposed action

Proposed actions for intensification, adaptation and mitigation of climate change include:

- Support to the development of agricultural markets;
- Rehabilitate the role of trees in cropping systems and watersheds;
- Develop water harvesting for complementary irrigation;
- Support the use of agricultural inputs;
- Develop the production of fodder and feeds for more environmentally friendly livestock systems;
- Promote mechanization and motorization in agriculture;
- Promote the recycling of organic wastes in agriculture;
- Develop energy production and distribution in rural areas;
- Facilitate access of farmers to credit systems;
- Develop crops and livestock insurance;
- Develop rural infrastructures;
- Reinforce decentralized food stock systems;
- Develop social nets alleviating vulnerability in rural areas.

The present chapter will focus on technical actions and their relationships; the next chapter will consider social actions and financial support to development.

5.2 Support the development of agricultural markets

Market development is the only sustainable way for increasing farmers' income and capacity for **intensification**, for increasing **resilience** to shocks. This is the first necessary step to unleash forces for **adaptation** to climate change. Market development is necessary for facing the increased development of the demand for agricultural products which will result from the population growth and from improving food consumption as well as from the growing demand from agricultural non food products. Market development is a powerful tool for limiting imports and facing the growing demand through domestic production. Thus market development is a crucial tool for **rural development**, a necessary condition for the deployment of **adaptation** to climate change. In turn, rural development provided the necessary conditions for the deployment of **mitigation**.

Market development should be **conducive** for reducing GHG emissions from agriculture and for developing natural traps for those GHG which are the two legs of **mitigation** in agriculture. Market development should be **oriented** for regulating the harvest of natural products, supporting in particular the maintenance or even the re-establishment of **bio-diversity**.

Market development should be supported through **public action and contributions from the civil society so that farmers have a better share of the added value to their products**. This empowerment is closely related to organization and to the establishment of regulations that would

promote fair business by stakeholders in production chains. Market development should include mechanisms for absorbing given levels of surpluses and for facing shortages generated by adverse climatic conditions through the federation of production chains operating with the same commodities. **Economic dialogue would thus provide for favorable conditions for adaptation**. On this basis, economic dialogue may take place so that mitigation would be marketable, providing economic incentives to stakeholders.

Those orientations are considered by FARA central to the joint success of adaptation and mitigation. It is recognized that the pathways are difficult to find that would be acceptable for all stakeholders. FARA has promoted the concept of **Innovation Platforms** through which, mobilizing the methodologies of Integrated Agricultural Research for Development (IAR4D), all stakeholders in a production chain develop markets and accordingly promote innovations in support to agricultural intensification, increased competitiveness and product development. This approach should now be extended to intensification, development, adaptation and mitigation.

5.3 Rehabilitate trees in cropping systems and watersheds

Developing trees in the cropped areas integrated in the production systems will provide resilience and mitigation. The plantation of hedges and the association of trees to crops by millions of farmers will generate more tree plantation than any public plantation of forests and will contribute to both adaptation and mitigation. It will fix carbon from the air, provide wind screen and shelter thus limiting the rise in temperature and evaporation by crops. It will limit wind erosion and reduce the load of soil particles in the atmosphere. Tree leaves provide abundant organic material for mulching and plant nutrients, recycle nutrients that have been leached out deep in soils. Their role may be higher than the role of crop residues in increasing the carbon content of top soils and in supporting intensification through improved soil fertility. Wood from young branches when properly shredded is particularly efficient for improving soil structure and soil water retention. Therefore the combination of mechanization/ motorization and tree plantations in the cropped areas provide for a completely new situation for sustainable farming development.

Developing trees in the watersheds facilitates water retention, land conservation and mitigation. Replanting trees on slopes rehabilitate the land and generates timber, wood for energy, fodder and non-food products if properly managed by entitled communities. It provides for carbon fixation, ecological services and income diversification. Replanting trees on waterways and in lowlands protects against damages caused by run-off, gives value to flood prone areas with accurate tree species. This action is also providing for carbon fixation, land resilience, ecological services, income diversification. Rehabilitating trees in the watershed provides support and shelter for biodiversity.

It is thus proposed that funding for tree plantation in cropped areas should be adapted through modified REDD+ in line with LULUCF orientations.

5.4 Water harvesting for irrigation

Water harvesting for complementary irrigation of rain-fed crops or for small scale irrigation is an important contribution to adaptation to climate change. It is thus recommended to promote in first instance local associations for water harvesting and the rules for water use and for the maintenance

of infrastructures related to water harvesting. For the sound development of water harvesting techniques, land use planning by local communities and local governments should be supported so that the settlement of water harvesting devices will be adequately inserted within land rehabilitation measures. Local governance, public and private investments, users' commitments should fit within a vision for watershed development.

In most cases, it is necessary to profile the land for harvesting run-off water, and particularly the cropped areas. Minimal terracing and the organization of protected waterways are combined with the development of local reservoirs and related spillways. Farmers should be involved in the development of landscaping in their territory so that they would be informed about maintenance techniques. Technical guidance, financial services and guidelines for decision makers in rural communities and local governments should be provided by specialized public services so that private suppliers and entrepreneurs will e able to develop the reservoirs with the necessary landscaping through accurate partnerships with concerned farmers.

Technical support and financial services should also be organized by farmers' organizations and public services for the promotion of adequate complementary irrigation techniques (low pressure drip and gravity systems) and for training farmers' associations about the best strategy for managing the stored water. It is necessary to organize prevention against water born diseases that may be generated by the reservoirs.

Water harvesting is also supportive for mitigation of climate change. It is a technology that encourages carbon storage in soils through increased production from irrigation. The harvested water can be used for securing reforestation and rehabilitation programs. It contributes if properly developed for reducing social vulnerability as far as it provide conditions for diversification and the corresponding cottage industry for processing generated goods.

Funding for developing water harvesting at large scale could be tapped from funds promised through the L'AQUILA Declaration by G8 and used through CAADP programming at country level. However, it is essential that most of such funding would be mobilized for decentralized action by local communities and governments through contractual approaches. Specific financing institutions with steering committees representing the parties should thus be established.

5.5 Support agricultural intensification through the use of inputs and motorization + mechanization – Develop rural infrastructures

Support to agricultural intensification should combine sustainable use of agricultural inputs and the promotion of mechanization and motorization in agriculture in order to provide for sound and progressive increase of labor productivity while generating resilience. Inputs are the fuel for the farming engine. Inputs efficiency is the leading factor for their economic impact. Better than looking for the maximal return from input use, which generally requires unaffordable investments for small scale farmers and increase financial and technical risks related to climate change, the programs should aim at the best efficiency, which is obtained with rather moderate inputs use as compare to their use for maximal return. Inputs are the first lever for increasing land productivity. Their use should thus drive action for limiting further development of the cropped area, if farmers would have

more economic advantage in using inputs on available land than in opening new lands for cropping. Water availability promoted through water harvesting should limit risks for cropping and contribute to secure the efficiency of inputs use. Inputs are key factors for improving the productivity of labor. Increasing this productivity is an efficient drive for limiting the economic advantage for opening new land for cultivation. Increasing costs for opening new land to cultivation through taxation by local communities could be combined to the monitoring of the availability and cost f inputs at farm gate to orient farmers towards intensification.

Improving the productivity of water, inputs are an important contributor to adaptation. Accurate plant nutrition gives some resilience to shocks to many crops. However, excessive nitrogen use in the contrary generates more susceptibility of those crops to droughts. Thus, there is a convergence between inputs use, adaptation and the reduction of transfer of nutrients to the environment. Improving land productivity, inputs secure the generation of food stocks necessary for addressing the regular supply of markets, if adequate storage and marketing systems are in force.

The efficiency of inputs is improved by the upgrading of the status of natural resources supporting the production systems. Efficiency of inputs is poor on degraded resource base. Inputs efficiency is also badly affected by the occurrence of risks when the resource base is degraded. Thus, through the improvement of the resource base, mitigation should provide for more efficient and secured inputs use. Improving risks management in cropping through the combined development of mitigation through reforestation and the rehabilitation of soil fertility by vegetation cover in the one hand and water harvesting for complementary irrigation will provide powerful support to the intensification of cropping systems through inputs use.

Mechanization supports labor intensification in agriculture for land cleaning and preparation, for crop settlement (especially in mulched based cropping recommended within conservation farming). Mechanization provides a wealth of new opportunities for saving labor for weeding, harvesting, post harvest activities and transport. Thus, the introduction of machinery is an important assistance to farmers to manage risks and to value opportunities. Traditional operations are tremendously improved with adequate hand tools (pedal pumps and Archimede wheels for water pumping, threshers, shelling machines, de-hullers, pickers, scythes and sickles for fodder collection). Animal draught should be encouraged wherever competitive and feasible for labor intensification. Adequate tools are generally available for motion by draught animals. An important function of draught animals is transportation. Carts are available. The multi functionality of draught animal is an important advantage of this option for mechanization (energy, dung, meat, milk, siblings).

Motorization is a big plus for adaptation with some antagonisms to mitigation. Indeed, motorization requires access to energy sources (gas, fuel, electricity) which generates GHG emissions. Motorization may address actions on a “fixed” site, for example for water pumping, for post harvest operations and processing. Biogas, vapor, electricity resulting from processing agricultural and consumption wastes may support fixed motorization. Proper organization and mobilization of organic material may contribute to mitigation. Motorization may address action through movement on a given area (land shaping, cropping, transport). Fuels are required for most actions through movement, which is against mitigation. However, bio-fuels (oil and methanol) may be locally produced and locally used through the development of wastes lands. If the carbon balance of such

production and use of such bio-fuels is not increasing the load of GHG in the atmosphere, this development may contribute to mitigation.

Developing rural infrastructures in support to agricultural intensification and the adaptation to climate change should aim at four objectives:

- Facilitate the marketing for inputs and outputs;
- Harness natural resources for development;
- Empower people and drive social organization;
- Monitor and mitigate risks.

Several domains will benefit from consistent investments. Those investments should combine public action and action from the benefiting stakeholders, this facilitating appropriation and maintenance. Among such investments domains, some may be highlighted: rural and feeder roads; water storage and distribution; dykes against floods; storage for agricultural commodities; decentralized energy generation mobilizing renewable resources; communication; capacity building.

Rural infrastructures and the corresponding investments are absolutely necessary for adaptation and for mitigation together and will serve the two purposes. Key concepts are proposed for identifying, planning and developing infrastructures: decentralization and the participation of stakeholders. Other key concepts are proposed for the management of local infrastructures: the development of users' association and the settlement of fees system for access and use in order to secure social access and maintenance.

5.6 Environmentally friendly livestock systems

Improved land management for livestock systems, livestock nutrition and livestock wastes management should be combined for improving the environmental impact of livestock.

Improved land management for livestock systems is based on social organization. Pastures should be rehabilitated through the use of leguminous species and species limiting de-nitrification (Bracharias). This would contribute both to mitigation and adaptation. The rotation of pastures with crops would increase carbon fixation in soils and contribute to mitigation. However, farmers have been reluctant from long t such development, possibly because the necessary mechanization for plowing pastures and for resettling pastures is not yet available. Grazing areas can be rehabilitated through the introduction of indigenous fodder trees, providing for both adaptation and rehabilitation. Paddocks could be organized for rotating livestock on the land, thus limiting trampling, facilitating re-growth of fragile species. Fencing with hedges is necessary if the use of metallic fencing is too costly, but requires time for establishment and maintenance. It would actively contribute to mitigation if socially acceptable. Indeed, in many cases this approach has been a way for farmers to take pastures from herders. No grazing feeding techniques could be encouraged, which provides for better use of areas with high fodder production and the mobilization of crop residues while reducing sol trampling. There is a conflict in conservation farming between mulching and the use of crop residues as fodder.

Improved livestock nutrition should limit the emission of methane by livestock. It would contribute to mitigation but requires in depth changes in the production and management of feed that seems out of scope for most African herders. An important herders' empowerment is necessary for such development.

The improved management of livestock wastes requires social, organization and regulations. Improved storage and mixtures with low nitrogen content vegetal wastes would reduce GHG emissions (Methane and Ammonia) and the pollution of surface and ground waters. This will contribute to mitigation. Facilitating the recycling of livestock wastes in cropping systems contributes to intensification and adaptation and will be considered in next chapter.

5.7 Recycling organic wastes in agriculture

The current situation for the use of organic wastes is contrasted. Crop residues are the most important organic waste in rural areas. Ratio of harvested products to wastes is by 1 to 1 to 1 to 2. Livestock systems when developed use large proportions of crop residues. Animal wastes are related to the nature of livestock and to the degree of intensification of livestock systems. Ratio of animal products to wastes is by 1 to 4 to 1 to 10. Post harvest residues are very different in relation to harvested products. The ratio of final products to wastes is by 3 to 1 to 10 to 1. Processing residues from cottage industries usually represent 10 to 20% of the final products, but may represent for some productions up to 80% of processed materials (non edible oils). Thus, at village level, agricultural wastes are 1.5 to 3 fold the mass of marketed products from farms. The logistics for the handling of those wastes for further use is problematic. Burning residues or keeping wastes hips is common, which generates pollution and GHG emissions.

Organic wastes have a significant potential contribution to adaptation and mitigation. Mulching all crop residues is feasible if crop yields are modest and would contribute to the fixation of carbon. However, such mulching may release Nitrous oxides. Biomass in excess from crop residues should be evacuated from the fields (sugarcane, intensified cereals). Recycling raw or composted animal wastes, post- harvest residues and residues from processing provides valuable inputs for cropping. However, transportation and incorporation in the cropped soils of those residues are serious issues. Processing organic wastes for energy production is possible if transport is available for bringing those bulky products to the energy plants.

5.8 Energy production and distribution in rural areas

Presently, most rural inhabitants have no access to energy, but for some transport through the commercialization of petroleum products. Local access to energy is a major lever for rural development and thus a factor for resilience. The traditional ways for generating power in rural areas are very costly, as combining costs for transporting fuel and costs for distributing power in addition to the cost for fuel. Alternative solutions are now available which would combine mitigation and development:

- Solar power for pumping drinkable water and for providing low intensity power (light);
- Biogas for moving fixed motors on farm or for storage (post- harvest and processing);
- Bio-fuels for local use of moving motors (tractors, transportation);
- Carbonization of wood products + cellulosic dry wastes for power at community level.

The advantage of carbonization is the production of BIOCHAR, high carbon content, light and very active product improving soil fertility and water holding capacity. This technical solution is thus supporting adaptation and mitigation.

6. The essential action for social risks management

6.1 Facilitate farmers' access to credit systems and develop crops and livestock insurance systems

Investment is the key word for Adaptation and Mitigation at community and at farm level. Combining credit and insurance is necessary in the context of increased risks as generated through climate change. Credit for agriculture is the multiplying factor for farmers' investments. Some recommendations may be stressed:

- A national credit system should better subsidize rural credit than inputs, as it has been successfully implemented in Brazil;
- A credit system should address agricultural inputs with contribution from the inputs industry and wherever possible from the production to consumption chains through contractual farming agreements;
- A special credit system should address farm mechanization and motorization;
- Policies should anchor farm credit on real assets through land deeds.

Insurance is a safeguard for investments and a shield for credit. Some recommendations may be suggested:

- Crop insurance should be based on documented decisions by independent commissions about climatic conditions. Thresholds of climatic conditions should generate indemnities;
- Livestock insurance should be based on documented decisions by independent commissions about the availability of fodder. Thresholds for this availability would generate indemnities;
- Insurance indemnities should first of all repay for credit, securing the financing system for agricultural intensification and adaptation.

6.2 Decentralized food stock systems

Such decentralized stocks are essential for providing immediate risks management in case of food shortage at community level. Some systems are already in place in Africa for generating and managing those stocks:

- Marketing arrangements may facilitate the earmarking of a percentage of trade products in order to support the composition of provincial security stocks of food on which providing communities have rights;
- Community stocks may be encouraged through the system "credit on stock" (warrantage) as a local insurance;
- Valuable wood products from plantations may be mobilized for food purchase by communities in food shortage situation.

6.3 Social nets alleviating vulnerability

Social nets are needed in order to alleviate vulnerability. Already some formulas exist which may support the implementation of adaptation and mitigation:

- Public support for employment and income to vulnerable people for mitigation purposes;
- Jobs at community level in relation to adaptation: water harvesting investment and management, trees development, energy generation in substitution to fuel wood and charcoal, keepers of common.

7. Conclusions

Climate Change is making more urgent the complex tasks for rural development and agricultural intensification. Adaptation and mitigation should be intricately inter- related and support rural development and intensification. For the joint implementation of mitigation and adaptation, social organization, private, cooperative and public investments should be closely coordinated; The role of the civil society in such development is essential but the government should be firmly committed and consistently organized through accurate planning, budgeting and monitoring. Education, information and empowerment of the civil society are essential for the necessary involvement of all concerned stakeholders. The organization of risks management is a pre-requisite to practical action for reducing the impact of climate change. The objectives are two prone: securing the asset of stakeholders and securing the development tools. Social nets should efficiently protect the vulnerable. Different financial tools should be mobilized: carbon markets, REDD + and other LULUCF financing mechanisms as well as CAADP funding and specific donor support as possibly generated through the L'AQUILA Declaration. This task is huge for the continent and requires intense and effective coordination.