Managing Southern Africa's Soils and Other Natural Resources for increased Agricultural Productivity under a Changing Climate

a

Background Paper

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A. Background and Introduction

1. The objective of the SACAU 2015 Annual Conference is to explore innovative and sustainable options for increasing the productivity of agriculture and of the key natural resources on which it depends to sustain production of food for a growing world population. The natural resources in question include soils and water; forests and woodlands (especially trees integrated in farming systems); rangelands; and fishery resources. Taking care of these resources is a matter of enlightened self-interest by the farming community since these resources are the foundations on which sustainability of farming and its prosperity rest. The SACAU choice of natural resources as the Conference theme is particularly fitting in that under Resolution A/RES/68/232, the 68th Session of the UN General Assembly declared 2015 the International Year of Soils (IYS). Within the framework of the Global Soil Partnership and in collaboration with Governments and the Secretariat of the United Nations Convention to Combat Desertification, the Food and Agriculture Organization of the United Nations (FAO) is to promote and coordinate implementation of the IYS 2015. The IYS 2015 aims to increase awareness and understanding of the importance of soil for food security and essential ecosystem functions – Box 1 gives its specific objectives.

Box 1: Specific Objectives of the 2015 International Year of Soils

- Raise full awareness among civil society and decision makers about the profound importance of soil for human life;
- Educate the public about the crucial role soil plays in food security, climate change adaptation and mitigation, essential ecosystem services, poverty alleviation and sustainable development;
- Support effective policies and actions for the sustainable management and protection of soil resources;
- Promote investment in sustainable soil management activities to develop and maintain healthy soils for different land users and population groups;
- Strengthen initiatives in connection with the SDG process (Sustainable Development Goals) and Post-2015 agenda; and
- Advocate for rapid capacity enhancement for soil information collection and monitoring at all levels (global, regional and national).

2. SACAU members therefore need to explore and preferably agree on what it would take to achieve agricultural productivity growth while ensuring resource sustainability – all this in the context of additional challenges brought by climate change. This introduction highlights why attention to natural resources sustainability questions is imperative; what the main trends are; and the macro-level questions to address in considering the theme of the Conference. Among questions members may have in mind as they discuss the topic could be:

- What is the trend in food demand and what drives it (physical, socio-economic, demographic, and political)?
- What is the gap between current performance and goals?
- Given the critical need to greatly but sustainably increase production and productivity, what promising approaches can enable us do this in a climate smart way?
- Where are the main opportunities for farmers?

- What are the key challenges and how do they affect key resources such as soil, water, rangelands, fisheries, and production systems in general?
- How is the resource base being affected by climate change and what gaps in knowledge can constrain our ability to act?

1.1 A pressing imperative

3. All human societies in the world value responsible use of assets, including natural resources – they may not necessarily practice it but they value behaviour that caters for current use of resources while ensuring sustainability for future generations. There is universal condemnation of prodigal behaviour – uncontrolled consumption today without a thought for tomorrow. Indeed one religious parable portrays and condemns a son for spending on riotous living and with abandon the advance share of inheritance he is given; his story shows him squandering all the wealth and going from feast to famine, with misery becoming his lot for the rest of his life if he does not beg for charitable rescue. Yet when one looks around Southern Africa and the prodigious pace at which its soils, forests, woodlands and fishery resources are being consumed, it is hard not to see the analogy with prodigal-son behaviour.

4. It makes things worse that population is growing at over 3% annually in some countries, with the sub-regional average probably around 2.5%. At this rate, population doubles every 25 years. In countries where family farm holdings are already less than 2 hectares, they will soon reach the lower limit of viability. Crop rotation will no longer be possible and if resource husbandry remains poor, further cultivation will increasingly become “mining” of the soil until it is completely exhausted. In both the crowded countries and larger ones, farmland is being expanded by clearing additional forests and woodlands, even up steep slopes where cultivation should not be an option. Farming is encroaching into wildlife areas. Growth of human settlements and infrastructure is adding to this pressure. Fish stocks are also under pressure – in many lakes, increasingly young and small fish are being caught for sale.

5. Yet in most situations, despite the above problems being highly visible, corrective action is either missing or anaemic. At the Mahe Annual Conference, SACAU and its member organizations need to discuss these challenges, to introspect on why apparently irresponsible behaviour is continuing with minimal restraint, and to propose effective solutions to them. They will need to explore what can be done; what they should encourage governments to focus on; what roles they and their members can play. Loss of the fundamental capital for agriculture - land, water and vegetation resources can become irreversible, with implications that are too drastic to contemplate. Consequently, there is need for urgency in responding; there is need to prioritise interventions; there is need to commit to long-term response and at a scale that can make a difference.

6. The consequences are made worse by ongoing climate change but the problem long pre-dates climate change. Responsible resource husbandry designed for better times is still needed now, only more so, given adverse climate trends.

1.2 Main trends

7. A rapidly growing population, changing dietary preferences and improving economic fortunes of consumers across the world have fuelled unprecedented demand for food, fuel and fibre. Farmers

will have to produce more food in the coming 40 years than they have produced in the last 500 years if they are to keep up with rising demand; agriculture must also increase output of fuel and fibre. It is clear that agriculture must produce more but in new, innovative ways so that the sustainability of key natural resources such as soil, water, rangelands, forests and fisheries are not threatened. Threats posed by climate change to agricultural production and to its natural resource base make this an even more daunting undertaking.

8. In the short term, increasing climate variability will have more impact than longer-term changes. Most immediately, climate change is causing increased variability (in both time and space) in temperature, precipitation, and winds, particularly the incidence and magnitude of extreme weather events, including some of the following:
   - the frequency and intensity of heat waves, heavy precipitation events and associated floods, and tropical cyclone events
   - incidence of extremely high sea levels owing to storm surges, and
   - likelihood of increased longer dry spells in some areas and the area affected by drought each year.

9. It is expected that other types of extreme events, such as cold spells and frosts, may decrease in frequency and intensity. Furthermore, although we tend to think of climate variability in terms of 'extreme' events (floods, storms, drought, heat waves, and wild fires), for agriculture even slight changes in temperature at a critical stage of plant growing can compromise a crop.

1.3 Big Questions at the Macro Level

10. The 2015 SACAU Conference Agenda has specific sub-themes, and in considering the natural resource issues posed under all of them, members may wish to keep at least five questions in their minds:
    a. *Most agriculture in Southern Africa*, being dominated by "low-input/low output" systems, *has low productivity*. This means that as population surges ahead at 2.5 – 3% annually, more land (including its forests, woodlands, and rangelands) have to be cleared to produce needs for food, feed, fuel and fibre; fish are being caught increasingly young. The question for SACAU members to face is how best to rapidly increase productivity per unit area and so arrest decimation and degradation of natural resources caused by inefficient/low-productivity farming and fishing;

    b. *Much information* in the text and annexed case studies *advocates conservation agriculture*, *agroforestry and their related approaches*: *almost all are silent on whether these approaches can increase productivity and production rapidly enough to cope with Southern Africa's existing and growing food deficit and rural poverty*. Being environmentally compliant is good but putting adequate food on the table is often even more important;

    c. The review suggests that in capturing production-enhancing opportunities, "business as usual" is not an option. For the managers of SACAU member organisations, the question becomes: *what advocacy should they focus on to make governments create key and sustainable incentives* (including critical public investments to make private efforts rewarding) for farmers and especially smallholders *to adopt productivity-enhancing measures?*;

d. *Climate change is integrated into the whole Conference theme and it is important. But in considering it there is danger of it being seen as the only challenge that matters: we can be made to forget that Southern Africa has a long history of agricultural underperformance, low productivity, poor farmer organisation etc which has kept most farmers producing too little and remaining poor even before climate change was announced – this amnesia can be dangerous*. Also, old and well-tested technologies and good husbandry practices could be sidelined by claimed "new and innovative" climate-smart ones which in reality are no better than use of sensible old-fashioned science; and

e. Finally: *rapid population growth is the key enemy*, especially when large numbers of people depend on farming rather than other economic opportunities. Although population problems cannot be solved by SACAU and its constituency, its members should probably not be silent in public policy dialogue on these matters. Southern African agriculture is unlikely to prosper, to be well-paying and to become highly productive as long as it continues to endlessly absorb masses of people into its economy.

B. Opportunities and Challenges

2.1 Sustainably Managing Soils and Water for Productivity

11. To achieve and sustain global food and nutrition security in the future requires that we continue to increase agricultural output. The question that Southern Africa alongside the international community must address is how best to sustainably extend and intensify agricultural production. Given the food deficit situation in many of its countries, Southern Africa must, despite adverse climate change, make history its record of low and declining growth rates in crop yields, land degradation, increasing competition for water resources, declining soil nutrient levels, and pressure on biodiversity and ecological services, among others. This requires that we (a) intensify crop production on land already under cultivation, while preserving ecosystem services, and preventing further land degradation, and (b) carefully expand the area planted. It is worth noting that if farm productivity is increased, the need to clear new forests/woodlands will diminish, which has positive impacts on sustainability and on responding to climate change.

12. Soils are the bedrock on which agriculture rests: if they are misused and their productive capacities are squandered, agriculture may perform or even briefly give a flush of output but eventually must fail. Soils must be nurtured, benefit from good husbandry if they are to produce sustainably. And there are no quick fixes for this – attention to soil condition must be an integral and permanent part of farming. This applies of course to soils at all times, but even more when climate change heightens the dangers of erosion and other forms of degradation. SACAU members will need to treat the issue of sustainably managing soil and water resources to improve agricultural productivity with even more care, given the predicted climate scenarios for Southern Africa. Some of the questions to keep in mind include:
    - What are the most pressing soil and water management issues and how do they affect farmers in different production systems?
    - What are the key productivity and sustainability goals and targets in soil/water management?
    - What are the current or likely impacts of predicted climatic changes for southern Africa on soil and water resources and how will this affecting productivity?

- What are the game-changing technological breakthroughs and innovative practices that can help farmers overcome these challenges?
- Do these potential breakthroughs make business sense for the farmer?

13. Increasing production[1] through intensification will require particular attention to greater use by farmers of all operational scales of yield-enhancing inputs, of which the top ones (expanded upon below) are (a) water, and (b) nutrients – both natural soil nutrients and fertilisers whether organic or chemical.

2.1.1 Managing Soils for Triple Benefits[2]

14. Good soil management[3] is said to offer triple benefits: it can raise productivity while improving resilience of the farming system and stabilizing the climate. Improved management should permit diversified farm output and include among its goals:
    - creating carbon-rich, productive soils
    - strengthening ecosystem functions (moisture and nutrient cycles)
    - restoring degraded soils
    - improving efficiency in the use of nutrients, especially nitrogen and potassium, and
    - improving water quality through a greater control of fertilizer application.

15. All of these benefits make agricultural production more sustainable, which helps foster food security and improves nutrition. They always involve recycling of organic matter as natural fertiliser, but can also accommodate use of chemical fertilisers, provided this is done sensibly.

16. All soil management practices should increase soil organic matter (SOM) and soil organic carbon (SOC) content, which increase the resilience of agro-ecosystems and bring the following triple-win benefits: richness in carbon, lower need for chemical inputs, and sustenance of vital ecosystem functions – such as moisture and nutrient cycles. The management regimes generally require improved management of organic matter (crop residues, mulch, manure, compost) to maintain productive soils. Exact approaches vary but many use residues such as organic mulch in combination with no-till farming and integrated nutrient management (i.e. the appropriate application of both synthetic and organic fertilizer). There is a diverse typology of husbandry practices which satisfy "good management" criteria, some types being - Conservation agriculture (CA); Integrated soil fertility management (ISFM); Organic agriculture; Zaï Planting pits and Stone Bunds; Systems of Rice Intensification (SRI); Improved grazing management on pastures or rangelands; and, mixed farming, i.e. combining crop and livestock systems. Box 2 profiles Conservation Agriculture as an approach to soil management.

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[1] But growing more food does not necessarily lead to better nutrition: it is essential that incomes increase so that those who do not produce their own food or those with inadequate subsistence output can purchase it.

[2] Adapted from the Climate Change Agriculture and Food Security (CCAFS) CSA Curriculum (forthcoming)

[3] Available to the conference as annexes to this back ground document are a number of case studies, as follows: Case 1: CSA Enhancement in China's Green Growth strategy; and Case 2: Managing Soils for Increased Productivity Under a Changing Climate in Southern Africa: What Prospects for Conservation Agriculture?

<u>Box 2</u>: Conservation Agriculture as an Example of Soil Management

Conservation Agriculture (CA) promotes the retention of permanent soil cover so as to protect the soil from wind and water-induced erosion; it advocates use of crop residues or mulch and these decompose to give soil organic matter, some of which is sequestered as carbon . CA also involves rotation of cereals and leguminous crops to help balance the carbon-to-nitrogen ratio of crop residues, which allows nitrogen to be released slowly and serve as a nutrient source for the following crop.

Conservation agriculture pursues agricultural management based on three principles:(a) minimum soil disturbance: zero tillage is ideal, but limiting tillage to no more than 20% to 25% of the soil may be accepted; (b) retention of crop residues or other soil surface cover: generally with 30% permanent organic soil cover as the minimum, but with the ideal site-specific; and (c) use of crop rotations (to help reduce build-up of weeds, pests and diseases) - if there is insufficient land to rotate crops, intercropping can be used; legumes are recommended as rotational crops for their nitrogen-fixing functions.

The following are among the <u>benefits claimed for CA</u>:

- ***Stable yields***: **t**he water- and soil-conserving effects of CA help to stabilize yields against weather extremes and CA often increases average yields in the long term;
- ***Drought buffering***: CA increases soil water content by increasing infiltration and reducing runoff and evaporation, which improve water use efficiency and buffers crops against drought. Infiltration averaging 24-38mm greater in CA fields than otherwise have been observed in Southern Africa. In semi-arid highlands of Mexico soil water content during dry periods being 10-20 mm higher in maize fields under CA than without; mulch cover also buffers the soil against temperature extremes;
- ***Reduced field preparation costs***: CA reduces costs associated with tillage: in manual maize systems in Malawi, CA fields required 20% less labour than conventional ridge and furrow fields; in mechanized rice-wheat systems in India, costs were 15% lower under CA;
- ***Reduced soil erosion***: Reducing tillage crop residues for soil cover can reduce erosion by up to 80%; and
- ***Climate change mitigation***: CA helps climate-change mitigation through carbon sequestration and reduced GHG emissions, but focus should be on promoting climate-change adaptation.

Possible <u>shortcomings of CA</u> include: (a) farmers may not be able to leave residues on the field to act as mulch, as they are needed for livestock fodder; and (b) yield increases are not immediate.

<u>Source</u>: Case Study adapted from the Climate Change Agriculture and Food Security (CCAFS) CSA Curriculum (forthcoming)

17. The above practices have always been beneficial but climate change,[4] which will significantly impact agriculture by increasing water demand, limit crop productivity and reduce water availability, requires that they be practiced with even more determination, including in areas where irrigation is most needed. Thus, sustainable soil management practices should be an integral part of Climate Smart Agriculture (CSA).

2.1.2 Managing Water for Sustainable Agricultural Intensification[5]

[4] Degraded soils are highly vulnerable to climate change due to loss of soil organic matter (SOM) and soil biodiversity, greater soil compaction and increased rates of soil erosion and landslides. In addition, land degradation is itself a major cause of climate change, releasing soil-sequestered carbon into the atmosphere.

[5] Drechsel, P., Heffer, P., Magen, H., Mikkelsen, R., Wichelns, D. (Eds.) 2015. Managing Water and Fertilizer for Sustainable Agricultural Intensification. International Fertilizer Industry Association (IFA), International Water Management Institute (IWMI), International Plant Nutrition Institute (IPNI), and International Potash Institute (IPI).

2.1.2.1 Water as Key

18. The world's cultivated area has grown by 12% over the last 50 years. Over the same period, the global irrigated area has doubled, and world fertilizer use has increased more than fivefold. Driven by the fast expansion of irrigation and fertilizer consumption and the adoption of improved seeds and best management practices, which triggered a significant increase in the yields of major crops, agricultural production has grown between 2.5 and 3 times since the beginning of the 1960s.

19. **Water** is key for agricultural productivity increases:[6] thus although irrigated agriculture accounts for only 20% of the total cultivated land, it contributes 40% of the total food produced worldwide. Globally, groundwater provides around 50% of all drinking water and 43% of all agricultural irrigation. Abundant supply of water is needed for farming: thus while 2 litres of water daily often suffice for drinking purposes, it takes about 3,000 litres to produce the daily food needs of a person. Much of this water comes from *rainfall* and cultivation practices can affect how effectively rainwater soaks in to benefit crops rather than becoming fast runoff. Water is also home to fish, whether in nature or aquaculture.

20. In addition, agriculture uses water for *irrigation*: some 70% of all water withdrawn from aquifers, streams and lakes goes into this. FAO estimates that irrigated land in developing countries will increase by 34% by 2030, but the amount of water used by agriculture will increase by only 14%, thanks to improved irrigation management and practices. Access to water for productive agricultural use remains a challenge for millions of poor smallholder farmers, especially in sub-Saharan Africa (Box 3), where only 3.2% of the total cultivated area is equipped for irrigation (FAO, 2011). Informal farmer-driven irrigation is in many regions more prominent than formal irrigation.

Box 3: Water Resources for Smallholder Farming Systems in Southern Africa in the Context of Climate Change

With rainfed farming systems accounting for over 95% of smallholder farming activities in Southern Africa, the advent of climate change significantly affects the agricultural production environment in terms of rainfall patterns, warming, greater frequency and extent of extreme weather events which lead to changed crop yields, pests and disease outbreaks, shifts in acreage planted to different crops, reliance on dryland and irrigated production systems etc. The impacts will be more profound in the drier central and western parts of Southern Africa. But there may also be regions that climate change will make more wet and so give them increased opportunities for improved agricultural productivity. As water availability declines, Southern African agriculture will face increased competition for water from other sectors.

Response to the impacts of climate change on water resources should focus on technologies and management practices the boost efficiency and productivity of water. Agricultural research and development and extension should develop and provide adapted crop varieties, advise on adjusted planting dates, and cropping patterns etc. Beyond the development of adapted water resources technologies smallholder farmers should have the

[6] Available to the conference as annexes to this back ground document are a number of case studies on water management, as follows: Case 3: Improved water management - Alternate Wetting and Drying (AWD); Case 4: Deficit Irrigation; Case 5: Protecting Peatlands in Northern China; and Case 6: Index-based livestock insurance to increase climate resilience of pastoralists in Kenya and Ethiopia.

means and rights to access the technologies.

The original paper presents a tabulated matrix of types and examples of agricultural climate change adaptation strategies related to water resources.

Source: Extracted and abbreviated from Opinion Paper by Charles Nhemachena, Greenwell Matchaya and Sibusiso Nhlengethwa, International Water Management Institute (IWMI), Southern Africa Regional Office

2.1.2.2 Improving Water Use Efficiency[7]

21. Water management (whether of rainfall or irrigation supplies) aims to improve water use efficiency (WUE) to ensure optimum soil-moisture conditions for plant growth. WUE interventions can range from enhancing the capture and retention of rainfall for avoidance and/or mitigation of flooding and improving irrigation and drainage systems. Irrigated agriculture uses the most costly way of applying water to farming and should therefore be a main concern. The principles of water use efficiency will become even more important as the impacts of climate change become deeper.

22. Efficiency can be considered at many levels, for example: farm; irrigation system or catchment (system level); or river basins and nations (strategic or planning level). Although many options for water management can appear generic at any of these levels, it is important to consider the specifics of a location to select WUE systems. At system-level there are choices in preference or combinations among water storage in reservoirs, groundwater or on-farm.

2.1.3 Managing Nutrients for Sustainable Agricultural Intensification[8]

23. **Nutrients** are the second element after water for agricultural intensification: in 2012, a reported 179 million metric tonnes (Mt) of *fertilizer* (in nutrient terms) was applied to 1,563 million hectares (Mha) of arable land and permanent crops; i.e., an average application rate of 115 kg nutrients/ha. Asia is by far the main consuming region, with East Asia and South Asia accounting for 38 and 18% respectively of the world total. In contrast, Africa represents less than 3% of the world demand, with chemical fertiliser use in sub-Saharan Africa estimated at 11 kg nutrients/ha in 2013, i.e. only 10% of the global average. At this low rate, farmers mine their soil nutrient reserves. It is nevertheless encouraging that from its low base, sub-Saharan Africa has witnessed the strongest fertiliser consumption growth rate since 2008.

24. New discoveries reveal that the traditional perception that water availability is essential for effective use of nutrients/fertiliser is also true when reversed: poor soil fertility limits the ability of plants to efficiently use water. Drechsel *et al* report that in the African Sahel, only 10 to 15% of the rainwater is used for plant growth, while the remaining water is lost through run-off, evaporation and drainage. This low water utilization is partly because crops cannot access it, due to lack of nutrients for healthy root growth. They report West African findings that root density of irrigated sorghum increased by 52% when N fertilizer was applied, compared with application of only water. Thus, even in dry environments, where water appears to be the limiting factor for plant growth, irrigation alone may fail to boost yields without consideration of the soil and its nutrient status.

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[7] See: Drechsel, P., Heffer, P., Magen, H., Mikkelsen, R., Wichelns, D. (Eds.) 2015 – see above.

[8]See: Drechsel, P., Heffer, P., Magen, H., Mikkelsen, R., Wichelns, D. (Eds.) 2015 – see above.

25. Globally, fertilizer demand is projected to continue rising. In general, future fertiliser demand growth can be slowed down by nutrient use efficiency gains, which have been observed for three decades in developed countries, and since 2008 in China. Other Asian countries may follow the same trend in the years to come.

26. Nitrogenous fertilizers are the most widely used fertilizers and deliver huge benefits in terms of productivity, especially in nutrient-depleted soils. Global experience suggests that although gross volumes of fertiliser application can help, proper application is essential for fertiliser to work best. When not properly managed, up to 70 to 80% of the added N can be lost in rain-fed conditions and 60 to 70% in irrigated fields. In contrast, N use efficiency levels close to those observed in research plots can be achieved by farmers when using precision farming techniques under temperate conditions in the absence of other limiting factors.

27. As countries adapt to climate change through adoption of Climate Smart Agriculture, their nutrient management will increasingly be about increasing soil organic matter through "Organic Agriculture" type approaches that reduce the need for chemical fertilizers. Intensification uses organic fertilizers (manure, compost and plant residues) increasingly supplemented by inorganic or synthetic fertilizers, which provide required macro- and micro crop nutrients.

28. The desire to reduce use of nitrogen fertilizers is driven by concern at their environmental damage through GHG emissions and nitrate pollution. One can question whether at only 11kg/ha, Africa's average use of mineral fertilisers can really significantly produce nitrous GHGs; in any case the climate change harm of Africa's current emissions from fertilisers is likely to be worth far less than the harm it suffers from hunger and poverty arising from too little use of fertilisers. Nevertheless, to the extent that they are harmful, these Green House Gas (GHG) emissions of fertiliser origin can be reduced by making changes in the rates, timing and type of nitrogen fertilizer applications; using slow-release fertilizers that control the formation of nitrates; and adding nitrification inhibitors containing ammonium to fertilizer. These practices help synchronize the demand and supply of nitrogen. Agronomic management can also control the biological processes that cause nitrate leaching and production of GHGs. Cropping patterns should allow the nitrogen produced from decaying surface residues to be released slowly and contribute to the growth of the following crop while minimizing losses.

2.2 Managing Arid and Semi-Arid Rangelands Sustainably

29. Southern Africa has extensive arid and semiarid lands – they are an important natural resource for livestock rearing, game ranching and natural habitat for wildlife. More moist margins of semi-arid lands blend into the savannahs of varying tree density that are home to Southern Africa's renowned large game. The subregions semi-dry and savannah areas support a wildlife-based tourism sector that at times can earn even more than ranching. It is therefore important for the farming community to be open about making incomes from more than livestock.

30. Some innovative rangeland management approaches being practiced by farmers are referred to below. All mention proven management approaches but they also explore the implications of a changing climate on productivity and management of rangelands. Some of the questions to keep in mind in considering rangeland management include:
    - What is the extent of arid and semi-arid agro-ecological zones in southern Africa, and what are the typical challenges for farmers in managing rangelands?

- What are the productivity and sustainability targets in rangeland management?
- In what ways is climate change shifting the boundaries of arid and semi-areas, and how is it likely to affect farmers in the region?
- What are some of the promising practices and technologies being applied to improve productivity of rangelands in arid and semi-arid areas?
- What are the costs involved and how do these compare with the benefits? What is the cost of doing nothing for the farmer?
- Under what conditions is it sensible to manage arid/semiarid lands, especially on savannah margins, for wildlife as much as or more for wildlife than domestic livestock?

31. As Southern Africa in general is becoming hotter and drier, the arid/semiarid lands are suffering even more. Rangelands have traditionally been kept in good shape when farmers have respected their carrying capacity limits. They have at times degraded their range through overstocking: such degradation is likely to be worsened and accelerated by climatic change. Both degraded and sound areas will need to respect well-known principles of good husbandry, rooted in respect for the fragile environment and its capacity limits. It is encouraging that Southern Africa is spearheading a new way to interpret "carrying capacity": - departing from viewing this as necessarily requiring very light stocking at all times. Instead, farmers are finding it viable to have ultra high density grazing (UHDG) for very short periods in rotation – this apparently mimics wildlife behaviour [see Case 8 by Zietsman (Karoi, Zimbabwe) and Case 9 by Lund (Karoo, South Africa) – Box 2). The contrasts between smallholder and commercial rangeland use in an arid environment is best illustrated, however, by the Rothauge case study from Namibia, presented in <u>Box 4</u>.

32. Both farmers and scientists stress likely accentuation of multiple problems as climate changes: less predictable seasons, less rainfall and therefore less water for pastures, late frosts that affect plant growth, prolonged drought periods followed by heavy rains that kills livestock and erodes soils. These climatic problems are compounded by socio-political trends, such as increasing conflicts over management roles and resource access. Progressive approaches exist but the challenge remains to make all farmers respect them: to have smaller numbers of animals that produce a much higher amount of products such as meat, milk, wool and mohair.

33. Case studies[9] will refer to climate smart rangeland management approaches that embrace delivery of participatory range management backed up by information systems; innovative grazing approaches, especially "Ultra High Density Grazing" in drylands where normal prescriptions call for very light stocking and grazing; improved animal nutrition, health and breeding to counter climate-based mortality and quality risks; development of capacity to manage herds and post-production to deliver higher quality products into national and international markets.

<u>Box 4</u>: Namibia - Managing Rangelands in Arid and Semi-Arid Areas:
Options for Raising Productivity Under a Changing Climate

A Hostile Environment: Namibia is the driest country in sub-Saharan Africa and has no perennial rivers: about 14% of its land (the Namib) is true desert and 1% is a saline desert (Etosha Pan); a further 35% (the Kalahari) is

[9] Annexed as the following Case Studies: <u>Case 7</u>: Managing pastures and rangelands for a changing climate in Southern Africa; <u>Case 8</u>: Ultra High Density Grazing – Innovation in managing pastures and rangelands for a changing climate in Southern Africa (Zimbabwe); <u>Case 9</u>: Karoo Grazing Experiment 2003-2012 (South Africa); and <u>Case 10</u>: Pastoralism in Laikipia, Kenya.

edaphic semi-desert. Rainfall is highly variable (coefficient of variation > 40%) and ranges from 20 mm (hyper-arid south-west) to 600 mm in the sub-humid north-east. Good, fertile soils are scarce and limit grass and crop production even in good rainfall years.

A Dualistic Agriculture: The country's dualistic agricultural sector usually contributes < 5% to GDP, of which about 80% of output derives from capital-intensive commercial and 20% from subsistence-based communal land farming. Despite its low commercial contribution, communal agriculture offers a livelihood to 50-60% of the population. In the semi-arid to sub-humid northern communal areas, where some 300,000 farmers engage in mixed cropping with drought-tolerant pearl millet ("mahangu"), sorghum and drought-intolerant maize, cattle and goat production. In the semi-arid east, communal farmers keep cattle and goats and in the arid south, goats and sheep.

Communal pastoral livestock systems are based on free access to rangeland and herd maximisation rather than turnover. This results in continuous grazing that causes severe range degradation and even desertification in arid areas. In contrast, Namibia's commercial farming sector is well developed and based on individual land ownership. About 6,000 commercial farmers work 44% of the land and engage in all kinds of input-intensive agricultural production, including game ranching and eco-tourism. Livestock production dominates and contributes 70% to agricultural GDP, with cattle mostly in the wetter north, sheep in the drier south, and small numbers of goats. Offtake from cattle herds is high (20-25%) and beef production exceeds 8 kg/ha on many farms (vs. about 1kg/ha in communal areas).

Manmade Ecological Damage: Poorly controlled selective grazing has exterminated perennial grasses from many farms, replacing them with less-desirable annual grasses and weeds; near-total exclusion of occasional fires has encouraged a wave of bush encroachment to cover the land even in arid areas. Bush encroachment is reducing the grazing capacity of the land to one-tenth its potential. Increasingly, encroacher bush is eradicated by unselective application of arboricidal chemicals, potentially endangering meat exports to health-conscious consumer markets. Bush thinning causes grass yield to increase dramatically but does not alter the botanical composition of the grass sward; still dominated by inferior grasses and weeds.

Responding to Climate Change: Making communal farmers less vulnerable to climate change requires (a) first and foremost a change in the land tenure system that equips communal farmers with a kind of tenure that is bankable, enabling them to access bank credit, even if not necessarily individual land ownership; (b) the removal of the veterinary cordon fence so as to integrate communal farmers into the mainstream agricultural economy of Namibia – this needs technical solutions to contain dreaded contagious animal disease; and (c) development of new export destinations which can accept Namibian meat even after the veterinary cordon is lifted, subject to dependable hazard and critical control point (HCCP) analysis and complete livestock traceability.

The following actions are extracted from a large suite of adaptive and mitigating actions possible[10] for communal farming areas, many of which would require policy shifts to work:

- Introduce cultivated pastures of perennial indigenous grasses in Northern and north-eastern Namibia. In this way, shift grazing pressure from native to cultivated pastures and so rehabilitate degraded communal grazing lands ecologically.
- Integrate pastures within extended crop fields and in rotation with cereal crops, given that grass leys (especially if mixed with legumes) improve soil fertility and stability.
- Using surplus grass from pastures grown in wetter areas, start a national fodder bank – also linked to feedlots for surplus animals and for emergencies - to buffer droughts in drier parts of the country so they can avoid over-stressing already sparse pasture in very bad years;.
- As climatic warming looms, find ways to profit from communal land livestock that are genetically highly adapted, heat-tolerant and water-wise – their attributes could be a saviour if research and breeding is

[10] For full list of measures, see author's document.

extended to them (now constrained by veterinary control measures).

Other interventions of a more purely technical nature could be implemented to reduce climate change vulnerability amongst Namibia's livestock ranchers, of which two examples are:

- Adding value to encroacher bush to stimulate its extraction from bush encroached rangelands should be a priority, including encouraging sustainable charcoal-making (i.e. not by deforestation), alternative energy and small-scale construction materials and followed by rehabilitation of weakened grass swards to improve the grazing capacity of the land sustainably;
- Promoting the use of "ecologically friendly" breeds of livestock such as goats and karakul sheep.

Source: Extracted and abbreviated from Opinion Paper by Dr. Axel Rothauge, AgriConsult, Okahandja, Namibia

2.3 Integrating Trees into Farming Systems

34. Many benefits are claimed for agroforestry, which is the use of trees and shrubs on a farm; they include: intensifying and diversifying production and farm income sources; provide other multiple benefits such as fruits, firewood, construction timber and aesthetic appeal; preventing or reducing soil erosion; diminishing the impacts of extreme weather – droughts, heavy rain and wind; reducing overgrazing and land degradation and enhancing livestock diets by improving the supply and quality of forage; facilitating water infiltration into soils; improving soil fertility; reducing soil temperatures; providing a supplementary source of energy; forage; providing shade for animals - reducing heat stress and boosting their productivity. More notes on potential benefits are given in Box 5.

Box 5: Examples of the Benefits of Agroforestry

Protection against extreme weather and landscape degradation: Certain trees can protect against landslides, floods and avalanches and raise rainfall infiltration rates, which limits surface flow and spreads out moisture release. For example, in central Kenya, napier grass and leguminous shrubs combined in contour hedgerows reduced erosion by up to 70% on slopes of above 10% inclination without affecting maize yield. Agroforestry can raise the soil's moisture absorptive capacity and reduce evapotranspiration. Tree cover can also reduce soil temperature.

Windbreaks: Windbreaks are rows of trees, shrubs or grass that protect crops, livestock, wildlife, people, farm facilities, soil and water from the damaging effects of wind and wind-blown material. For grain, vegetable, hay, vine or orchard crops, net yield gains of 10 to 20 percent have been reported when fields are protected by windbreaks. Livestock have better weight gain due to lower feed costs; wildlife can hide in them and viewing hides can be located in them too. If income-producing plants such as fruit, nut or woody florals are used for windbreaks income gains can also accrue. Heating and cooling costs for the farmstead can also be reduced and a more comfortable living environment results. Windbreaks can be aesthetic including by blocking out undesirable views.

Increasing Farm Productivity: Intercropping with leguminous crops may sustainably increase farm productivity and also provide energy. Certain species of trees or bushes offer edible products (such as fruit and nuts), thereby diversifying food and potential income sources.

Climate Change Mitigation: Perennial crops and trees can sequester substantial amounts of C and – if the agroforestry trees are not cut for long periods of time - can store C for longer periods than annuals in the biomass of roots as well as in stems and branches. Thus agroforestry mitigates GHG emissions by directly increasing carbon sequestration.

Climate Change Adaptation: Increasing the use of perennial crops and maintenance of shrubs and trees on the farm supports ecosystem services including the following dimensions relevant to climate change:

- Grazing management: improved soil carbon sequestration when grazing pressure is reduced as a means of stopping land degradation or rehabilitating degraded lands. In these cases, enteric emission intensities can also be lowered as animals eat more diverse forage. A side-benefit is more rapid rates of weight gain due to availability of more nutritious forage. Restoring degraded grassland also enhances soil health and water retention, which increases the resilience of the grazing system to climate variability;
- Pasture management and nutrition: Pasture management measures involve the sowing of improved varieties of pasture, typically the upgrading of native pasture using grasses with higher yielding and more digestible forages, including perennial fodders.

35. The above claims appear all-encompassing and the impression could be gained that agroforestry is the magic bullet with which to solve all agriculture/natural resource interface problems. Reality is otherwise and therefore there is need to systematically and dispassionately answer the following questions that arise when dealing with tree integration in farming: (a) what is the rationale of tree-crop systems and what has been the response from farmers?; (b) can agroforestry improve productivity enough and soon enough to help Southern Africa quickly defeat hunger and rural poverty? (c) what are the typical challenges in agro-forestry systems?; (d) are the benefits significant enough to justify the required investment?; and (e) is climate change redefining the agroforestry debate? - what new dimension has it brought and how is this likely to influence decision making by farmers?

36. Given these many benefits,[11] the questions to arise first is whether agroforestry is technically, economically and socially such an ideal technology that it should be promoted everywhere to replace more simple/specialised agriculture, including the extensive monocultures of maize, sugar, tobacco etc. In a subregion that is in net food deficit and where rural poverty is widespread, would agroforestry be the answer? Or if it is only a complement to other agricultural approaches, under what conditions is it best promoted and how? Normally in development, specialisation is associated with higher productivity of the chosen product: mixed systems that produce a little of everything, with limited surpluses of each, can be disadvantaged: is agroforestry different?

37. Agroforestry is important both for climate change mitigation (carbon sequestration, improved feed and consequently reduced enteric methane), and for adaptation and productivity. Costs and barriers to adoption of agroforestry include lack of available seed material, high mortality of seedlings during their first few years, and the often long timescales needed to reap the full benefits of various agroforestry species.

38. The Conference may desire clarity on these questions: in the absence of definitive knowledge, it may call for more in-depth work to ascertain under what circumstances agroforestry would yield its most important benefits to sustainable and highly productive agriculture able to cope with the fast-growing demands for food, feed, fuel, fibre and rural poverty reduction.

[11] Selected case studies are annexed showing some approaches to applying agroforestry and demonstrating its benefits are attached: Case 11: From slash-and-burn to agroforestry in Central America; Case 12: Intercropping coffee with banana in East Africa; and Case 13: Livestock diet intensification through agroforestry.

2.4 Of Fisheries and Marine Ecosystems

2.4.1 Large but Poorly Documented Potential

39. Estimates[12] are that fisheries and aquaculture support the incomes and livelihoods of about 10-12 percent of the world's population, some 660-820 million people. The sector has an important role to play in poverty reduction and food security; it generates first-sale values of over US$ 218 billion annually, and about 38 percent of production is traded internationally. Fisheries offer much room for gender equality in economic opportunities. More than 85 percent of the global fish supply of over 150 million tonnes is used directly for food, accounting for 15 percent of the world's protein and an essential nutrition contribution for around 4.3 billion consumers. Fish are part of rich aquatic biological diversity – with at least 27 000 species of fish, shellfish and aquatic plants, in a wide variety of ecosystems, so far identified. Expanding populations and rising incomes are driving demand growth for aquatic foods which will make fisheries a continuing important economic activity.

40. Regarding Southern Africa, apart from its rivers and their associated wetlands, some among Africa's largest, the sub-region is well endowed with natural lakes and large dams; a few countries also have many small dams integrated into farming systems. Island and coastal states in the subregion have some of the largest Exclusive Economic Zones and rich fishery resources, prime among them the fishery dependent on the Benguela current off the Namibian coast. There are reports of excessive exploitation of some stocks, especially those close to shore but also in lakes; but information is inadequate to say if on the whole the fishery potential is being fully used to contribute to economic development and food security.

41. Among the questions that arise in dealing with fisheries and marine ecosystems (some of which are covered in this section) are the following: (a) how significant are the contributions of fisheries and marine resources to livelihoods in the region?; (b) is this an underutilized resource and what is potential for expansion?; (c) what potential is there for integration of fishery activities into farming?; (d) what are the common challenges and, in cases of pressure on stocks, what responses are most likely to work?; (e) how is this sub-sector likely to be affected by climate change and what are the impacts on livelihoods of fisher folk and communities reliant on these resources?; and (f) what technological and institutional changes are needed for sustainable management of fisheries and marine ecosystems?.

2.4.2 Potential Climate-Change Induced Dislocation in the sub-Sector

42. In the absence of good information, it is best not to succumb to the temptation of presenting too gloomy a picture of likely climate change scenarios about fisheries. Nevertheless, it is well to speculate about what climate change impacts could occur, both directly and indirectly. For example, some conjectures claim that in the fisheries value chains, major climate risks are: increasing severity of coastal storms and flash floods, infiltration of saltwater affecting infrastructure, settlement and health, coastal erosion, and ocean acidification that is degrading fish stocks and corals. Given more and more severe extreme weather events, direct *economic impacts* could include: damaged infrastructure and fishing gear; increased danger at sea; loss/gain of navigation routes; and flooding

[12] Source: Climate Change Agriculture and Food Security (CCAFS) CSA Curriculum (forthcoming)

of fishing communities. Socio-economic impacts could include: influx (or exodus) of migrant fishers; changed disease patterns; changing comparative profitability relative to other sectors; resources available for management; and reduced security. *Ecological impacts* (severity not known yet and possible positive impacts also not determined) include: change in yield; change in species distribution; increased variability of catches; and changes in seasonality of production.

43. Small-scale fishers are particularly exposed to and least able to respond or anticipate direct climate change impacts. Because they generally live in the most seaward communities, they are at greatest risk from damage to property and infrastructure from increasing storm intensity and frequency and should sea level rise. Worsening storms also increase the risks associated with working at sea, and changes in weather patterns may disrupt fishing practices that are based on traditional knowledge of local weather and current systems.

2.4.3 Management Response Possibilities in the Fisheries Sub-Sector

44. In much recent writing, the impression given is that all attention should go to climate change and its implications for fisheries. Not enough is said about what is already ailing the sub-sector even without climate change considerations. There may be abuses, including overfishing; poor equity in access to stocks; marginalisation of small scale fishers for lack of support for them to fish further into the extended exclusive economic zones; dominance of foreign fleets in Southern Africa waters with unfair advantage in open sea capture (some from subsidies by their governments) etc. SACAU members will need to be briefed about these realities before they can make decisions that risk being slanted only towards addressing climate change when more fundamental challenges and opportunities exist.

45. Management approaches vary according to whether focus is on marine, large lake/dam, farm dam, or pond aquaculture fisheries. It is not productive for the Conference to engage in details of any of these but for areas of particular interest, it could set up task groups of interested persons, supported by experts, to study and present options and their recommendations for further consideration.

2.4.3.1 Increasing the Productivity of Fisheries and Aquaculture

46. Globally, approximately 30 percent of assessed stocks are thought to already be overexploited and fish catches are by now static or even declining. Consequently, artificial raising of fish (i.e. fish farming, called “aquaculture”) can only grow in importance as marine capture of stocks in the wild fails to meet all demand. Aquaculture must be carefully planned to minimise the challenges of competition for land, water, energy and feed resources as well as how to manage pollution arising from it. Box 6 gives a snapshot of the Vietnam experience with intensive aquaculture.

<u>Box 6</u>: Farming Catfish Intensively in Vietnam

Around the globe, catfish aquaculture is arguably the most efficient source of protein for human diets, yielding an average of 250 to 400 tonnes per hectare. In terms of water consumption per tonne of produce, it is close to rice paddies, but with around 50 times greater yields from the same area; the sector does far better than shrimp ponds or freshwater fish tanks.

There is now a vibrant commercial export industry based on initial backyard ponds, generating over 1 million tonnes of food every year and bringing in USD 1.4 billion as of 2009. The catfish boom occurred within a decade and today over 1.2 million tonnes of fish are harvested annually from less than 6,000 ha of ponds; they employ over 170,000 people in Vietnam. Intensification, supported by the plentiful water supply in the Mekong delta, is key to this high-output system.

Pollution is an environmental concern but research suggests that the impacts are comparatively low - one good opportunity for a smaller footprint (and for climate-smart synergy) is recycling wastewater to irrigate and fertilize crops. Going forward, the industry also needs to address growing threats from climate change. In the short term, the most urgent problem could be disease outbreaks triggered by rising temperatures; in the longer term, aquaculture planning must consider the likelihood of saltwater intruding into the delta.

Climate change considerations:

- ***Adaptation*****:** Combining cropping and aquaculture gives water savings and increased resilience. More needed on infrastructural measures (dyke heightening/reinforcement, improved water storage and water management) and practice and technology improvements (relocation of production, modified stocking cycles/rates and development of salt-tolerant species).
- ***Mitigation*****:** Catfish ponds have a low environmental footprint per unit of output. Water use and impacts on water quality are low. Discarded fish parts are converted into oil and animal feed, and nutrient-rich wastewater can be reused as fertilizer, further reducing waste and emissions.

Partners: For certification, government, national exporter's association, Aquaculture Stewardship Council, other standards.

<u>Source</u>: Case Study adapted from the Climate Change Agriculture and Food Security (CCAFS) CSA Curriculum (forthcoming)

47. The prime ambition must be to increase output through productivity enhancement (intensification)[13] and overarching principles of such sustainable expansion of output, the reference best practice principles are in the *FAO Code of Conduct for Responsible Fisheries*. These principles may be progressively adjusted in normal context but also apply to situations of climate-change threat, for which experience is being progressively gained. Apart from acting to increase yields and productivity in fish and aquatic products, there is need to reduce losses and waste, to expand value addition, and to enhance efficiencies in product distribution.

48. Globally but also (with adaptation where needed), there are two main approaches for increasing productivity and efficiency:
    a. For **capture fisheries**, the most important issues are to reduce excess fishing fleets' capacity, and to maintain healthy and productive stocks and systems. Ecosystem approaches to resource

[13] Annexed is one case study to complement Box 6, which partly illustrates what is involved: <u>Case 14</u>: Rice field fish rings in Bangladesh.

management would reduce the potential risks of overfishing and the collapse of key stocks while better stock conditions could improve the catch quality. Though total output might not increase significantly, these and related improvements could reduce costs and improve economic efficiency.

b. For **aquaculture,** raising productivity calls for some approaches similar to those for agriculture. Key is to emphasise intensification of production, using better integrated systems, improving stocks, making feeding more efficient, reducing disease and post-harvest losses. Dependence on fishmeal and oil is often cited as a primary constraint to future outputs and growth for aquaculture. This dependence is declining as alternative feeds are being developed and as a wider range of species is being cultivated at levels on the food chain closer to the primary production stages. However, attention has to be paid to competition for land and water resources. Environmental concerns are also raised regarding pollution and nuisance (small) considerations.

2.4.3.2 Marine Fisheries

49. Fundamental to surviving or even surmounting dislocation of marine fisheries, even under climate change, is respect for and better implementation of long-held good resource husbandry practices: good management for sustainable stocks, building the resilience of fish stocks and communities and taking account of uncertainty. This kind of good fisheries governance has been recommended for decades, irrespective of climate change. To underpin this must be adequate, sustained and affordable/locally feasible early warning systems which feed into long-term integrated coastal and disaster management risk planning.

50. There is need for rehabilitation of costal mangroves and coral reefs, and long-term adaptive monitoring systems coupled with participatory management of coastal resources. Investment towards protection of coastal infrastructure, improved post-harvest cooling and storage, and improving access to freshwater for fisheries value chains are also important. Adaptation to sea-level rise and increased storm and surge damage will require hard defences (e.g. sea walls) and soft defences (e.g. wetland rehabilitation or managed retreat), as well as improved information systems to integrate knowledge from different coastal sectors and predict and plan for appropriate strategies.

51. Economic impacts show up as threats to income security: to combat this requires diversification of products and markets so as to reduce economic shocks. For this, information technologies now allow more access to market opportunities and problems – even to small-scale fishers; this strengthens capacity to better navigate local and international markets and achieve fair prices for their fish.

C. Matters for Possible Follow-Up

52. The SACAU Conference has a unique formula in that its participants are a combination of technical and policy/administrative leaders. This attribute gives the conference special opportunities for follow-up of a policy and strategic nature to be well grounded in technical realities. In the matter of managing natural resources so they can remain a reliable bedrock for a prosperous and dynamic agriculture, matters calling for policy and strategic interventions are many, including those where SACAU members may wish to focus their policy advocacy to unlock opportunities and create incentives that encourage removal or minimisation of hurdles to agricultural performance.

53. Given that many in SACAU have historically been focused on crops and livestock, natural resources have particular attributes which may be unfamiliar to them. The Conference may therefore after identifying main opportunities of particular interest for follow-up, set up task groups of interested persons, supported by experts, to study and present for future consideration recommendations on options for natural resources engagement by SACAU and its member organisations. With appropriate task teams to guide the work, among the areas for possible follow up if the SACAU Operational Plan can make room for them, could be the following areas :
    a. Updating in summary from the state and trends of natural resources for agriculture: **land** - summary of total land, degraded land, land under threat of degradation, rangelands, forest and woodland cover, extent of formal reservation, main land uses of land under woodland/forest/shrub cover, ownership and tenure regimes, broad breakdown of small/medium and large farms; **water** – update on rainfall patterns, extent and types of irrigation, water bodies relevant to agriculture. Highlight the extent to which the state and trends suggest that agriculture and its sustainability face imminent threats requiring determined action to address [*to the extent possible, disaggregate the information and analysis to show contrasts and commonalities between small/medium holders and large scale*];

    b. In order to place the direct contribution of natural resources in context alongside agriculture, confirming the economic contribution of natural resources to national economies [**forests** (natural, plantations), **wildlife** (including associated tourism), capture **fisheries** and aquaculture) in production terms, alongside agriculture] - production, consumption, trade (domestic, exports, imports) [*to the extent possible, disaggregate the information and analysis to show contrasts and commonalities between small/medium holders and large scale*];

    c. Profiling transitions in management from natural resources to domestication and the policy environment affecting pace of change: (a) in **fisheries** – transition from the "hunter and gatherer" marine and lakes capture of fish in the wild to aquaculture; (b) in **forestry** – similar to fisheries between natural forests and plantations and tree planting on farms; (c) **wildlife** – state of conservation, commercial returns; emergence of game ranching agriculture [*to the extent possible, disaggregate the information and analysis to show contrasts and commonalities between small/medium holders and large scale*];

    d. Prepare a dispassionate professional overview of how realistic Southern Africa climate change scenarios would affect the above;

e. Drawing on all the above and other sources, review policy and strategy options for encouraging more responsible management of natural resources alongside agricultural pursuits[14] followed by prioritised proposals with timelines for:
   - policy advocacy by SACAU and its members;
   - action by SACAU members.

   [*to the extent possible, disaggregate the information and analysis to show contrasts and commonalities between small/medium holders and large scale*]

[14] Bearing in mind that the most important factor for conservation of remaining resources is making agriculture more productive so that it does not destroy more of its natural resource base.

Annex 1: Cases of CSA and Good Practices in Resources Management

GENERAL

Case 0: CSA Enhancement in China's Green Growth Strategy

China's priorities for agriculture cover continued modernization through market development, technical innovation, intensification, food safety, regional development, improved land tenure security, disaster management and climate-resilient low-carbon agriculture. The strategy moves away from quantitative targets and aligns with China's vision for agriculture in 2030 as part of a broader green growth strategy.
Support measures include: input support; support for watershed and sustainable management; research; insurance and climate-risk management; use of weather-based information; use of improved climate-resilient varieties; and a continued shift away from cereals towards higher-value products.

Regarding climate risks, China's priority is to strengthen the resilience and reduce the emissions of the agricultural sector through technology enhancement, rural energy and land and water management. In this, China has made progress in key grain-production areas by changing cropping patterns, irrigation and water-saving technologies, and use of more resilient varieties; it has focused on water-stressed regions, coastal regions and ecologically fragile areas.

Thanks to its longstanding reforestation and watershed management programmes, China is now a net 'sequesterer' of carbon from land-use and forestry. Its Loess Plateau program restored degraded landscapes while increasing productivity. Its reforestation programs have helped stem watershed erosion and have adapted over the years to use of a greater diversity of species and more effective community management.

Case 1: Climate Smart Agriculture in Southern Africa [Extract from Opinion Piece by Godfrey Kundhlande, World Agroforestry Centre (ICRAF)]

A 2006 UNEP report suggests that southern Africa will be among hardest hit regions by rising temperatures as a result of climate change. This would severely impact agriculture due to anticipated change in growing conditions for crops and livestock, reductions in yields, increased incidents of pests and disease, and erosion of the genetic base for future crops. Poor agricultural performance would undermine socio-economic development of southern African countries, given that in many of them, agriculture, agriculture-linked industries, and other climate sensitive sectors are the backbone of national economies.

With a view to adapting their agricultural sectors to the adverse effects of climate change, the countries are adopting strategies and measures to cope, including in agriculture, where policies and investment increasingly seek to increase productivity, help sequester atmospheric carbon and conserve carbon in agro-ecosystems and forests, and to build resilience to climate change – all three being pillars of what is termed "climate smart agriculture". Unfortunately, available information suggests that climate smart agriculture practices are [probably for lack of knowledge] not yet widely used in rural communities in southern Africa, which suggests need for researchers, farmers, government, the private sector and NGOs to partner in promoting widespread adoption of adaptation initiatives and innovations.

Given likelihood of droughts in the region being predicted to worsen in frequency and intensity due to climate change, among the climate smart agriculture practices is the use of drought tolerant cultivars of crops, the breeding of new varieties that are better adapted to the changing ecology of southern Africa. The greater use of drought tolerant plans needs to be accompanied by greater storage and more efficient use of water, including through conservation tillage, terracing, soil bunds and micro-catchments that can mitigate the negative effects of dry spells but also improve soil fertility and reduce soil erosion. Agroforestry is a further promising tool to improve and sustain agricultural productivity and to enhance rural income in the face of climate change. The benefits of this have been outlined in Section 2.3 of the document including its Box 5.

Preparedness for disasters will become more important and is an area for intervention. It is important to increase attention to generating and disseminating advance information, including timely seasonal weather forecasts in formats that meet farmers' needs is necessary at a time of increasingly frequent and extreme climatic events in the region.

Success will also require broader enabling policies and institutional to create incentives for farmers to invest in climate smart innovations. Changes are needed over the whole agricultural value-chain from resource tenure, infrastructure to reduce transactions costs and improve access to markets, inputs and output and financial market efficiency etc so that farmers find it rewarding to invest in improved climate adapted technologies. Naturally, even more than ever, countries must respect the 2003 Maputo Declaration commitment to increase budgets and public investments in agriculture including its dominant smallholder segment.

SOILS

Case 2: Managing Soils for Increased Productivity under a Changing Climate in Southern Africa: What Prospects for Conservation Agriculture?

[Extracted from Opinion Paper by Herbert M. Mwanza, African Conservation Tillage Network (ACT), Zambia]

Background: In Southern Africa, over 61% of its people depend on agriculture and at a time of reducing rainfall/ infrequent flooding regimes, increasing temperatures and rampant deforestation, they also face severe degradation of agricultural lands due to destructive management practices – particularly ploughing of the soils and burning of crop residues that destroy the soil structure and reduce soil organic matter respectively.

The ACT supports and acts upon the ideals of Conservation Agriculture and promotes them to "guarantee" economic benefits, environmental safeguards and better sustainable living. CA combines farming technologies that when used together, limit/arrest/ reverse the effects of unsustainable agricultural practices that have led to accelerated soil erosion, soil organic matter decline, and physical degradation of agricultural lands; it can serve to address climate change challenges too even though it was developed well before its advent.

ACT Strategies for promoting Conservation Agriculture: ACT promotes six key strategies in an integrated manner, as follows:

Strategy 1: Raising soil productivity even under a climate change environment - Given that Southern African farmers have labour productivity 30 times lower than in developed countries (land productivity is also low, at 1.5-1.7 mt/ha), the challenge is to employ affordable practices to raise land productivity and reduce production cost especially among resource-constrained and vulnerable small-scale farmers. Focus is on disseminating innovative knowledge and skills of:

- enriching poor through crop residue management and CSA cropping practices;
- employing cereal/legume systems, such as maize/pigeon pea rotations that can give maize yields 5 times that of average of sub-Saharan Africa
- integrating *Faidherbia albida* trees/agroforestry technologies into maize systems;
- pursuing organised/managed crop-livestock integration where livestock nutrients/power are fed into the crop system, and the crop system feeds the livestock system;
- growing of N-fixing legume green manure cover crops to improve soil fertility and to feed livestock (but challenges of dry season);
- dealing with soil and water conservation works especially on sloping land; and
- crop diversification.

Strategy 2: Appropriate localised research support - Research and extension to solve problems of:

- weeding challenges - high costs, poor knowledge on herbicide use, low purchasing power; use of mulch in weed suppression.
- how to increase participation and performance;
- improving access to and two0way data/information flows for productivity enhancement; communication and memory.

Strategy 3: Mechanisation - The ACT promotes whatever is most locally appropriate among mechanisation options: hand-based, animal powered and/or motorised. With sub-Saharan Africa having 65-75% of its farmers depending on manual/hand labour, 15-25% on animal traction, and 5-10% on motorised power, amount of land that can be cultivated gets limited and there are issues of timeliness, labour and health of the workforce, and poor yields. The back-breaking manual agricultural system is also believed to repel the youth, who drift into urban areas in search of alternative jobs.

Strategy 4: Environmental protection - The ACT promotes CA-based practices such as optimising utilisation of land and resources; and reducing greenhouse gas (GHG) emissions.

Strategy 5: Government Support - ACT advocates an enabling environment, effective extension services in touch with and responsive to the needs of the farmers or land users.

Strategy 6: Knowledgeable Farmers, Ownership and Placing Farmers in the Lead - ACT stresses empowerment of farmers through knowledge about the causes/effects/challenges/impact of climate change on their farming systems and livelihoods; potential/available adaptation and mitigation strategies from which to respond to; timely accessing available sources of such information; and farmer assessments and decision making processes. It has in mind a union initiative that will build/support CSA farming systems with participation of its members, of both commercial farmers and an inspired/empowered small-scale agricultural land users.

WATER

Case 3: Improved Water Management - Alternate Wetting and Drying (AWD)

Flooded rice systems (irrigated, rainfed, and deepwater rice) emit significant amounts of CH4. Research suggests that flooded rice systems might contribute about 10–12% of anthropogenic emissions from the global agriculture sector. There is a large potential to reduce GHG emissions from rice paddies with the systematic use of AWD. At present, AWD is widely accepted as the most promising practice for reducing GHG emissions from irrigated rice for its large methane reductions and multiple benefits.

Alternate wetting and drying (AWD) is a form of deficit irrigation used in lowland rice that saves water and reduces GHG emissions while maintaining yields. AWD is the periodic drying and re-flooding of the rice field, as follows: About two weeks after transplanting, the field is left to dry out until the water level is at 15 cm below the soil surface. Then the field is flooded again to a water depth of approximately 3–5 cm before draining again. This irrigation scheme is repeated except during flowering time, when the field is maintained at a flooded water depth of 3–5 cm. The number of cycles of flooding and drainage will vary. Benefits:

- ***Reduced water use***. By reducing the number of irrigation events required, AWD can reduce water use by up to 30%. It can help farmers cope with water scarcity and increase reliability of downstream irrigation water supply.
- ***Greenhouse gas mitigation***: In the 2006 IPCC methodology, AWD is assumed to reduce methane (CH4) emissions by an average of 48% compared to continuous flooding. Combining AWD with nitrogen-use efficiency and management of organic inputs can further reduce greenhouse gas emissions. This suite of practices can be referred to as AWD+.
- ***Increased net return for farmers***: When used correctly, AWD does not reduce yields compared to continuous flooding, and may in fact increase yields by promoting more effective tillering and stronger root growth of rice plants. Farmers who use pump irrigation can save money on irrigation costs and see a higher net return from using AWD. AWD may reduce labour costs by improving field conditions (soil stability) at harvest, allowing for mechanical harvesting.

Case 4: Deficit Irrigation[15]

Deficit irrigation (DI) is a watering strategy that can be used with different types of irrigation methods, based on a thorough understanding of the yield response to water (or how sensitive a crop might be to drought) and of the economic impact of reduced harvest. Deficit irrigation focuses on farmers being more profitable by maximising crop water productivity instead of maximizing harvest per unit of land; it can make more sense where water is very short. Under DI, irrigation is applied during drought-sensitive growth stages of a crop and, outside them, is limited or even not applied if rainfall can provide a minimum supply of water.

It is reported that DI can raise yield: for example in Turkey, planned DI increased winter yields by 65% as compared to output under rainfed cultivation; water use efficiency was double that under rainfed and fully irrigated winter wheat. For cotton, Turkish and Indian results show that using DF, there is only limited yield losses when irrigation water use is reduced up to 60 percent of the total water

[15] http://en.wikipedia.org/wiki/Deficit_irrigation

requirement. In the USA, forcing drought (i.e. deficit irrigation) on peanut plants early in the growing season caused early maturation of the plants but maintained sufficient yield of the crop.

For other crops (especially when crops are sensitive to drought stress throughout the complete season, such as maize) deficit irrigation result in a lower water use efficiency and yield. Field experimentation is necessary for correct application of DI for a particular crop in a particular region. The following are among the **constraints** observed for deficit irrigation:

- There must be exact knowledge of the crop response to water stress;
- There should be sufficient flexibility in access to water during periods of high demand (drought sensitive stages of a crop);
- A minimum quantity of water should be guaranteed for the crop, below which DI has no significant beneficial effect;
- An individual farmer should consider the benefit for the total water users community (extra land can be irrigated with the saved water), when he faces a below-maximum yield;
- Because irrigation is applied more efficiently, the risk for soil salinization is higher under DI as compared to full irrigation.

Case5: Protecting Peatlands in Northern China

Origins and progressive damage: The case study profiles national, provincial and local programmes that are working to conserve the Ruoergai peatlands, an ecosystem which provides precious grazing resources and a natural buffer against flood and drought. The act like a giant sponge. Located on the eastern edge of the Tibetan Plateau, the Ruoergai peatlands absorb water rushing from the Himalayas and release more slowly and steadily into the Yellow River. Their efficacy in doing this has declined with time as human activities have compacted and damaged the sponge—initially (as early as 5000 years ago) gradually then brutally. By the 1970s, demand for food and rangeland was rising, roads were appearing, and traditional husbandry changed, with grazing intensified and peatlands being drained for pasture. Over the last 40 years, the degraded area nearly doubled; less than 20% of the peatlands are still in good condition.

Response: Given its irreplaceable grazing grounds , storage of 750 megatonnes of carbon, and regulation functions on water for millions of people, the Ruoergai is worth saving and China has responded at multiple levels: (a) since 2009, there is the national programme Tui Mu Huan Cao (i.e. "Returning Grazing to Grasslands") which offers financial rewards to herders who lower the number of livestock or fence pastures to grow hay for the winter instead of grazing animals on frozen peat bogs; (b) provincial policies prohibit drainage and fund peatland restoration - provincial regulations for wetlands conservation were adopted in 2007 and 2010; and (c) local pilot projects are carrying out restoration, are engaging herders and other stakeholders in planning and decision making, and support local people to play key roles in protecting remaining good patches from overgrazing and further degradation. The following are among Key lessons and impacts:

- Officials tried technical measures to restore peatland functions, but had only minor and temporary successes. The missing ingredient was management of grazing intensity.
- Sustainable grazing can only be achieved by actively involving local people in decision making.

Partners: The central government, the provinces of Gansu and Sichuan, national and international partner organizations and local stakeholders have all worked to protect and restore peatlands.

Climate Change Mitigation: Untouched and restored peatlands store millions of tonnes of carbon, and slowing degradation can significantly reduce emissions.

Case 6: Index-Based Livestock Insurance to Increase Climate Resilience of Pastoralists in Kenya and Ethiopia

Insurance based on satellite tracking of ‘greenness’ helps pastoralists cope with droughts in the Horn of Africa. The intervention relates to losses to farmers from extreme weather events such as droughts which lead to widespread livestock mortality, caused primarily by forage scarcity, which undermines pastoral livelihoods. Index-based livestock insurance (IBLI) gives pastoralists the option to insure themselves against these events.

Unlike conventional insurance, IBLI tracks local forage conditions using real-time, publicly available satellite data (‘greenness maps’) to determine the severity of drought, predict area-average livestock losses and calculate policyholders’ indemnity payments. Insurance cuts in when a contractual threshold—or ‘strike’ point—of forage loss or predicted livestock mortality is reached; the IBLI contract is then triggered and policyholders receive a pay-out proportionate to the number and type of animals insured and the severity of vegetative loss and expected herd loss in the policyholder’s geographic area. Thus, IBLI aims to provide a productive safety net for households affected by livestock loss and help them effectively manage the resulting shock. IBLI may also incentivize investment in livestock and nourish the economy in pastoral areas.

IBLI has been piloted in the Marsabit district of northern Kenya since 2010, with the active participation of a Kenyan insurer and technical support towards product design from Cornell University and the International Livestock Research Institute (ILRI). Following the success of the pilot, IBLI was also introduced in southern Ethiopia in 2012, where the product was tailored to accommodate local needs.
Key lessons and impacts

- ***User reaction***: IBLI contracts are attractive to pastoralists, and substantial demand for these insurance products was observed in the pilot areas.
- ***Private sector interest***: The involvement of commercial financial institutions has enabled testing of the market readiness of IBLI products and will aid in scaling up.
- ***Food and income*****:** Droughts and other extreme weather events are marked by food insecurity, and the pay-outs received from IBLI enable pastoralists to fulfil their household needs, reduce distress sale of livestock and lessens the likelihood that they will reduce the number of meals taken by their family.
- ***Adaptation*****:** Insurance increases pastoralists’ resilience to extreme weather.
- ***Mitigation*****:** This program does not aim to provide mitigation benefits.

Partners: ILRI, Cornell University and the CGIAR research programs for Dryland Systems and Climate Change, Agriculture and Food Security. Donors include the Australian Agency for International Development (AusAID), the UK Department for International Development (DFID), the European Union, the Global Index Insurance Facility (GIIF), the US Agency for International Development (USAID) and the World Bank.

ARID AND SEMI-ARID RANGELANDS

Case 7: Managing Pastures and Rangelands for a Changing Climate in Southern Africa [Extract from Opinion Paper by Sikhalazo Dube, Irenie Chakoma, Lovemore Gwiriri and Godfrey Manyawu, ILRI Southern Africa regional Office, Harare, Zimbabwe]

Rangelands accounting for 41% (394 million ha) of the total SADC land area and their vegetation is predominantly Miombo and Mopane woodlands, with grassland, arid and semi-arid-savannah, nama and succulent karoo as understorey. Rangelands reportedly support over 200 million people through livestock production under agro-pastoral and pastoral systems, industrial livestock systems and mixed-crop livestock systems.

There are many **opportunities in rangelands**, including the climate change related one of carbon sinks. Payment for Ecosystem Services (PES) has been cited as a viable option to improve rangeland management examples being the Ecosystem Service Trading Model in South Africa and CB-PES – they have yielded benefits but are not commonly applied to rangeland management but have been developed for forests protection or watershed management. There are also many **challenges to rangelands and pastures**, which include:

Population growth has been cited as the main reason for challenges related to rangelands. Range is decreasing due to encroaching human settlements and introduction of land-use changes including crop cultivation; establishment of government and private ranches and tourist game parks. Loss of common property resources is increasing, with relatively high livestock densities a contributor, given that rangeland herbage densities have reduced significantly and are only capable of supporting low animal densities.

Changes in weather patterns: particularly change in rainfall frequency and intensity determine rangelands species composition, with most annual species not reaching maturity and seeding. Variability in rainfall makes predicting sustainable stocking density and grazing management options difficult.

Changes in species composition: With an increase in unpalatable species and intrusion of non-native varieties of plants and weeds (e.g., *Lantana camara, Sporobolas pyramidalis*) due to grazing pressures and rangeland degradation.

Insecure land rights: there lack of clarity on ownership. Unclear rights limit access to land result in rangeland lacking management plans and apparent lack of ownership and accountability. Benefits to communities from rangelands are therefore segregated and non-supportive to communal management strategies. Policy that supports rangeland management is often lacking, and where it exists is seldom enforced.

<u>Case 8</u>: Ultra High Density Grazing – Innovation in Managing Pastures and Rangelands for a Changing Climate in Southern Africa. [Extracted from Opinion Paper by Johann Zietsman, Farmer - Karoi, Zimbabwe]

Background: The traditional precepts that appear to govern all official grazing management prescriptions appear contrary to the efficient functioning of natural grasslands: they generally measure productivity in terms of individual animal production and "desirable" species composition without much regard for the ecosystem and overall economics. are:

- Conservative stocking rate: there is a belief that cattle are intrinsically bad for grassland and that the only way to minimise this negative effect is by limiting numbers;
- Allow animals to graze selectively: To ensure maximum individual performance;
- Minimise soil disturbance: believing that this will minimise soil erosion;
- The use of fire and technology (chemicals; machinery): in order to treat the symptoms of low animal numbers and low stock density (moribund grass; bush encroachment; bare ground / reduced plant cover); and
- Controlling grazing and recovery time: use of a minimum number of paddocks (not more than 8 paddocks per herd) so as to limit overgrazing.

Conventional grazing management in brittle environments (seasonal rainfall) results in land degradation and extremely low productivity when measured as profit per hectare or return on investment. This is due to low stocking rates, poor grass utilisation and ineffective ecosystem processes (poor soil aeration; high water run-off and evaporation; decreased soil fertility; decreased plant density; bush encroachment). Some farmers have bucked the conventional wisdom: the Charter Estate Trial in Zimbabwe proved that grassland did not deteriorate at a stocking rate double the officially recommended norm. Ranchers and farmers have shown that degraded land could be improved and that stocking rates can generally be increased to between double and quadruple the conventionally recommended norm.

Mimicking Nature: In the process of grazing, herbivores such as cattle, especially if they are in the presence of predators or if they are forced to graze at high stock density, also trample plants and soil resulting in increased water infiltration, greater soil fertility as well as a seedbed for the establishment of grasses. The breaking up of a soil surface cap results in the establishment of grasses rather than weeds. If the time taken to graze an area is short (high stock density) and the recovery period relatively long then grass vigour is high and the tannin content of trees and bushes low resulting in palatable browse and a consequently high physical impact (breaking of branches; stripping of leaves and bark) by cattle on trees and bushes. All these actions, if they happen in unison are extremely positive and they favour grass growth.

The only way man can successfully manage rangeland is to mimic nature and this involves studying and managing the whole a combination of severe grazers (cattle); grassland (grasses, forbs, bushes, trees) and the predatory effect (dense herds). Nature does this on the Serengeti plains of East Africa.

Implementing High Animal Impact and Non-Selective Grazing on a Ranch Scale:
To mimic Serengeti, ranchers have to create high stock densities. During the 1970s a trial was done at the Charter Estate which highlighted the necessity of high stock densities; it used 16 paddocks per herd (vs. The conventional 8 paddocks per herd) but this did not create anywhere near the stock density required for effective grazing management.

Greater stick density is achieved on commercial farms by creating constantly supervised grazing strips (25 – 200m wide and 1km and longer in length depending on the environment) with corridors to water that are constructed at right angles to the strip and cross-fences in the strip that lead to the required stock density and the impression of thousands of "paddocks" per herd.[16]

Ultra High Density Grazing on Pumula Farm, Karoi, Zimbabwe: (a) Degree of crowding - Ultra High Density Grazing (1000 – 5000 LSU / ha) was initiated on Pumula farm on 12th January 1995. In 1994 / 1995, the driest year on record (375mm instead of the 900mm average) stocking rate was doubled; two years later stocking rate was treble the norm. It is unfortunate that the maximum stocking rate for this environment has not been determined.

(b) Performance: without a control to compare with, it is difficult to be certain of the decline in individual animal performance resulting from non-selective grazing. It is estimated that calving rate declined by approximately 10 – 15% to approximately 70% at treble stocking rate. This was entirely due to the poorer body condition of conventionally selected cattle (Beefmasters) resulting from non-selective grazing. This drop in individual performance must be seen in perspective. In the absence of ultra high stock densities (the equivalent of 2000 "paddocks" per herd and approximately 8 "paddock" shifts per day) cattle would have died of malnutrition at treble stocking rate and conventional management. Another way of measuring calving rate would be to say that it increased from 85% (selective grazing; conventional stocking rate) to over 200% (3 x 70%). The only way conventional management could achieve this would be via twinning!

The Lessons Learnt from Pumula Farm: Considering what was achieved on Pumula farm and trials in other countries (South Africa, the USA and Mexico) the following conclusions and recommendations can be made:

a. Stocking rate can generally be increased to between double and quadruple the conventional norm;
b. In order to improve grass utilisation, without an undue drop in body condition, stock densities need to vary between 100 and 3000 LSU per hectare depending on environment;
c. Sufficient animal impact for land improvement will occur at the higher densities (1000 – 3000 LSU densities). At the lower densities (mainly dry country) animal impact will have to be created where necessary by the use of attractants (feed cubes; hay), herding, night paddocks or a combination of all;
d. In higher rainfall, fast growth environments recovery periods after grazing need to be short enough in order to allow a high intake of nutritious grass. It will be necessary to rotate intensively grazed (growing season) areas with dry season stockpiled areas;
e. In low rainfall areas with nutritious grazing the emphasis must be on long recovery periods to ensure grass vigour and to serve as a drought reserve;
f. A drought reserve must be planned in all areas in order to ensure sufficient grass for animals to be carried from one growing season to the next;
g. It is essential to monitor changes in plant species composition and all ecosystem processes in order to modify management (time; timing; stock density; impact) when necessary;
h. An efficient functioning rumen is essential in regard to grass utilisation and body condition. Protein and mineral supplementation is essential in most environments;

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[16] With this kind of control management decisions carry a penalty (poor body condition) or a reward (land improvement; high stocking rate; good individual animal performance). Even with animal mismanagement (poor body condition) land will improve and profits increased provided there are sufficient paddocks per herd. The ultimate objective must be a high stocking rate and optimum body condition.

i. Matching cattle genotype to the environment is essential. This relates, in particular, to nutritional adaptation (high relative intake; inherently good body condition) which is favoured by a smaller frame. Conventionally bred cattle are generally not nutritionally adapted. In many cases it may be necessary to breed a locally adapted composite. African breed cattle are unique in regard to nutritional adaptation.

<u>Case 9</u>: Karoo Ultra High Density Strip Grazing (UHDSG) Grazing Experiment 2003-2012 (South Africa) [Note from a picture essay by Andre Lund, Karoo farmer, South Africa]

Andre Lund has been in farming for over 50 years and reports on Ultra High Density Strip Grazing (UHDSG) in the Karoo drylands of South Africa. UHDSG focuses on range reclamation and claims regained potential to 50-75% relative to capacity lost over 200 years of bad range management. It is about managing for non-destructive balance between the veld and the livestock pressure.

<u>**KAROO GRAZING EXPERIMENT 2003- 2011**</u>

Through my whole farming career of over 50 years I worked to find a way by which veld and stock complement each other instead of destroying our resources. My research on Ultra High Density Strip Grazing was done on semi- arid Karooveld with remarkable results. For most people (stock farmers and scientists included) it is hard to think that one can still improve on grazing management.

However, UHDSG is to my mind the only and closest to natural stock and veld management with reclamation the main objective. There are some important natural factors build into the system that makes it extremely suitable for all conditions. You also don't need to be a rocket scientist to understand the philosophy behind this way of managing natural resources. It is all just common sense by which you can regain potential (50% -75%) that have gone lost over the past 200 years of bad Management. The overpopulated world cannot take it any longer, so we will have to change.

ANDRE LUND

Case 10: Pastoralism in Laikipia, Kenya

The Laikipia Wildlife Forum is a 500-member organization that includes pastoralists, commercial ranchers, and small and large-scale farmers spread over 10 000 square kilometres in the area surrounding Mount Kenya. In 2008, the Laikipia Wildlife Forum initiated a 10-year rangeland rehabilitation and management programme, which emphasized rehabilitating bare land across the district as part of a strategy to build the region's resource base and reduce competition for natural resources, such as pasture land and water.

The Rangeland *Rehabilitation* and Management Programme focuses on capacity building (defined as 'competence, confidence and commitment') and makes use of two well-developed tools: planned grazing and vision setting. Planned grazing is a technical solution to land degradation while vision setting provides the human or managerial context for improved practice.

A key foundation is a ***grazing plan*** for 6 000 cattle and 3 000 sheep and goats in their dry season reserve, designed and implemented at community level. The plan involves dividing a controlled area into blocks; allocating grazing days for the herds in each block based; and combining animals into as few herds as possible, which move through the blocks by a pre-determined sequence according to water availability, grazing competition, distance, and other factors. Most importantly, animals are gathered into tight herds as they graze to maximize soil disturbance, and graze a different section of the block in use each day to prevent overgrazing. The immediate ***results*** included: improved land health, livestock survival and productivity, youth involvement and community unity. The following are the most fundamental lessons from Laikipia:

- Land degradation is more a social than a technical issue;
- Creating the 'transformation process' involves interconnected personal; relational; collective, and systemic (structural) elements. The social aspects are key and require a great deal of effort and attention if the technical aspects are to succeed.
- Social transformation cannot be subcontracted to others: intervention staff should connect psychologically with communities and in pastoralist settings, there must be pastoralist intervention staff.
- No one issue can be sustainably tackled in isolation. Only alignment of all aspects can bring lasting, positive results: aligning the 'what' with the 'who', 'how', 'when' and 'where.'
- Every situation is unique. Common-sense principles and processes, rather than off-the-shelf 'fixes', in the hands of managers rather than experts, give the flexibility necessary to respond to each unique situation based on willingness and ability.

AGROFORESTRY

Case 11: From Slash-and-Burn to Agroforestry in Central America

In traditional slash-and-burn systems, a family needs about 6 hectares to maintain itself on a diet of corn and beans. The family exploits a plot for two years and then sets it aside for 14 years. In agroforestry systems a plot is exploited for 10 years, producing, along with corn and beans a variety of other products, often including livestock. The plot is then set aside for only 5 years. A family thus needs 1.4 hectares to sustain itself and enjoy a more diverse and balanced diet. Land is therefore almost 4 times more efficient.

Efficiency also increases because in agroforestry systems, yields (which are comparable the first year) do not decline over time as they do very rapidly in slash-and-burn systems. In fact, yields can even increase slightly over time in agroforestry systems. Productivity of labour and of capital is also higher in agroforestry systems. Costs are reduced, especially for fertilizers, because of more organic matter in the soil and better use of nutrients by the plants.

At the community level, diversification of production triggers the development of local markets. Consequently, in terms of resource use, agroforestry systems are efficient at safeguarding food security and the environment. Agroforestry systems are also much more resilient:

- Yields are less variable, because of better humidity retention.
- They provide for more diverse production, which ensures in turn a buffer against both the variability of crop yields and price volatility.
- They offer diversified sources of income, including through selling wood for various uses (and at various time scales), which can also provide a buffer against some economic shocks.
- They protect the soil from erosion, which is a major concern in these areas. Studies have shown that in agroforestry systems erosion is reduced by a factor of more than 10.

Case 12: Intercropping Coffee with Banana in East Africa

Intercropping coffee and banana appears to be more profitable than coffee mono-cropping. Intercropping improves the productivity and returns of the farming system; the combination also contributes towards improved food security and increased family income. The benefits of intercropping can probably be further increased by improved soil management practices (e.g. use of mulch, manure and fertilizer), optimal plant densities and planting arrangements, and appropriate agronomic management practices (e.g. pruning, de-trashing)

Bananas occupy a substantial portion of the agricultural land in the region compared with coffee and intercropping therefore offers room for the crop's expansion. Agricultural diversification has furthermore been encouraged in coffee-producing countries by the International Coffee Organization (ICO) as a way of coping with declines in coffee prices.

Case 13: Livestock Diet Intensification through Agroforestry

Ruminant diets with high-quality nutrients lead to higher meat and milk production. One way to intensify livestock diets is by feeding them the leaves of trees such as *Leucaena leucocephala*, which is widely grown in the tropics. Adding even a small amount of Leucaena leaves to dairy cattle can treble milk yield per day and quadruple weight gain per day so helping to improve farm income.

This improved diet also helps with GHG mitigation: the diet can reduce methane by a factor of 2 per kg of meat, and by a factor of 4 per kg of milk. If more livestock farmers used this diet, we would need fewer ruminants to meet future demand for milk and meat, which would reduce the world's 'carbon hoof print'. At the same time, the use of agroforestry trees can increase carbon sequestration.

FISHERIES AND MARINE ECOSYSTEMS

Case 14: Rice Field Fish Rings in Bangladesh[17]

Microhabitats (fish rings) are man-made habitats that help maintain the biodiversity of ecosystems and make sure that fish thrive in rice fields by trapping fish that would otherwise be washed away with tidal flows and monsoon flood recession. The microhabitat is made up of 3 small cemented rings which are usually used as outdoor toilets and are easily available (costing 900 BDT or $12). The monsoon season in Bangladesh brings extremely variable weather and tidal flows. Some fish enter rice fields from nearby rivers and canals but they can be trapped when water levels recede and eventually die. The monsoon season also coincides with the spawning period for most floodplain fish. If a fish ring is established at the onset of the monsoon season, it can ensure that fish remain and survive in rice fields, providing nutritious fish for consumption.

According to current climate-change scenarios, southern Bangladesh will experience extremely erratic and unpredictable rainfall patterns, which could mean more floods and droughts in years to come. Weather variability and anomalies in the beginning of the monsoon season can make it difficult for fish to enter and survive in the rice field. In the dry period (November-April), many farmers struggle to grow crops.

Fish found in the fish rings at the end of the monsoon (October) may provide extra income opportunities and food. Smaller fingerlings can also be caught and cultured in homestead ponds in preparation for the dry period. Fish rings therefore, provide farmers with a secondary livelihood opportunity. It also means that farmers can catch nutritious fish if flooding ruins rice crops. The rice field fishery can become more productive.

[17] Source: WorldFish, 2014