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TRADITIONAL KNOWLEDGE

SYNTHESIS ON IMPORTANT AND WIDELY APPLIED TRADITIONAL KNOWLEDGE ON A SUBREGIONAL AND REGIONAL BASIS AND ON A NATIONAL SCALE

Note by the secretariat

By its decision 14/COP.2, the Conference of the Parties requested the secretariat to complete its ongoing work on compiling the most important and widely applied traditional knowledge on a subregional and regional basis and on a national scale where appropriate, and make a synthesis of this work available to the Committee on Science and Technology at its third session (ICCD/COP(2)/14/Add.1). This synthesis has been prepared by the secretariat for consideration by the Conference of the Parties.

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SUMMARY

(i) Different communities have evolved a wide range of traditional technologies through active environmental interactions and empirical experimentation, in their bid to improve living conditions and the quality of life. Technologies recognized in this survey include the following sets of empirical information and packages.

Site amelioration technologies

(ii) Site amelioration practices are perhaps the most basic tools for taming harsh dryland ecosystems. Common practices include:

- Mechanical measures using palisades or grids of straw, or clay-pebble platforms of related local material that are erected between a given property and the sand line,
- Biological measures such as live fences, shelter belts or plantations of woody plants.

Soil and water management

(iii) Techniques of water and soil management are crucial because water deficiency and soil infertility are the major constraints to production in dryland. The common structures are cut-off drains, waterways, terraces and retention ditches, that are built of earth, stones, pebbles or masonry.

(iv) Farmers have developed precise technologies using different structures that are appropriate to given terrains, soils and production systems.

Crop production

(v) Although agricultural production in drylands is limited to pockets of relatively moist areas, dryland farmers have managed to expand their cropping fields through diversification of crop species/varieties and integration of crops with livestock portfolios and other strategies that satisfy their needs for food and income. The major technologies include conservation tillage, nutrient management, incorporation of complex systems such as the agro-pastoral–forestry systems that capitalize on agronomic management through niche diversification, crop complementarity and their mutual support, and opportunities for hedging options.

Water management

(vi) Water resources management practices date back to early times and range from simple catchment and diversion structures to sophisticated underground canals found in North Africa, the Middle East and China, such as *Faggaros* in North Africa and *Karez* wells in Pakistan. Groundwater is also tapped through hand-dug wells that extend from riparian areas to depths of over 100 m, on higher ground.

Biomass energy

(vii) Local communities continue to rely on biomass energy from fuelwood and agricultural residues for cooking and heating. Preferences range from wood and charcoal to animal dung, depending on local conditions. Conservation strategies include the development of energy-saving burners.

Animal production

(viii) Animal production dominates land use with pasturage and water management being guided by customary rules. Common technologies include investment in a wide portfolio of animals: cattle, goats, sheep, donkeys, mules and poultry. This is supplemented in some areas with domestication of wild game such as ostriches, and native livestock such as llamas and alpaca in South America. Herd mobility, dispersion, shifting of households, utilization of wildlife and range rehabilitation provide powerful strategies for sustainable pasture use. Notable technologies are specialization in animal health management, water resource use, and fire management.

Forestry

(ix) Woody plants constitute important components of the farming system and play a central role in supporting all aspects of dryland ecosystem functions. Proactive management programmes include tree planting and management of natural vegetation to support food security, as defence lines against sand dunes, protection against dry/cold winds, provision of wood and non-wood products and conservation of biodiversity.

Wildlife resources management

(x) Traditional communities have coexisted with wildlife for millennia. Cultural beliefs in abstinence from wanton killing of wild animals, and regulated hunting or fishing habits are a clear reflection of people who have concern for their environment and biodiversity. Thus the concept of multi-animal management is widely observed and wild animals graze freely in community lands.

Specialist skills

(xi) A number of specialist skills are recognized in areas such as the harvesting of wood and non-wood products, crop knowledge and management including the zoning of agricultural land, and crop species/variety matching with sites using rational environmental indicators. Skills on seed and food storage are particularly impressive. Examples of traditional biotechnology skills in food preservation and fermentation in the production of fermented food such as *chicha* in South America, and *masi* by Polynesians of the Solomon Islands are noted.

(xii) Applications of traditional integrated pest management systems and use of indigenous indicators of climatic and weather variations, and site quality are highlighted. The knowledge and application of ethno-medicine for human and livestock diseases management are also acknowledged as areas with potential for future scientific research and development.

Recommendations

(xiii) The great potential of traditional technologies, existing confidence and trust between CBOs and NGOs, and their experiences and understanding of traditional technologies are recognized. The mobilization and promotion of organized participatory approaches to documenting, screening and assessing promising traditional technologies for mainstream sustainable development is recommended. It is stressed that such approaches should be mounted by teams of biological, social scientists, and community partners in networks at different levels, focusing on the documentation, validation and valorization of promising practices through modern processes. It is also emphasized that such work should employ standard common methodologies so that results at the national, regional and international levels amy be comparable.

(xiv) Parallel activities proposed include training and capacity-building at the community and scientific levels; and research and development on priority scientific, technical, policy and legal issues.

I. INTRODUCTION

1. The arid, semi-arid and dry sub-humid lands of the world, which are affected by drought and desertification, cover about 5.1 million hectares, about one third of the earth's surface (UNEP 1992). This is concentrated in the land surface between latitudes 72° north and 57° south, particularly in Africa and Asia, where large land areas have lost most of their original biotic functions. Unfavourable topographic, edaphic and climatic conditions make drylands ecologically fragile when subjected to intensive use. Consequently crop production is limited to a few wet areas leaving pastoralism as the main pillar of the economy. The topography and latitude play important roles in the distribution and amounts of rainfall in these areas, causing great variability in the precipitation which comes in the form of rain, snow and water from melting ice.

2. The original natural dryland vegetation varies from scrub, through open grasslands to wooded grasslands that are generally characterized by scattered trees and shrubs interspersed with herbaceous elements, and open spaces between tree canopies which allow a luxuriant growth of graminaceous species and forbs. These plants have evolved diverse drought-resistant traits that enable them to cope with the harsh environment. Droughts and high evapotranspiration rates are common experiences.

Traditional technologies

3. Traditional and local technical knowledge, know-how and practices, often collectively referred to as traditional technologies represent accumulated cognitive and perceptive experiences of interactions between a group of people, their physical and biological environments, and the production systems. The quality and quantity of traditional knowledge varies among community members, depending on gender, age, social status, intellectual capability and occupation (hunter, spiritual leader, healer, etc.) or trade. Language, religion, bio-physical imperatives, and socio-cultural aspects, e.g. tenure and environmental traits, are important driving forces in shaping these practices.

4. Traditional technologies are dynamic and have built-in mechanisms for innovation and growth of new dimensions according to changing challenges and circumstances. In practice, communities continue to learn from one another, through interactions between neighbours, cross-border marriages, and adaptation of a given culture to new environments following conquest and subsequent domination. Many cultures have also borrowed from modern and scientific developments.

5. But a few strong enclaves of original cultures are still found among nomadic, pastoral and hunter-gatherer communities in corners of nearly all continents, such as the Incaic traditional culture in the Andean world. Remnants of European culture such as the Mennonite culture found in Paraguay, the Welsh in Patagonia and the Italians in Cuyo, have been adopted partially in the new environments, and continue to subsist in the production systems.

6. On the whole, traditional technologies have been ignored by modern development and scientific institutions since the dawn of industrial society. Indeed, a marked erosion of traditional technologies occurred during colonial times and more recently, during the influence of research-driven and concerted global promotion of the green revolution in the 1960s and 1970s. It is only in the past decade that this knowledge has been recognized by the Western scientific community as a valuable source of information. Today, a growing body of literature attests not only to the presence of a vast reservoir of information regarding plant and animal behaviour, nutrition and medicinal potentials of natural products, but also to the existence of effective indigenous strategies for ensuring the sustainable use of natural resources. Consequently many scientists, community-based organizations (CBOs) and non-governmental organizations (NGOs) working with peasants have compiled a large body of traditional technologies associated with different production systems and agrarian typology. But vast quantities of information remain undocumented, while very little validation and appraisal of efficacy and sustainability has been done.

7. Dryland communities have a rich heritage of managing and living in these environments despite heavy erosion of traditional technologies due to different factors. Some of the knowledge lives on, and is evident in extant traditional farming and range management practices throughout the regions. Still more of this knowledge remains locked in the hills, mountains and valleys of the landscapes, awaiting archaeological analysis. Traditional technologies recognized in this survey include sets of empirical information and packages on improving site quality, management of farming systems, animal production, food processing and storage, management of health of man and livestock, water and wildlife resources.

II. SITE AMELIORATION PRACTICES

8. Communities living in open degraded sites and areas affected by sand invasion, such as sandy deserts or desert margins, and seafronts worldwide are constantly threatened by sand invasion, mobile dunes, dust storms and dry winds. The openness of the ground and prevailing high winds in these areas lead to rapid movement of dunes from place to place with concomitant disturbance of residential areas, road and railway networks and agricultural fields.

9. These communities have consequently developed a wide range of mechanical and biological measures, largely through experimentation using available materials and in consistence with prevailing factors for mitigating aeolian effects. These technologies are particularly important because their moderating influences produce amiable and pleasant conditions that are critical for provision of a healthy environment, development of reliable transport systems, increased crop and livestock yields. Land degradation as a consequence of shifting sand dunes has obliterated many civilizations in virtually all continents, in the past.

A. Mechanical measures

10. These have one common feature, operating on the principle of creating a barrier to the wind by producing areas of reduced sand-carrying capacity ahead of and behind the belt. Locally available materials are preferred: straw grids supported with wooden posts, stone walls or terraces and clay/pebble platforms. The palisade or terrace erected on top of a dune on the windward side or in checkerboard patterns such as U-, V-, or L-shaped configurations along the property or seafront has been used successfully in Africa, the Caribbean, the Middle East, West Asia, China, South America and elsewhere. Ditches or dykes from 50 to 100 metres wide excavated upwind between a property and the sand line also provide efficient defence against dunes.

11. Mulching with brushwood or man-made materials such as plastic, polyfibre, nylon, acrylic netting or other products derived from petroleum have been used where these materials are available, such as by oil companies in the Taklimakan desert of China. Binding the surface by wetting in areas where water is available also minimizes sand movement. Chemical fixation of shifting sand by applying saline water or products such as asphalt is successfully used in China.

B. Biological measures

12. These include establishment of live fences, shelter belts or windbreaks upwind of areas requiring protection from drifting sand. Different configurations of multi-fence belts are used in dryland areas worldwide as an integral component of rehabilitation programmes and/or integrated land-use systems.

13. Shelter belts and windbreaks provide several benefits, such as protection against wind erosion, and sand drifting, sources of fuelwood or poles, wildlife refuge, enhanced aesthetic value and micro-climatic advantages to human beings. They reduce the wind speed and evaporation rates and hence ameliorate the micro-climate and increase crop yields.

14. Several communities have instituted dune stabilization programmes which embrace schemes for dune fixation, afforestation and attainment of goods – such as fuelwood – as programme objectives. The size, porosity, morphology and composition of fences vary between places but operate on the same principle of creating a barrier and producing areas of reduced sand-carrying capacity ahead of and behind the vegetation belts. Establishment is contingent on the availability of drought-tolerant woody plants and application of suitable planting techniques. Sand binder species with tolerance to hot temperatures, aridity and infertile soils, fast growth, large crowns and well developed root systems have provided good results.

15. Multipurpose fence belts incorporating a combination of perennial herbs mixed with shrubs and trees under arrangements and densities that allow each component to contribute its desirable traits fully is considered advantageous. Woody multipurpose trees and shrubs, if used, provide a supplementary source of forage and fuelwood from pruning and soil improvement. Live fences of proven species may also be established alongside a stabilized mechanical structure. Wood lots of multipurpose trees and shrubs established between the edge of the sand and a given property also fix dunes while providing forage and other utility products.

16. The rehabilitation of saline environments that are common in drylands is also dependent on successful establishment of a vegetative cover. Depending on the site conditions, grasses or trees may be suitable. In severe cases, “pioneer” species are often used to ameliorate the site sufficiently before the more desirable plants can be established.

17. There are many isolated cases of successful application of biological measures. In Bouza in southern Niger, every street is lined with trees, and the town is being encircled by woods. Green belts are being planted around the capital cities of Ouagadougou and Niamey in Burkina Faso and Niger. The Tunisia-Morocco green belt is also noteworthy.

18. Integrated programmes for sand dune fixation on the northern littoral and the protection of adjacent market gardens in Senegal, and regional programmes for sand dune fixation in Mauritania, the State of Rajasthan in India, North Africa, the Middle East, and the former states of the USSR are important landmarks demonstrating the efficacy of road-side shelter belts in protecting road and rail networks. Windbreaks are also of considerable importance where they have been established, on the large plains and windy southern part of South America, such as Patagonia. Sudan is restocking its gum belt, which acts as a barrier to the desert, while Peru has an ambitious programme for the rehabilitation of its Andean sierra.

19. Irrigated agriculture in these countries would be inconceivable without the protection of windbreaks to afford protection from the hot winds and sand dunes. An irrigation project in Tunisia with wooded surrounds has increased agricultural yields many times over. The application of windbreaks for the protection of agricultural crops is highly developed in the drylands of China in order to protect crops from desiccation and physical damage from wind-blown sand and loess.

20. Vast areas of farmland and villages in northern China which had been buried by shifting sands were rehabilitated from the mid 1950s onward through these technologies. In this instance straw barriers were erected at the foot of mega-dunes and inter-dune depressions, and vegetation belts subsequently established behind the straw checkerboard. Consequently the southward movement of sand dunes was completely controlled and large areas of farmland were brought under effective protection by the shelterbelts.

III. SOIL AND WATER CONSERVATION PRACTICES

21. Prior to the emergence of farming communities in dry zones, theses areas were occupied by hunter-gatherers and fishing communities who depended entirely on subsistence under nomadic or semi-nomadic modes. Gathering, hunting and fishing remained paramount for many years. The settlement of farming communities in the drylands marked the introduction of traditional patterns of shifting cultivation in areas amenable to crop production such as forests and riverine belts, introducing a much wider range and variety of land use than their hunter-gatherer and pastoralist neighbours could employ.

22. Slash-and-burn agriculture, one of the first systems of crop production, was efficient and sustainable in the absence of land hunger when the number of people and livestock was low. People understood that it was necessary to leave the land fallow for sufficient time to allow enough tree re-growth to provide sufficient ash and heating of the soil. During colonial times and the emergence of modern states with increased numbers of people and livestock, adequate fallow periods became unachievable. Consequently, the farming communities began to build up complex economic systems and agricultural production systems. But following wide adoption of intensive land use, land degradation became the contentious issue, particularly in drylands.

23. Alarms raised from the 1930s about the potentially damaging consequences of soil erosion prompted a long history of external interventions by governments that enforced mass adoption of traditional soil and water conservation systems. The experience of the “Dust Bowl” in the United States proved highly influential in policy thinking from this time onwards. The prospects of such disasters afflicting the newly established colonies worried many administrators and politicians of the day and major programmes of soil conservation were initiated in countries where state control was strong. The result was the emergence of a set of interventions focused on mechanical and agronomic soil and water conservation technologies.

24. By the late 1940s, a wider environmental awareness had become paramount framing land-use policy. Soil fertility decline, overgrazing and deforestation were added to the list of ills inflicted on the land by non-sustainable farming and livestock husbandry. Thus the scope of soil conservation in the drylands has remained wide, embracing soil, water, and farm management and addressing enhanced, sustainable soil fertility, and soil-water-plant relationships for sustained crop yields.

25. The water relationships of dry zones are perhaps the most critical for determining the basic life support systems. Techniques of water and soil conservation are crucial because water shortage and soil infertility are often the most important constraints to production. From years of experience, farmers across drylands have built up an intimate understanding of the mechanics of soil and water resources management, and practices for managing different soil types, slopes and production systems. Under this process, the management of watersheds has primarily

focused on the conservation of soils and control of surface water derived from the upper reaches, and the subsequent run-off impounded or absorbed in the landscape. On the slopes, technologies aim at minimizing run-off and soil loss and promoting infiltration. In the lowlands and bottomlands, dominated by alluvial plains, the major technologies are concerned with prevention of flash floods and sedimentation, enhancement of recharge of aquifers, water storage, and maintaining and improving soil fertility through good husbandry.

26. In the case of irrigation, proper application of water, prevention of salinity/alkalinity and minimization of sand encroachment are paramount. The most common conservation structures are cut-off drains, waterways, various types of terraces, and retention ditches that are built of earth, stones, pebbles or masonry. With the benefit of hindsight, many farmers, pastoralists and resource managers now clearly see the benefits of soil and water conservation and related practices.

Cut-off drains (diversion ditches) and waterways

27. These are graded channels with a supporting ridge or bank on the lower side constructed across a slope to intercept surface run-off and convey it safely to an outlet such as a waterway. They may also be used to protect cultivated land. Such structures are usually trapezoidal in shape and have larger capacities than ordinary terraces. Farmers often introduce a good grass cover (trimmed from time to time) on the embankment and along the upper edge of the bank for stability.

Infiltration (or retention) trenches

28. These are made by excavating affected sites over 30-50 m, backfilling with stones and wood and then covering with soil, to retain run-off. Well planned and managed cut-off drains, waterways and infiltration trenches are commonly used by peasant farmers in sub-humid land areas.

Terraces

29. Different types of terraces ranging from rudimentary stone lines to sophisticated terracing are built mainly to conserve the soil and stabilize steep land, while providing level areas for sustained cropping. At a rudimentary level, lines of stones are laid out in parallel or along a grid pattern on compacted, denuded land. In this situation the stone bunds present a semi-permeable barrier which allows the passage of excess run-off while trapping sediments. The level of sophistication is greatest where the process of levelling behind the bunds is accomplished by deliberate landscaping. In some cases the process of cultivation leads to the natural formation of benches over time.

30. Terracing is widely used in dry farming on hillsides and in irrigated farming in suitable areas. Some practices involve systems of intense and permanent cultivation on hills, using terraces protected by storm drains and with woody plants and grass planted on ridges along the contour that date from early times. In most

cases, farmers maintain pre-existing trees and shrubs on undisturbed parts of a slope or by adjusting terrace design and construction. Such terraces established by sedentary farmers in the Kainam hills south-west of Lake Manyara, United Republic of Tanzania, in the late 18th century, are still well conserved after almost 200 years of cultivation, and feed a large, growing population.

31. Bench terraces comprising a series of more or less horizontal steps cut along the contours, with the excavated material placed on the outside of the cut and embankment so that the cuts and fills create level platforms for cultivation are widely applied in crop lands. Where soils are readily erodible, fairly level benches may develop between the trenches in two to six years. Woody plants and fodder grasses are often planted on the risers where the soil is the deepest and most fertile. When covered with vegetation, the ridges catch eroding soil which helps to build them up further and create substantial flat areas behind them. The natural process of water carrying sediment is strengthened by planted vegetation.

32. The construction of bench terraces with stone walls is justified where stones can be found in adequate quantities close to the site, and the potential productivity of the land justifies the expense. The construction of stone wall terraces at intervals on the contour not only protects the land from erosion but simultaneously clears stones, which facilitates cultivation and increases crop production.

33. Besides protecting and improving the existing cropping system, terraces provide new planting niches with favourable conditions for speciality crops or for establishing valuable trees. For example, farmers may plant fruit and nut trees along the toe of terrace rises and thereby allow the successful establishment of tree crops that would otherwise be unable to survive under dry conditions. Bench terraces are found in all the three continents where farmers find them appropriate.

34. Examples of stone bunding and terracing on hillsides occur on the Jos Plateau in Nigeria, and in several regions of Ethiopia, Sierra Leone, the Sahelian countries, Rwanda, Yemen, different regions of China, North Africa particularly Tunisia, Algeria and Morocco, the Middle East, etc.

IV. AGRICULTURAL PRACTICES

35. A relatively small portion of drylands is amenable to rain-fed crop production. The harsh climatic conditions make crop production a risky undertaking, leaving pastoralism as the mainstay of the economy. Currently agricultural production is limited to pockets of relatively wet areas where crop production is possible under rain-fed conditions, in irrigated and wetland areas, and under water harvesting systems.

36. Traditional farming systems are characterized by diverse varieties and species of crops and domestic animals, with higher proportions of indigenous species and varieties or breeds. The living mode itself is based on the use of a vast number of domesticated and wild taxa. Indigenous perceptions of biodiversity are evident in social values, beliefs and practices that sometimes make reference to the importance of biodiversity, including reverence for such biological units as forests, trees and some animals.

37. Dryland communities have, through different epochs and civilizations, learned and accumulated precise technologies for managing their resources. Traditional technologies have assured sustainable crop production through minimizing soil erosion by water and wind and improving productivity through appropriate practices that were consistent with biophysical features such as the slope, microclimate, and soil characteristics. This understanding continues to guide the farmer as to where a crop should be grown, what crop is to be cultivated, and how the fertility of the soil is to be maintained. Farmers use such traditional knowledge in recognizing different soil types, and site potentials for growing different crops. For instance, in the Sahel farmers limit cultivation to north-west facing slopes, where the soil remains moist for long, and the plateau on the cloud belts. The ability of the soil to support a good crop and increased production depends on the soil type, and how the soil is treated and managed. Peasants have evolved efficient methods of land preparation and agronomic practices appropriate to specific soil types, rainfall regimes and crops. These include tillage practices, nutrient and moisture management and cropping systems.

A. <u>Conservation Tillage</u>

38. Conservation tillage, also often called minimum tillage, is an approach that has become popular with mechanized farmers in the last 30 years in areas that are subject to drought or erosion. But this practice has been widely used by farmers since the dawn of agriculture. Conservation tillage systems involve:

- Improving soil structure;
- Reducing the amount of soil inverted during cultivation;
- Leaving residues on the surface;
- Disturbing the soil no more than required to promote infiltration of water and germination of seeds;
- Reducing the cost of cultivation.

The following systems of conservation tillage have been well developed by small-scale dryland farmers:

Slash-and-burn agriculture

39. Slash-and-burn or shifting cultivation is one of the traditional cropping systems. In early times, clearing of the bushland with hand axes and hoes was limited to removing branches of trees, leaving tree stumps to regrow (coppice). The

surrounding field was cleared of grass, most of the organic material burnt and the residual material including ashes spread over the field. Local variations were developed to suit different conditions. The cleared area varied from small patches, such as a circle around prominent trees (the *Chitemene* system practised in central Africa) to open patches in the woodlands. Shifting cultivation was also practised in non-wooded areas along the desert margins, when the cultivated field became degraded due to loss of nutrients or salinization.

40. Slash-and-burn agriculture was efficient and sustainable when human and livestock populations were low. Burning leaves a clean seedbed in which crops are planted directly without disturbing the soil. The ash fertilizes the soil and the heating destroys weeds and soil-borne pests and diseases. The garden, also known as swidden fields, was cultivated for one to three years. In the past, the land could be given up to 20-30 years to recover, hence assuring sustainability. But today, with increased numbers of people and livestock, adequate fallow periods are not possible and the trees do not have enough time to regenerate. Slash-and-burn agriculture is still practised in developing countries but the fallow period has been shortened to eight years or less in the Sudan and elsewhere and the large circles have shrunk with declining tree resources.

Hand hoeing

41. This is the main tillage technique used by the majority of small-scale farmers who do not have oxen. The seedbed is dug to a depth of about 20 cm. Large clods are obtained and the surface is rough. The technique does not spoil the soil structure and it encourages high infiltration of water into the soil. Another hand hoeing may be required before planting to remove grass weeds and a further hoeing is normally done at weeding time.

Ploughing and harrowing

42. These are conventional tillage methods that involve primary and secondary cultivation by ox-drawn implements. The ploughing and harrowing operations depend on the type of seedbed required. Small grains require a fine tilth, which is obtained by harrowing after ploughing. Large grains can do with a much rougher seedbed. A rough surface with clods improves infiltration and minimizes the risk of erosion. Ploughs range from the simple chisel type to the mould board type.

Stubble mulch tillage and trash farming

43. This involves chopping crop residues and spreading them on the surface. Cultivation is usually done with a sharp implement such as a chisel plough. Another technique that is similar to stubble-mulch tillage is *trash farming*. The technique entails harvesting the standing crop, then cutting and spreading the crop residues on the surface then ploughing and cultivating in the normal manner. A certain amount of residue remains on the surface, thereby promoting soil and water conservation.

B. Nutrient Management

44. Experience has shown that repeated cultivation without fertilization reduces the content of nitrogen, carbon and exchangeable cations to low levels. Even long fallowing under grazing fails to restore soil nutrients to the levels found on uncultivated land. Fertility management is therefore critically important for the sustainability of arable farming. Dryland farmers practise different soil improvement options: inorganic fertilizers, *boma* (farmyard) manure, alternative organic sources (compost, mulches, green manure), and use of nitrogen-fixing legumes as inter-crops, crop rotations or farm trees. Except for the use of nitrogen fertilizers on profitable crops, manure has been the mainstay of soil improvement efforts since the 1930s and 1940s, when it acquired a commercial value. Adoption is widespread. However, supply constraints (number of livestock or working capital available) restrict its application on most farms to levels well below those desired for optimal nutrient supply.

Farmyard manure

45. This is available on most farms where there are livestock but the quality is often low due to poor methods of preparation and utilization. Some farmers in dry areas have been reluctant to use manure because of the risk of burning the crop if the weather is dry. But many farmers have realized that this problem can be overcome by using more bedding to increase the quantity but lower the strength of the manure, as it matures after removing it from the boma, or using it together with crop residues and other materials to make compost.

Compost

46. Composting is a natural process of turning organic material into a valuable plant food called humus. Humus is a blackish substance which gives a dark colour to the topsoil. It is a complex colloid preserved by tannins that break down relatively slowly. The material has a sponge-like capacity to retain water and cements soil particles together to give a crumb-like structure. When properly made and applied, compost provides readily available plant food and does not contain as many weed seeds and pests as farmyard manure, because of the heat generated. Compost manure can easily be made on the farm using crop residues, garden weeds, kitchen and household wastes, hedge cuttings and any other vegetative material.

47. Composting offers an additional avenue for nutrient management and by combining manure with plant materials, it can double the supply of organic materials available. It was first promoted by missionaries in the 1930s, but did not become popular then. Recently, it has been taken up again by NGOs promoting organic farming.

Green manuring

48. Green manuring is the practice of growing a crop, usually a legume, and ploughing it under when the crop is young and green or at the flowering stage. Small-scale farmers do not usually find it profitable to grow a crop and then plough it under, consider this to be costly, and seem to prefer other types of manure. However some annual legumes such as *Crotolaria ochraleuca*, are advantageously used for this purpose in central and southern Africa. Such nitrogen-fixing legumes are also inter-planted with cereals such as maize. After the maize is harvested, it provides forage for livestock, which in turn produces manure for enhanced fertility. In this way a whole season’s harvest is not lost through green manuring. A closely related species, *Crotolaria juncea* (sun hemp), is also widely used for this purpose in Zambia and Zimbabwe.

49. Another legume which is excellent at fixing nitrogen and has given good results in Central America, Indonesia, Kenya and Zambia under green manuring and fodder is the belvet bean (*Mucuna* sp.). The lupin (*Lupinus albus*), also a legume, suited to cooler climates around 2000 m above sea level, is commonly grown by small-scale farmers in the African highlands.

Mulching and use of crop residues

50. Dead plant material such as dry grass, straw, maize stalks, dry leaves, banana leaves, sugarcane trash and other crop residues that are spread on the bare soil surface or placed around the stems of plants can be used to control soil erosion and conserve moisture. The mulch protects the soil from surface sealing, holds water and allows it to infiltrate slowly into the soil.

51. Besides helping to control erosion, mulches also reduce water loss through evaporation, improve water retention, increase the number and activity of micro-organisms in the topsoil, and suppress weeds. An experiment in Laikipia, Kenya, under semi-arid to sub-humid conditions showed that, in the absence of a mulch, 40-60 per cent of the rain that fell was lost as evaporation from the ground. If 40-50 per cent of the ground surface was covered with a mulch, run-off losses were reduced almost to zero and evaporation losses were halved. The result was a doubling or tripling of maize yields and a major increase in the yield of stover, part of which could be fed to livestock and part kept for mulch in the following season. Mulches also tend to lower the soil temperatures during the day and reduce heat losses during the night.

Optimization of the crop residue and woody plants

52. With the gradual onset of settled living followed by a diminution of the grazing area, the dynamics of the indigenous innovations have entered a cycle embracing the use of the crop residue in which the animal is allowed to consume a small portion in the field, while the rest is transported using draught power close to the living quarters and skilfully piled singly or mixed with other agricultural

wastes such as bean husks. Such concentrated feed stock is fed to milking cows or draught animals.

53. The level of use of crop residues indicates the level of scarcity of animal feedstuffs. Hence this technology allows farmers to raise the carrying capacity of their land through a process of recycling.

Land fallowing

54. In this system, which was also introduced through early missionary and government intervention, farmers cultivate the land for three to eight years and allow it to rest for two to four years. This practice is basically akin to shifting cultivation, is low-input and familiar to local communities. But the shortage of agricultural land has tended to work against this technology.

Relay cropping

55. Relay cropping is the practice of planting a second crop as an inter-crop after the first crop has reached its reproductive stage, or after a certain amount of growth, but before it is ready for harvest. In areas where maize is grown during the short and long rains, relay cropping is practised at the start of the second season to avoid delay in planting. This method provides soil cover all the year round because, when the field is prepared for planting the second crop, cover is still provided by the first crop. Similarly when the first crop is harvested, the second crop takes over immediately to protect the soil from the raindrop impact and excessive heat of the sun. Work done by the International Council for Research in Agroforestry (ICRAF) in Chipata, Zambia, has demonstrated marked increases in maize yields under *Sesbania* relay fallows (ICRAF 1996).

Nurse cropping

56. The practice of inter-cropping a newly established perennial crop with an annual crop, to increase production and maintain a good ground cover, is common with peasant farmers. Once the main crop is capable of providing the required ground cover, the nurse is discontinued. Farmers in East Africa always inter-plant millet with sesame. Nurse cropping is also practised in afforestation programmes under the *taungya* system, whereby annual crops are inter-planted with trees for a few years until the trees reach a level at which they cannot be smothered by weeds. The young tree seedlings are given the necessary care during crop cultivation, leading to high rates of seedling survival and establishment.

Cover cropping

57. Cover cropping is a practice used to provide the cultivated ground with protection from erosion by raindrop splash and overland flow. The cover crop also protects the soil from excessive heat from the sun and creates a good environment for micro-organisms. The fallen leaves of the cover crop decompose and add organic

matter to the soil, thereby reducing its erodibility. A quick-growing crop, such as sunflower, can be used as a cover crop, but because of the cost involved, most farmers would expect to harvest seed before ploughing it in.

Crop rotation

58. Subject to land availability farmers practise crop rotation, a landuse practice that simulates nature, introduced by early missionaries and government extension services. The practice of crop rotation entails growing different crops in sequence. Crops vary in their nutrient demands, susceptibility to pests and diseases and ability to cope with erosion. A good system of crop rotation facilitates restoration of the soil structure and fertility, the controls erosion and reduces pests and diseases. Certain weeds such as Striga, can be controlled or limited by crop rotation. On many small-scale farms, cereals are rotated with pulses, root crops and occasionally grass. Grain crops are relayed after two to three years of each, followed by a legume crop such as beans, groundnuts or sunflower. It has since been tried by virtually all communities practising crop farming in drylands. Some Brazilian communities practise rotations between crop and livestock production.

Strip cropping

59. Strip cropping is the practice of growing alternate strips of different crops in the same field. The practice, which is also called contour strip cropping when contours are employed, can be used to control water and wind erosion. For controlling water erosion, the strips are always on the contour but in areas prone to wind erosion, they may be placed perpendicular to the direction of the prevailing wind.

60. A fallow strip comprising a narrow band of grass usually about 0.5-1 m wide and spaced at normal terrace spacing which depends mainly on the slope planted to a fodder grass such as Napier or left unploughed with natural grasses. Grass strips are often allowed to develop a thick basal growth to slow down run-off and retain eroded soil material. Hedges also serve as barriers but they are inclined to be gappy at the bottom and are most effective when combined with a narrow strip of grass on the upper side. As run-off is usually only a few centimetres deep, it is most important that the grass strip is dense at ground level and without gaps. Direct grazing of grass strips is avoided. Such grass strips may over time lead to the formation of terraces, mainly because of deposition on the upper side, but also because of the practice of pulling soil away from the lower side of the strip during weeding.

61. Although most grass strips are established on a permanent basis, some farmers tend to plant them on a rotational basis. After a few years new strips are established between the old ones and the latter are uprooted. In this way the productivity of the strips is maintained and the benefit of increased organic matter is distributed more widely.

62. In general, close-growing crops such as grass are alternated with strips of wider spaced row crops such as maize. When water flowing from the crop reaches a strip of grass, its speed is reduced and silt is deposited. Contour strip cropping combined with crop rotations, the use of manures and fertilizers, and minimum tillage is an effective method of soil and water conservation.

Trash-lines

63. Trash-lines are constructed by laying plant residues or trash in lines along the contour. Trash-lines help slow down the flow of run-off and trap eroded soil. The trapped soil assists in building up bench terraces over time but only if the trash-lines are kept in the same place from year to year. On very steep land, farmers sometimes put in pegs on the lower side to prevent the trash-lines being wasted away. They also combine trash-lines with grass strips.

Contour ridging

64. Contour ridging is commonly practised for growing potatoes or other low crops. The ridges are constructed across the slope. Ridging is often done during weeding. The crop is earthed up to increase room for the formation of tubers. The spaces between the ridges form depressions or furrows in which rainwater collects and infiltrates into the soil. Contour ridging can be done by hand, or by ox-drawn or tractor-drawn implements. For small fields, hand ridging is the better option, while large fields require animal or tractor power. Contour ridging can be very effective at preventing run-off from small storms, but during heavy storms water tends to collect at the low points and can break through.

Mound cultivation

65. Mound cultivation is another successful traditional farming method practised by dryland farmers. It involves incorporating grass into the soil so that it rots and fertilizes the soil. This method has the advantage of allowing people to settle and work the same land for a long time. It is also practised in fields susceptible to temporary waterlogging.

C. Multi-cropping systems

66. Dryland farmers practise different cropping systems according to site-technology compatibility and potential gains to the farmer. Trees maintained under parklands or agroforestry systems support self-sustainability by providing products such as fruits, leaves and roots for daily use or as emergency food, energy in the form of fuelwood and charcoal, wood for building and farm implements, poles and posts, medicine for both people and livestock, fibre and other material for handicrafts, fodder for livestock, bee forage and beehives, material for thatching and mulch, etc. They can also provide a variety of services such as shade and shelter, boundary marking, windbreak, erosion control, soil fertility improvement (acting as nutrient pumps), environmental protection, restoration of degraded areas,

micro-climate improvement, employment opportunities and income generation. The following systems are commonly practised.

Parkland

67. The parkland system, characterized by mature trees dispersed in croplands, is probably the leading agricultural landuse system in sub-Saharan Africa and other tropical countries. The ability of parklands, or multi-tiered systems, to enhance and stabilize crop production has been much studied over the past 20 years, particularly the *Faitherbia albida/Prosopis* grain systems predominating in the Sahelian zone and in some parts of East Africa and *Prosopis* and/or other woody legumes or grain in Asia and South America. The increases in yields under this system range as high as 100 per cent compared with crops grown away from the trees (CTFT, 1988).

Agroforestry

68. Agroforestry is defined as any landuse practice that involves the deliberate retention, introduction and management of trees or shrubs in agricultural systems, where ecological, economic or social benefits result from interaction between agriculture and/or livestock and tree husbandry. This involves raising crops or animals among trees especially managed as a way to conserve the soil and improve cropyields.

69. Trees may be grown with crops or in pastures at the same time and in the same field or at the same time in adjoining fields, or at different times in a variety of ways such as:

- In cropland, either scattered or planted in lines;
- Along boundaries, paths and roads or as live fences;
- Along soil conservation structures;
- For windbreaks;
- Around homesteads for shade or beauty;
- In fruit orchards and home gardens;
- For improved fallows using nitrogen-fixing species;
- In small wood lots for poles and fuelwood;
- In cropland or pasture land for fodder or browse;
- For gully reclamation and stream-bank stabilization.

70. In practice, farmers apply agroforestry technologies that they have refined in their own fields. The most outstanding of these include: multi-strata home gardens, live fences and hedges along residences, wind belts in fields and plots, hedges along terraces, inter-cropping, mulching, fodder banks, wood lots, parklands, etc.

Inter-cropping

71. Despite the strong campaign for promoting the packages of the green revolution under a strong drive for decentralization, individualization and mono-cropping, the majority of small-scale farmers have continued to practise inter-cropping. In the Sudan, millet and sorghum are inter-cropped with sesame in the same hole to serve as windbreaks. Wind erosion is a major constraint to sesame production in the area, and farmers have found that inter-cropping with sorghum helps guard against wind damage.

72. Inter-cropping (also referred to as mixed cropping) refers to the growing of two or more crops (companion crops) simultaneously in the same field in the same season. Leguminous and non-leguminous crops are commonly inter-cropped. Production is intensified in both time and space and the farmer spreads the labour requirements for the different crops throughout the year. Inter-cropping ensures the spread of risks should one crop fail, and enhances food security for the farmer. Common examples of inter-cropping are maize with beans, peas, groundnuts, cowpeas, pigeon peas or sweet potatoes, cotton with beans, and kales with beans.

73. Fast-growing legumes, such as beans and cowpeas, provide soil cover early in the season before maize or cotton develops and adequate canopy to shield the soil from the impact of raindrops. When maize, beans and pigeon peas are grown together, the beans provide soil cover through the dry season and into the next rainy season. Leguminous crops fix nitrogen and make it available to other crops, either through leaf fall or root exudate. This transfer of nitrogen helps to maintain fertility and crop yields.

74. The idea behind inter-cropping is that different crops are grown in one field to ensure that some output can be obtained from the field. Should drought conditions or pests adversely affect one crop, the other crops might produce some yield. Under conditions of limited resources and erratic rainfall, inter-cropping enjoys wide appeal. In the event of rain failure, a single crop would spell disaster to a whole household. Moreover, because many farmers cannot afford to expand their cultivation through land clearing, they grow several crops on the same field to take advantage of the limited area they have cultivate.

75. Intense inter-cropping is particularly prominent in the home gardens. Fertility is maintained by use of organic manure, crop residues and household refuse. This practice also helps cut down weeding costs since several crops are weeded at once when they are in the same field. The dense cover during the cropping season greatly minimizes erosion while enhancing nutrient management by capturing the full nutritive contents of the harvest.

Multi-storey cropping

76. The practice of growing tall and short crops simultaneously in the same field is known as multi-storey cropping. Often multi-purpose trees form the top canopy, followed by moderate-sized crops such as bananas, coffee, beans and vegetables. Each of the different crops grows to a different height. The deep-rooted crops draw water and nutrients from the lower horizons of the soil. They shed leaves and twigs, which provide mulch. Mulch adds organic matter to the soil, prevents excessive evaporation and encourages microbial activity. This benefits shallow-rooted crops that utilize the recycled nutrients, moisture and improved soil aeration. The system is almost self sustaining; it requires very little external input, and soil erosion is minimized. However, it is only suitable for areas with moderate to good rainfall.

Alley cropping

77. This practice involves growing annual or biannual crops between rows of leguminous trees and shrubs. The shrubs fix nitrogen and make it available to crops. The legumes can also be cut down and the green biomass buried in the soil to provide nitrogen and other plant nutrients, or fed to livestock. Experiments show that alley cropping enhances soil structure, fertility and productivity but it has not yet been widely adopted because of the work involved in maintaining the shrubs and the risk of competition with the food crop when rains are poor.

V. WATER MANAGEMENT TECHNIQUES AND PRACTICES

78. Dry zones are characterized by deficient and erratic rainfall. Water is generally scarce and underground water, where available, is exceedingly brackish with very few pockets of sweet water for drinking. Droughts, which can last for up to three to five years, resulting in much distress to the population and animals, are common phenomena. At such times people and livestock are forced to travel over long distances in search of water. The major driving force to establish authentic technologies for water harvesting and management is influenced by the need to provide all seasonal supply for domestic and livestock consumption, and to irrigate small fields.

79. Thus land use and economic activities in drylands are strongly influenced by the availability and distribution of water resources. To a large extent, their inadequacy is the main limitation to sustainable development. Water is not always readily available to all communities, except during the rainy season. During the dry season, water becomes scarce and may only be found in water bodies such as lakes, rivers, reservoirs, and various pristine areas, and in maintained wells and boreholes. Marshy areas also constitute important water bodies supporting many people and animals for at least a part of the year. Marshes also provide natural sinks an important water-purification function, absorbing wastes from contaminated water.

80. Experience in the dry zones under review shows a great deal of commonality in approaches to soil conservation and water management. But the finer detail of water collection techniques varies from region to region according to the nature of the countryside, namely topography, importance of wetness or aridity, nature of soils and the usage of collected water (cf. chapter III). The main technologies for water harvesting and conservation, detention, dispersion and diversion structures and/or their modifications are found in virtually all dryland areas.

81. The story of conservation and water management can be traced back to the dawn of human civilization. For example, researchers have found signs of early water harvesting facilities believed to date from over 9000 years ago in the Edom mountains of southern Jordan (Bruins et al., 1986). These monumental achievements comprised integrated approaches to soil, water and farm management, in which all physical soil conservation practices contributed toward the overall targets of improving and maintaining soil fertility and soil-water-plant relationships, and subsequently, the attainment of sustainable and productive agriculture.

82. It can be calculated that 1 mm of rain represents 10,000 litres (10 m^3) of water per hectare. Although this would not have any effect on biological productivity in a hectare of land, if such a millimetre is collected and stocked, it can be used for domestic needs, plant cultivation, and for livestock use.

83. In addition to the soil and water conservation practices already discussed in chapter III, the following are among the common water collection techniques in drylands.

Roof catchment

84. This technique was popularized by early European influence and currently provides reliable results when used on tin- or tile-roofed houses with maintained gutters. Tanks are constructed using natural stones, cement blocks, ferro-cement or reinforced concrete. They range in capacity from 100-200 litres, to large structures of 200–500 m^3 built with stone masonry. But the use of small water jars (13-50 m^3) or metal drums is also common. Development projects and NGOs have been promoting reinforced concrete and ferro-cement tanks of about 2–46 m^3 in schools and community centres. For example, a roof of 120 sq.m in an area of 300 mm annual precipitation will yield approximately 45,500 litres of water annually (Khan et al., 1988).

Rock catchment

85. In rock catchment, rainfall on exposed rock or a hardened raised surface is collected and directed through gutters into a reservoir, with a capacity of about 8000 m^3. Materials generally used for surface hardening are plastic sheeting, butyl rubber, metal foil, etc. But the most effective and economical treatment being used for rain water harvesting is the application of mud plaster (soil and wheat straw), which can yield an average maximum run-off of 78.14 per cent of the total rainfall

received by the catchment plot. Rock catchments are useful where the right conditions exist but have inherent problems including:

- Low water quality due to open reservoir;
- Difficulty in keeping the catchment area clean and free of vegetation or silt;
- Difficulties in waterproofing and sealing the reservoir; and
- High evaporation losses from the reservoir surface.

Ground and road catchments

86. In this system, the ground is cleared of the vegetation to induce increased surface flow or road run-off and the water is subsequently diverted into underground tanks or ponds. Such tanks are excavated and lined with concrete, stone masonry, ferro-cement or murram. The major problem with this technique is low water quality because run-off causes erosion and the water carries a large amount of clay, silt and organic debris. Thus periodical maintenance and de-silting is necessary. This system is suited to watering crops and livestock.

Sub-surface dams

87. Sub-surface dams consist of sub-surface vertical barriers across the river bottom established to intercept water flowing within the alluvium as well as part of surface floods. The water is collected in the sub-surface reservoir created by the barrier. Evaporation losses are minimal, and expensive spillways are avoided, as peak discharges flow down the stream channel undisturbed. The problem with sub-surface dams is the limited space and the need for a secure foundation and waterproofing of the barrier. Water quantity is better than from open surface reservoirs, since it is less accessible to contamination. Deflection dams and gravity canals have also been observed in the very ancient urban settlements of Jawa (3200 BC) in the North East of Jordan. These communities had pioneered hydraulic technology, soil and moisture conservation technologies especially the well-known stone mounds that had served as “stone mulch” and “air wells” protecting the surface soil from excessive heating and drying. These technologies had supported vines growing in these arid environments in the region.

Desert sand tanks

88. Low rainfall coupled with extreme heat make it necessary to conserve water in some sort of concealed water tanks in arid and desert areas. A unique type of reservoir called the ‘desert sand tank’ was introduced more than a century ago and is still being used in some areas of the Middle East and Pakistan. A sand tank consists of a dam or other impervious structure built across a stream bed or large desert “sand wash”, preferably at a place where there is a rock outcrop. The dam is firmly bound to the bed rock and canal walls. In this way, evaporation losses are very much reduced and water is kept for a longer time free of contamination from animals and insects, since it lies in a relatively deep bed of sand. Such dams may

be privately or communally owned. In North Africa, such dams support irrigation in regions where surrounding mountains supply abundant water.

Detention structures

89. These are built of locally available materials such as soil, gravel, stone, boulders, and roots. The purpose is to slow down and retain flood water as well as to heal gullies. The detention structures are suitable for water detention in relatively deep wadis with gullied sides. Such structures are therefore site specific and require a considerable amount of stones and haulage of construction material.

Diversion structures

90. These structures are designed to divert flood flows partially through a channel other than the main course of the wadis in order to benefit additional areas from the detention site through dispersion of flood water. This technology is found in the very ancient human settlements in the Middle East and West Asia. Diversion structures may be led to large individual community ponds or dams for longer-term storage, a practice that is common throughout the drylands of sub-Saharan Africa.

Dispersion structures

91. Dispersion structures are overflow structures designed to spread flood water over larger areas in the flood plain. They are low-level structures (2-4 m high) constructed of gabions extending across a portion of the alluvial plain. The dams are located at raised sites, and flood flow is caused to disperse over large areas of the flood plain, without allowing back flooding of upstream communities. The result is an increased amount of water flowing into the alluvium outside the banks of the normal channel. These structures are found in areas where big rivers traverse dryland plains, such as the Nile valley, where farmers synchronize planting with flood recession and the subsequent rains.

92. The rainy season brings river flooding, covering huge flood plains with biomass, water, silt and nutrients. This regular flooding gives rise to localized areas of nutritious grassland for grazing of wildlife and livestock, and also provides the basis for flood plain agriculture.

93. Water spreading and infiltration may be aided by permeable bunds (ridges) which follow the contour lines. The bunds, which are made of soil, stones, bundled sticks, crop residues or living fences, are used to channel run-off into a depression, a seasonal streambed, or agricultural fields. The silt accumulates at the dam entry and builds terraces which are used for agriculture, while the infiltrated water makes crop production possible.

94. In some situations fish also follow the water and nutrients, breeding and feeding in the flood plain. The fish spawn and the fingerlings grow before they return to the rivers, while insects found in the flood plains provide food for the small fish. Flood plains are thus very productive environments.

95. Run-off trapped in diversion or dispersion structures may also be stored in underground storage systems such as water pools whose surfaces are lined with stone and mud or subsoil water reservoirs found in central Gansu Province, China.

Underground canals

96. Drought in areas below mountain ranges is traditionally mitigated by the construction of deep tunnels dug into the hillside wherever base flow is detected. The tunnels may extend over a wide area of farm lands to living settlements. Aquifers in these areas benefit from run-off from the mountains. In sub-temperate areas and areas close to ice-capped mountains such as Mt. Kilimanjaro, the catchments benefit from melting ice during the warm or hot seasons or in spring time.

97. The canals called *Qanat* in Iran, *Faggaros* in North Africa and Cyprus, *Aflaj* in Oman, *Karez* wells in Pakistan and *Magara* in Jordan may extend for several hundred metres and serve to capture groundwater mainly for drinking purposes and to a lesser extent for irrigation. This technique is well established in almost all old cities in the Middle East, China and elsewhere, and is effective in preserving water from excessive evaporation, especially in the hot summer times.

98. As a strategy for protecting water from evapotranspiration, local residents engaged in crop cultivation in Turpan, China, have recently dug canals on the alluvial fans from the foothill to the depression, covering a long stretch with wells located every 100-200 metres. The density of the wells is designed according to the frequency of irrigation and the extent of irrigated farmland.

99. Similar channels are used for water transport on the Peruvian coast in South America. Deflection dams and gravity canals developed by the Nabataeans around 3200 B.C. (Helms 1981) in the ancient sites of Jawa, an urban settlement located in the north-east of Jordan, are living relics of man’s age-old battle with drought. Structurally, the entire water scheme at Jawa is a matter of earth and stone. The ow soil infiltration rate makes it an ideal fill for deflection past a series of irrigable fields to a sluice gate, where some flows into an underground cistern. The main canal continues to another sluice gate where it divides to serve the town’s drinking water containers then passing into a field. Similar structures have been reported from the Negev in Israel, where it was extended into irrigation fields.

100. Karez wells are ancient systems of water management that are common in the arid highlands of Balochistan in Pakistan. In this case, water is taken from its original source, generally a spring, to low-lying areas for human and animal

consumption. It flows through an underground canal (2 to 2.5 m deep) dug with intermittent openings to the surface spaced out at suitable intervals, to serve communities along the route over which the main channel passes, as it traverses several kilometres of settled area, before coming to a final outlet. This system is still widely used in Balochistan for irrigation of fruits and vegetables, etc.

Nabataean dams

101. The Nabataean wadi barrier differs from the modern examples in being constructed of large boulders rather than of earth or small stones. Clearing and terracing of slopes was a method used by the Nabataeans along with most other Near Eastern peoples. The technique aims at improving and protecting arable land on such terrains. In addition, the terraces help prevent water from running off the slopes following rainfall, thus increasing moisture storage in the soil profile.

102. One dam is 10.66 m long x 4.36 m wide x 3.65 m high, beautifully constructed and located in a small canyon just south of Humayma. The dam was built of blocks of limestone set in mortar in a head-and-stretcher arrangement and recharged by an aqueduct, the most remarkable surviving example of Nabataean hydraulic technology so far reported anywhere. The main line extends from an elevation of 1,425 m for 18.9 km to the Nabataean reservoir at the north end of the habitation centre, at 955 m above sea level. The aqueduct consists of a heavy rubble foundation wall 0.8 m across, carrying long stone conduit blocks framed by rubble packing set in mortar. Untrimmed but for the most part, flat, slabs of limestone were laid over the top, covering the water course. This roofing was designed to protect the water from excessive evaporation, contamination, obstruction by falling debris, and possibly from unauthorized diversions.

Shallow wells

103. Shallow wells are fed by the recharge from surface water and rain that filters into the ground until it reaches the base-rock where it sits in spaces in the soil or in porous and fractured rock as aquifers. Groundwater is very important all the year round throughout the regions, particularly during the dry season. The depth at which water is found ranges from 30 m to over 100 m. Water quality varies greatly, especially the level of dissolved solids that make water salty, but groundwater is protected from evaporation, so much less water is lost than from reservoirs, and it is more reliable. Hand-dug wells are one of the oldest means of water supply. They began as simple water holes in sand rivers, but the concept of finding water by digging in riparian areas has since spread away from the river course itself, reaching up to 100 m in depth.

104. Wells dug by hand may be helicoidal in shape and wider at the bottom, with narrow platforms at various depths to enable the drawers of water to pass the buckets from hand to hand to the surface, or they may be more or less vertical, with the water being drawn off by buckets on ropes, or with hand pumps.

105. Improvements in well-digging techniques are mainly aimed at making the work easier and safer, and at the same time improving the sanitary integrity of the well to prevent pollution. Any water-lifting technique involving the introduction into the well of ropes and buckets calls for care because contamination will create a possible source of unhealthy pollution. More sophisticated lifting devices such as hand pumps have been installed by some villagers, who have been trained in pump operation and maintenance.

106. The water may also be drawn up from the well by draught animals such as bulls, donkeys or camels. A rope is passed through a pulley, one end being fastened to a bucket and the other end harnessed to the animal, with two operators, one unloading the bucket and the other taking care of the animal.

107. Some appropriate technologies have been adapted by communities of South America, such as the irrigation systems developed by Welsh communities using wind-driven pumps.

108. If geological conditions do not guarantee free-standing well sides which are unlikely to collapse, the sides are lined with concrete culverts about 1 m in diameter. Alternatively, the lined portion of the well may be confined to the bottom of the hole, extending to about 1 m below the water table. This allows the hole to be backfilled on top of a concrete slab, which seals off the reservoir.

109. In completing the well at the surface, whether it is left open or covered with a slab and a pump, the top is grouted or sealed to prevent contaminated surface water from infiltrating down to the water table.

110. Modern development projects have introduced deep-tube wells with enhanced availability of clean water, outside the normal range of traditional wells. Due to high construction, equipment and operational costs, these are unsustainable under communities’ own management.

111. One advantage of a dug well over a borehole is that community participation is assured from the start. Self-help labour is usually used to dig the well, and women and children can all help with the fetching and carrying of sand and gravel. The immediate rural economy thus identifies itself with the construction of the dug well, and establishes a sense of communal ownership that is vital for the sustainability of the water point.

Wetland patches

112. Wetlands include flood plains, banks of streams, rivers, lakes, swamps, estuaries and coastal plains that are dotted in the dryland landscape. They provide water for domestic livestock and wildlife as well as for irrigation. They are important dry season grazing areas but also provide temporary habitats for migratory species, a refuge for some wildlife during droughts and a breeding ground for fish.

113. Dryland communities have developed sustainable packages for wetland management, practices that constitute valuable drought-coping strategies. Under these use patterns, pastoralists keep away from wetlands during the wet season to avoid cattle-foot fungal diseases, while at the same time observing unwritten rules of reserving these areas for dry season grazing, and allowing off-season crops to mature. Wetland farming increases food security by providing crops when other plots fail and hence opens up opportunities for cash cropping of vegetables and other utility products.

Integrated approaches for establishing desert oasis

114. In China, due to the existence of mountains and river valleys and the wide distribution of snow, most desert and sandy lands are rich in underground, meltwater. In North Africa, such water sources are recharged through run-off from the surrounding mountains. In order to prevent the oasis and villages from sand movement, sandbreaks, windbreaks and farmland protective shelter belts are established. Inside the oasis, narrow tree belts are designed to form a reticulate structure that is moderately penetrable by wind. This increases the protective effects and prevents sand from being deposited around the tree belts. The main tree belts are perpendicular to the directions of the prevailing winds, and may be followed by a plantation of multi-purpose species of varying sizes. These tree belts not only protect oases, villages, farmland and crops and improve the micro-climate, but also provide timber, fuelwood, fodder and shade to animals in the hot and dry season.

VI. ENERGY

115. Wood is still by far the most widely used domestic fuel in drylands and virtually every family in the rural areas relies on wood for all or part of its domestic heating, cooking and to some extent lighting needs. Fuelwood accounts for more than 70 per cent of total energy use. In most places, dead wood which has naturally dried is collected in the form of twigs and branches. Even where cutting tools are available, the felling of whole trees for domestic rural firewood is rare, though live branches and twigs are frequently lopped. These are stored and dried, preferably during the dry season. Wet wood tends to be smoky and generally yield low heat. The collection of fuel is frequently the responsibility of women and children, who carry the wood home in head loads. Men may also bring wood home on a cart or vehicle but often the men collect wood for sale.

116. Charcoal is the fuel of choice in big cities but wood is also used, particularly by the urban poor. Traditional food-processing industries also rely heavily on fuelwood, as in the case of beer brewing, and smoking of fish and meat. Agro-processing (e.g., tobacco curing and jaggery processing) and rural cottage industries (e.g. brickmaking, salt drying, and ceramics production) are two other important users of fuelwood.

117. Hard-wood trees are preferred because their charcoal does not spark. In charcoal-making the wood is cut usually with an axe, and stacked in a big heap about 4 by 4 by 4 m. The stacked wood is then covered with a layer of grass or leafy twigs about 10 cm thick and then a layer of earth 10 to 15 cm thick, and the pile is ignited. Charcoal is harvested after 36 to 48 hours, and is produced by specialists who learn the job as apprentices.

118. Generally, the availability of wood does not preclude the use of other fuels. Materials such as coconut shells and maize cobs, various crop residues such as cotton stalks, rice husks and straw, millet, tobacco, and maize stalks, twigs, leaves and other light combustible materials provide common fuel.

119. Dung is one of the most common biomass fuels in areas where the land is unproductive and wood is scarce. Indeed the use of dung and agricultural waste as fuel has persisted for hundreds of years and is deeply ingrained in the customs of communities in Africa and Asia. The dung is dried and made into bricks, or cakes, dried and kindled with brushwood and burned in a perforated tin or other burners. Dung tends to burn slowly and may give off an acid smoke. Despite its smokiness, in southern Africa it is preferred to brushwood as a cold-season fuel because it burns slowly and provides warmth for the dwelling as well as heat for cooking. The bushes, in contrast, burn quickly without creating coals or giving off much heat.

120. Elsewhere, charcoal briquettes made from charcoal fines and biomass, such as wood wastes and crop residues (such as cotton stalks, coffee husks) are currently gaining interest and can make a substantial contribution to the fuelwood balance. By this means, materials that are otherwise wastes, often an environmental nuisance and difficult to handle, are converted into a form suitable for the large urban market. The residues are briquetted before or after carbonizing.

121. The types of wood stoves commonly used in the villages are of low efficiency. The improvement of wood-burning stoves is, therefore, an imperative task that is essential for redressing the demand side of the rural energy equation. It is technically feasible to save one third or more of fuel and hence to lower fuelwood requirements by this amount, by using stoves that are better designed and better used. The wood stoves commonly used in Asian, African and South American countries have recently been improved from the point of view of combustion and smoke reduction. These have been found to reduce the consumption of fuelwood for cooking by up to 70 per cent. Better charcoal stoves in many countries have also brought about a marked reduction in consumption. Improved crematoria also save as much as 40 per cent of the fuel needs. A considerable saving of fuelwood could also be achieved by improved charcoal conversion and processing techniques like briquetting.

Windmills and wind energy

122. Wind energy and windmills are used widely to generate electricity for villagers in rangeland areas in northern China, South America and parts of Africa. Small windmills are constructed around the settlements to meet daily needs for

pumping water and generating of electricity. The potential for wind power in dryland development is immense, but cannot be tapped unless the capital costs are affordable.

Biogas and solar power

123. Biogas and solar power are viewed as environmentally sound alternative sources of energy for cooking and lighting. Biogas is popular in Asia, especially China, while solar power has yet to find its niche in developing countries. The current costs of applying any of these technologies for rural domestic use are prohibitive and hence remain unsustainable, under available technical pathways.

Solar energy-powered greenhouses

124. The building and running of greenhouses using solar energy is very popular in northern China, especially in desert areas where the human population pressure causes heavy losses of the vegetative cover. Greenhouses made of clay are normally screened with a straw matrix, internal walls painted black to enhance solar heat absorption, and the outside wall protected with a belt of some evergreen trees and shrubs. These arrangements are aimed at protecting the greenhouse from heavy wind and rain impact, increasing soil moisture and air temperature in winter or decreasing air temperature and humidity inside the greenhouse in summer. Successful models are available in Gansu, Xinjiang, Shaanxi, Inner Mongolia, Heilongjiang and other arid and semi-arid provinces.

VII. PASTURE AND RANGE

125. Livestock keeping is the most widespread form of land use in drylands. Animal production dominates land use, with crop cultivation being limited to irrigation, riverine agriculture and water harvesting systems. The land is either state owned or tribally owned and used communally. Pasturage and water are the two essential elements for pastoral production, and are primarily managed by the customary principles which sanction their unlimited access. Pastoralism has been practised widely for centuries over large areas in harmony with the environment. Cattle, sheep and goats are common, as are donkeys, mules, poultry and pigs. Camels are found in eastern and North Africa, West Asia, and the Middle East. Many native species such as llama and alpaca in South America, and guineafowls in Africa have been domesticated and managed under traditional systems. Partial domestication of wild fauna such as ostriches, carpincho and the honey bee is gaining popularity. The ability to train animals is particularly noteworthy.

126. Many pastoralists practise some form of transhumance, particularly for cattle. In the transhumance system which dominated land use in the past, a pasture was intensively used for a short period and then left to rest. This was successful because overgrazing is not so much a function of animal numbers but the of time the pasture is exposed to grazing. In more recent times, increased sedentarization of herders has led to more permanent grazing in one location, with little or no time

for the pasture to rest, resulting in localized degradation. Prior to the colonial period and the advent of modern governments, pastoralists were able to move over large areas, practising wet season grazing in the lowland areas, taking advantage of the annual flush of vegetation after the rains, and dry season grazing in the hilly or wetter areas. In subtemperate to temperate zones, the movement is between summer and winter grazing areas. Some communities set aside large tracts of land for use in times of drought.

127. The marked population increase in recent times has generated pressure for the settlement of people from the wet areas in the drylands. The creation of national parks, forests and game reserves has further reduced flexibility of seasonal grazing orbits by pushing many lowland and coastal communities into the more arid lands. These developments have triggered an inexorable disruption of the traditional economy although a number of traditional technologies are still practised widely, of which the following are recognisable.

A. **Herd diversification and flexibility**

128. Pastoralists often maintain a diverse portfolio of animals, some of which may be split into separate herds according to age, sex, type, productivity, etc. Herd diversification, including taming of local wildlife species, constitutes an efficient land-use option, offers a broad spectrum of animal products and secures a steadier supply of products, spreading risks and maximizing opportunities for tiding over difficult times.

129. Sheep and goats are particularly important in household nutrition, being sources of milk, meat and cash income. Camels and goats give milk even in dry periods, when lactating cows can hardly be milked. As well as the overall milk yield, the waiting time for the first availability of milk after a drought is vital for the nomadic household: goats lactate after five months, cattle after nine months and camels after one year. The other aspect of a herd’s productivity is its fertility. Camels are fertile at four years old, cattle at three and sheep and goats at one year old. Goats and sheep which have a 30-40 per cent yearly reproduction rate can easily compensate for the high cattle losses which occur in times of drought. Since they can be exchanged later against cattle, they play an important role in post-drought recovery. Camels, donkeys and llamas provide essential draught power.

130. Pastoralists worldwide have maintained multiple animal management systems that accommodate wild game. In Africa, this includes antelopes, ostriches, giraffes, etc., while in South America the range supports native animals such as the llama, alpaca, and deer. The camelids of South America, and camels of Africa and the Middle East are adaptable to extreme conditions, have less impact on the environment and provide a wide range of products.

131. Some communities in Ethiopia promote the use of mules (hinnies), hybrids of donkeys and horses, as draught animals because of their superiority in strength, feed requirements, hoof quality, longevity and endurance.

B. Livestock breeding

132. Indigenous cattle and camelids are resilient and well adapted to the harsh environment. Traditional cattle breeding strategy emphasizes drought- and disease-resistant animals, with only strong and healthy bulls used for breeding. These communities have resisted pressure from governments to adopt exotic breeds. Mules are gaining popularity in parts of Africa and South America. While the productivity of a herd is important, its ability to survive is crucial for the nomadic household. In South America, many communities are taking advantage of the superiority of the native livestock (camelids). Increasing efforts to domesticate wildlife such as ostriches and guineafowl (in Africa) and carpincho and birds in South America are also noteworthy.

C. Herd management and production technologies

133. Pastoralism is a highly specialized subsistence activity in the dryland ecosystems and is sharply synchronized with the productivity, security, and continuity of the main resource bases that are also the most important building blocks for achieving sustainability in these ecosystems.

134. The associated adaptations are reflected in different styles of herd management, including regular movements of transhumant pastoralists and the movements of nomadic pastoralists that are dictated by the need to find water and pasturage, which fluctuate in geographical availability both seasonally and annually. This is closely tied up with herd diversification and breeding strategies and other practices designed to cope with the risks and challenges of drylands, as described below:

Mobility

135. Transhumance is practised in all dryland areas. It is a system that uses rationally the forage resources in time and space. Mobility of herds is the basic requirement for pastoralism to avoid overexploitation of pastures. The head of the household chooses a different grazing orbit at least every two days according to the herd’s forage needs and to prevent deterioration of particular points in the pasture. Daily migration rarely exceeds a distance of 5 km from the homestead. Small blocks of up to 400 ha per household (range reserves) are maintained around the homestead for grazing small stock and sick cattle among some pastoralists in sub-Saharan Africa.

(a) Seasonal migration

136. This is a regular pattern of land use and pasture management. Pastoralists continue to employ this centuries-old system of nomadic herding of livestock by moving from place to place in search of feed and water. In the past, they managed to carry on this activity in a sustainable manner despite keeping herd sizes much larger than the carrying capacity. The traditional routes of movement are strictly followed and the length of stay at a particular point is determined by the amount of forage available.

137. The routes followed enable herds to spend winters or wet seasons in appropriate areas and obtain summer grazing in the highlands or appropriate dry season grazing enclaves. In North and Southern Africa, the Middle East and Asia, migration alternates between the summer and winter grazing fields. In South America, herds move according to the seasonally determined availability of pastures and water, such as between central Chile and Argentina. There is virtually no control of the stocking rates on the open access land and the major migration routes are severely grazed by passing livestock. At this time, their use of pasture and water holes is based on a negotiated understanding with the resident landowners. In Botswana and Lesotho, cattle are driven to the mountains during the summer to avoid conflict with crop production and to stay away from *maboella*; and are returned to the village zone during the winter after crop harvest. Elsewhere herders similarly move their animals from the crop lands and return after the harvest, at which time the animals are still left to feed on the crop residues and produce manure. In some cases, herders contract with the cultivators to ensure mutual benefits of access to feed stock.

(b) Shifting of household

138. Among the Masais, migration of entire households occurs once every five or more years, mostly in times of severe drought. The main reasons for shifting the household are decreasing quality of pasture or shortage of water in the neighbourhood. But displacement may also be triggered by outbreaks of disease, quarrels within the neighbourhood, or the fear of inter-tribal warfare or civil war.

139. In some areas the competition between the settled farmers and nomadic pastoralists has gone beyond the level of mutual accommodation, particularly in the wetlands and the plateau. This has led to a displacement of pastoralists, forcing them to move to drier areas. But a few have settled into sedentary agriculture under a mixed farming system.

D. Herd dispersion

140. All forms of herd dispersion have the same goal: minimizing risks and hedging options by spreading chances. Among some East African pastoralists, the cattle herd is often divided up during the dry season, with the sub-herds of small ruminants, camels and some lactating cows remaining close to the family settlement.

A few lactating cows accompany the herders to supply them with milk during their time away. However, in hard times such as severe droughts, when there is very little decent pasture to be found, the whole herd migrates. Some communities spread risk by distributing their cattle to relatives and friends. Pastoralists in East and Southern Africa enjoy traditional systems of reciprocal exchange of cattle, locally recognized as *tilia* and *mafisa* respectively.

E. Dry season reserves

141. Many pastoral communities have designated certain areas to be closed from use in normal seasons, and used exclusively during drought years. Among the northern Somali, the Pokot, the Masai (Warren, Skikkerveer and Bokensha (1995)), and the settled pastoralists in Pakistan, the local council of elders can impose penalties on those who illegally enter the dry season reserves. These reserves are kept closed during the wet season so that the vegetation can recover. The elders decide when to open and close the pastures, after a prior inspection. The closed areas are guarded, with fines imposed by elders on violators. This system does not only allow the pasture to rest, but also provides a reservoir of seed of the palatable species that are likely to be selectively depleted in the open areas. Some traditional communities continue to practise rotational grazing to improve the range condition and to avoid degradation.

F. Animal health

142. Pastoralists recognize and avoid areas infested with pests. Riverine areas and wetlands are also avoided during the rainy season. This is because wet heavy soils cause foot diseases if the herd is kept in them for a long time during the rainy season.

143. The communities use a wide range of plants in treating sick animals for common diseases, such as intestinal worms, East Coast fever, and ticks. Mathias-Mundy and McCorkle (1995) have made a comprehensive literature review on the development of ethno-veterinary medicine. Other examples include vaccination against infectious diseases such as bovine pleuro-pneumonia by the Masai and against rinderpest by Somalis. Even where modern medicine is available, there is continued reliance on traditional methods for animal health care.

G. Division of labour and production

144. Pastoralists have strong culturally prescribed norms for the division of tasks and responsibilities between age groups and sexes. Although this varies between communities under the eroding Western influences, adult married men are responsible for governance and political affairs. They further enjoy overall managerial responsibility for planning grazing orbits, herding movements, animal health and welfare, herd splitting, watering and location of residences. They also organize and undertake construction and maintenance of water points and enclosures for livestock.

145. In some communities, children and women are responsible for watching animals during the cropping season. Generally, adult women make all major domestic decisions, particularly those relating to child care, food preparation, collection of water and fuelwood, milking, looking after young and sick animals, and other duties which vary between communities. In practice, the women shoulder numerous and heavy duties and responsibilities, but their contribution to the traditional economies remains shielded by the "kitchen and household curtains". The children do almost all the herding and house chores.

146. In households that engage in cropping, women do the planting with some help from men on land preparation. Where the men are involved in trade or have taken jobs in the towns and cities, their wives assume the daily responsibilities of household heads.

H. Soil and water management for range rehabilitation

147. Some communities practise precise technologies for combating erosion and range rehabilitation by pitting, stripping and planting aloes or sisal across the gullies to form a natural barricade for site amelioration, and soil and water conservation. This may be reinforced by piling brushwood along the row of aloes. The barricade slows down the speed of run-off, trapping sediments and debris. As the aloe grows, the barricade catches more soil until the gulley is gradually healed.

148. Pitting is a technique used to rehabilitate grossly degraded, eroded, and unproductive range. It involves construction of a series of small pits of varying width and length, supported by the construction of short trenches 2.5–3 m long, 0.75 m deep and 0.75 m wide, spaced at 0.9–1.2 m and overlapping each other along the contours. A 50 cm deep hole is dug at the centre of the pit to act as reservoir for the mini-catchment. The pits collect water and allow it to infiltrate and trees are planted on the trench embankment. When the area is closed for 2-3 seasons it allows natural regeneration of grass between the trenches. Although not widespread, some communities are practising different aspects of these treatments, albeit in small scales.

I. Water use

149. Water management is the key to increasing and sustaining productivity of croplands and pastures. Information already reported shows that these communities have developed a wide variety of water harvesting and conservation techniques for different soils and climatic conditions. The provision of sufficient and well distributed watering points not only assures easy access to drinking water but also enables uniform use to be made of the grazing land. During the dry season animals are watered every second to third day, as opposed to daily watering. This is important for assuring the animals' proper forage-to-water intake.

J. Fire as a management tool

150. Traditional societies found burning a useful tool, and depended on it for centuries in their day-to-day activities. Among agriculturists it was (and still is) used to clear bush for settlements and gardens. Fire was also used to improve grazing, eliminate ticks and other pests, and increase wildlife numbers by maximizing production of food supplies. Traditional hunters used fire not only as a hunting weapon to force animals out of hiding from particular sites held sacred, but also to direct them into open areas for an easy kill.

K. Training of animals

151. Use of cattle for ploughing and drawing carts, and of donkeys, llamas, mules, camels and horses for transportation is practised widely, depending on availability and economic circumstances of a given area. Some communities train livestock on grazing orbits, an achievement that makes grazing an easy and low labour input task. Quite often, herds home on their own. The highest level of animal training has been achieved in Asia, with buffaloes and elephants, but these do not seem to support dryland economies.

VIII. FOREST DEVELOPMENT

152. Forest development is a kingpin of all land-use programmes. Forests regulate ambient temperatures and shield against dunes and harsh winds that stress the living environment and property. Properly distributed tree growth is beneficial to agriculture, conserves soil moisture, and increases atmospheric humidity and crop yields.

153. Woody plants provide shade for grazing animals and are important sources of timber and fuel. They further provide nutritious browse and fodder in the form of leaves and pods during lean periods of the year. By virtue of their deep root systems, such trees bind the soil, reducing erosion risk. In addition to ameliorating climatic conditions, trees supply readily available fuelwood, thatching materials for huts, food, medicine and a wide range of non-wood products for domestic use and industries.

154. Traditional forestry was mainly based on observing patterns of low impact harvesting of plant resources for wood and non-wood products, reverence for certain plants and sacred groves, and the natural regeneration of native species. Harvesting was totally prohibited in sacred groves, and sacred trees were exempt from felling in parts of Africa and the Indian sub-continent. Such trees could not be cut or uprooted except under specific circumstances and cutting was accompanied by organized community rituals.

155. Following the introduction of tree planting and the awareness of the consequences of degradation, the number one priority has been to restore the natural frontiers of trees that served as the final barrier betweeen the human settlements

around the oases and the desert. Tree planting has been used as a first line of defence against sand dunes in all affected areas, including regions affected by high dry winds, for protecting farmlands, settlements, pastures and communication networks. In arid and semi-arid hilly areas, various dryland afforestation techniques have been used by the people to establish plant cover by conserving moisture. These rain-water harvesting and moisture conservation techniques include contour trenches, ditches, different designs of micro-catchments, water spreading, low technology drip irrigation (earthen tubes or pitcher planting), and planting of roots or cuttings.

156. Once an area has been selected for treatment, the first step is to employ water management techniques, such as flood water spreading on the land that is to be reclaimed. The techniques vary widely between sites; some use simple earth embankments while others involve complex dams and delivery channels.

157. Reclamation of degraded areas has also been facilitated through the use of resilient tree species such as *Tamarix* and *Atriplex* which are adapted to salinized soils and irregular rainfall. By using the flood water to raise woody plants, the expense and complication of tree nurseries has become unnecessary. Water is simply diverted to a new location and then nature takes its course, because these species colonize through natural regeneration from seeds.

158. In China, a wide range of concepts and techniques have been demonstrated, such as the establishment of particularly wide belts of trees and shrubs to reduce the sand content of desert winds; systems of multiple belts and ditches; purposeful variation of rows of species of varying final heights in order to enhance roughness; combinations of species to match different sites; planting on the windward side of dunes in order to reduce their height; planting tall cuttings on the lee side depressions of dunes in order to block their advance and gradually level them off; combinations of lower windward side planting with later shrub planting to consolidate levelled areas; and stabilization of lower dunes with tree, shrub and grass mixtures. A wide range of woody species are used with these technologies, in different areas of dry zones.

159. Once the sheltered trees have matured they provide a much needed source of fuelwood and fodder. By modifying the microclimate, the shelter belts have succeeded in greatly reducing the frequency and force of the sandstorms that otherwise batter the region and the accompanying moisture loss through excessive evapotranspiration. Consequently, larger areas have been planted, especially during the season following the rains. As more crops are harvested in protected fields, more money is pumped into the local economy, allowing people to make improvements. Reports from the Middle East, the Sahel, North America, and Asia including India, Pakistan and China show that crop and livestock production has doubled in the past decade through benefits from planted woody species, meaning more food for local people, for their livestock and for sale.

160. Most countries in dry regions have attempted to rehabilitate the forest resources base by promoting the planting of fast-growing exotic species. But this has not been popular with rural people for many reasons. Although these trees provide good poles, they lack the array of benefits associated with natural woodlands, and in some cases they provide resting sites for pests such as quelea birds in western Tanzania. Eucalyptus, an important rural forest tree, is currently resented for its allelopathic effects on other crops and excessive water use.

IX. UTILIZATION OF WILDLIFE

161. Many species of wild animals have distinct physiological and ecological advantages over traditional domesticated livestock species in arid and semi-arid areas. Amongst the most significant are their ability to thrive in the absence of surface water (by movement in time and space) and make optimal use of vegetative resources, and their minimal impact on the environment. They also have tolerance to diseases, heat and drought.

162. Hunter-gatherers, who have existed in arid zones from prehistoric times, rely heavily on harvesting, processing and utilization of wildlife products as the basis of their livelihoods. This way of life persists today in remote arid areas. But to pastoralists and marginal cultivators in these zones, wildlife has often represented an emergency food resource, particularly in times of drought, and a source of supplement and variety during normal seasons.

163. These societies had well developed wildlife conservation strategies that helped to regulate exploitation of wildlife, and ensure that the communities had adequate natural resources readily available. These strategies were deliberately aimed at the preservation of the resource bases for the benefit of the present and future generations, and were deeply enshrined in the traditional values of the societies.

164. Some African communities enforced wildlife conservation measures with varying degrees of effectiveness, through seasonal hunting and trapping of animals and birds for home consumption. This practice discouraged indiscriminate hunting, and encouraged selectivity in killing wildlife.

165. Various communities have evolved distinctive hunting traditions. According to the *chacu* system found in the Andean and some peripheral areas, a group of wild animals is surrounded, and the sick, injured and old are identified and detained. The rest are left unharmed and set free. Indigenous perceptions of biodiversity are evident in social values, beliefs and practices that sometimes make reference to the importance of biodiversity, including reverence for some biological units such as forests, trees and animals. Many communities observed widespread cultural beliefs in abstinence from wanton killing of wild animals, especially those which the society held in contempt such as hyenas and monkeys, and also the young of all species. Fish were also protected, with some sites held sacred. Some communities,

such as the Masai of East Africa, hold wildlife as a last-resort resource that must remain untouched in normal seasons.

166. The Ila-speaking peoples of Zambia practised a well-known traditional wildlife management system, the *chilla*. This was a system of seasonal hunting expeditions either once a year or at intervals of two to three years, depending on the population of the animals. There were strict rules governing such hunts. Chiefs and elders were the only people with authority to sanction *chilla* and they could do so only after ascertaining that animal populations were not declining to extinction. Oral history further suggests that there was an element of selectivity in the actual hunt, with females and juveniles spared while males were targeted.

167. Subsistence hunters trap, snare, shoot with bows and firearms, and spear their quarry. Fire is also used to drive animals from cover, and smoke to eject rodents from their holes. Trapping and snaring enable the animals to be caught alive so that slaughter can be delayed until an opportune moment. These methods, in general, cause relatively little disturbance to wildlife populations provided that techniques remain traditional and undue commercialization has not crept in.

168. The meat acquired by subsistence hunters is either eaten fresh or preserved by drying and/or smoking for later consumption. When large animals are killed, the reduction in weight of the meat by drying is an important consideration in relation to transport back to the village by head load. After evisceration, small animals are often dried and smoked whole, whereas larger ones must be cut into strips to facilitate drying.

169. Apart from domestication of camelids in South America, and guineafowl and ostriches in Africa, little attention has been accorded to planned management of these resources. But considerable progress has been recorded on programmes of consumptive and non-consumptive utilization of wildlife under joint community and government initiatives in some developing countries.

170. Examples of ungulates that thrive in the harsh environments of drylands in Africa, Asia and South America are:

Western Africa:	Scimitar-horned oryx (*Oryx dammah*); addax (*Addax nasomaculatus*); gazelle (*Gazella dorcas, G. dama, G. leptoceros*).
Eastern Africa:	East African oryx (*O. gazella*); gazelle (*G. granti, G. soemmeningi*, etc.).
Southern Africa:	Gemsbok (*O. gazella*); springbok (*Antidorcas marsupialis*).
West Asia:	Arabian or white oryx (*O. leucoryx*); gazelle (*G. gazella, G. subgutturosa, G. dorcas*).
Central Asia:	(*G. gutturosa, G. subgutturosa*).
South America:	Vicuna (*Vicugna vicugna*), pampas deer (*Blastoceros campestris*), guanaco (*Lama guanacoe*).

171. Wild animals further provide the basis for foreign-exchange-earning tourist industries and are an important subject for the conservation of biodiversity. To a much lesser extent, in some localities hides and other products are traditionally processed for domestic use. In recent times, skins and animal trophies have been processed to meet the demand for these articles from tourism through local crafts and rural industries. Export demands for certain products exist in some countries.

172. Income from wildlife management and rational harvesting is particularly important for the drier lands of central, eastern and southern Africa as well as parts of the former USSR. Strategies for the shared use of land by domestic livestock and wildlife have been advanced in Africa and are being tested, together with the possibilities of game ranching.

173. Apiculture, involving domestication of native bees, is practised in many countries of Africa and South America, for production of honey and beeswax. These products are important for local consumption and sale. Wax and honey, together with carmine (a colourant extracted from insects), were the most important exchangeable products in South America in the colonial times.

174. A number of insects, particularly termites in East and West Africa, caterpillars in central Africa, rodents in central Africa, West Africa and South America and mushrooms in nearly all regions, provide important food supplements to dryland communities.

X. SPECIALIST SKILLS

A. Traditional management systems

175. Virtually all communities had well established governance structures, with well articulated customary laws that accommodated inter-personal relations, property ownership and protocols for resources use. Such structures have evolved as unique social, economic and political grass-roots governance organs, that provide effective mechanisms for environmental conservation. Primacy of community ownership and/or access to land with specific rights of individual families and collective obligations for the care of the resource bases is strongly established. In practice the system enjoys decentralization in centralism, in which power is rested on the clan (tribal) chief and his committee of elders with defined roles and responsibility stretching down to households. Policy “fences” placed by elders are observed through total community compliance, under the influence of seers and warriors, underpinned by a strong commitment to traditional religion, taboos and beliefs.

176. All community members are responsible for overseeing what the others are doing and any act of violation is reported to the elders. Shared beliefs provide a strong sense of group solidarity. An infringement of a taboo or act that compromises the community’s security is a concern of the whole community. After

all, any subsequent punishment or retribution is likely to affect all, not the offender alone.

177. Production is embedded in the socio-spatial matrix, enriched by cross-linking relationships with well recognized social equity and sustainability rules. Despite the absence of a written medium of communication, the structure of governance, lifestyle, and resource management rules have been transmitted effectively from generation to generation. This has left local communities with great organizational prowess, buttressed by an entrenched sense of solidarity and reciprocity.

178. The creation of institutional curbs, such as sacred areas for purposes of worshipping ancestral spirits, spirit mediums and rain-making oracles, served to regulate societal attitudes toward the natural environment. Spirit mediums, particularly, controlled large ritual groves and protected forests where no one was allowed to hunt, graze livestock or cultivate. The management of resources under customary law endured for centuries due mainly to this strong link with the ancestors and the low population densities, which helped to maintain a sound ecological balance. Despite the eroding forces of modern governments, religion and affluence, traditional resource-management systems remain promising for building community-driven resource management paradigms.

B. Harvesting of wood and non-wood products

179. Virtually all communities are cognizant of the importance of biodiversity conservation practices that they have evolved over many years. Such conservation rules vary between communities but are all associated with respect for all forms of life (plants and animals), a feature that is strongly embedded in taboos and respect for ancestral spirits. Common examples include reverence for totems, sacred plants, sacred groves and sites.

180. In the past, farmers and pastoralists applied conservative and low-impact methods for harvesting wood and non-wood products and generally refrained from wanton cutting of trees. Harvesting of woody plants was largely restricted to chopping and pollarding of branches in a manner that allowed regrowth from the main stem. Harvesting of medicinal plants was also discrete, and limited to old people. Unless it was extremely necessary, only leaves, pieces of bark and lateral roots were cropped. Collectors avoided tapping freshly exploited plants and often covered exposed root areas, purportedly to avoid recognition by passers-by. This gave the target plants time to recover prior to the next harvest.

181. Households involved in tapping gums, resins, oils, dyes, etc. have also developed non-destructive tapping methods, with the bulk of the products coming from naturally exuded materials. Such trees were further conserved under the tree tenurial rules, which are well developed for acacias in Sudan and frankincense in Somalia. Many communities have domesticated a wide range of dryland plants

particularly in dune fixation, parklands and other agroforestry systems and along irrigation canals, with a very favourable pay-off.

C. Traditional crop knowledge

182. Traditional crop knowledge is omnipresent in many traditional societies. They are particularly conscious of the value of biodiversity as a form of food security, insurance against crop failure and source of dietary variety. Based on simple but practical criteria, farmers and pastoralists tend to stick to crops and breeds that (i) they know; (ii) suit local agro-ecological conditions and cropping/land use patterns; (iii) meet dietary acceptance; (iv) fit production costs; and (v) have market potential. A study carried out in 1998 showed that 614 out of 740 ethnic groups in Africa derived their livelihood from the wild woods around them (Makombe 1993).

D. Seed selection, storage and planting methods

183. Farmers have an extensive knowledge of the taxonomy of species of food crops such as millet, sorghum, maize, groundnuts, beans, rice and multipurpose plants. They recognize varieties suited to the uplands, lowlands, wetlands and saline soils and those that would remain productive well into the dry season, and often strive to improve these through breeding.

1. Selection of locally adapted seed

184. A strong commitment to using drought-tolerant and/or drought-evading crops such as millet, sorghum, pumpkin, groundnuts, cassava and sweet potatoes, is evident among all communities. The modern cultivars have proved to be far less resistant to drought, pests and diseases and to depend on inputs such as fertilizer and pesticides, which are often unavailable.

185. Seed selection for planting is comprehensive, generally based on seed quality, emphasizing the following, among other parameters: head weight for sorghum and cob weight for maize, size of the grains, length of husks and absence of pests and diseases, seed colour, grain size and agronomic stability, suitability to different types of soil and terrain, drought and disease tolerance, palatability, storage and processing.

2. Seed storage

186. In Africa, selected seed for the following season’s planting is often kept above the fireplace inside the house. The storage systems are well adapted to the ecosystem. Groundnuts, maize, millet grains and beans are often mixed with ash and kept in bins made from straw and loam. In humid areas, traditional granaries are used for the storage of maize. The principle in use is the need for good ventilation of the often wet-harvested maize. Some farmers store maize seed on the cobs hung from a tree.

187. Some farmers mix plants with botanical potential such as leaves with their stored products. Beans may also be stored mixed with sand in bins. The farmers tap the storage bins lightly so that the beans are completely surrounded by sand. This results in a situation where beetles cannot move enough to copulate, and the sand damages their shields, which causes them to dry out.

3. Pre-sowing seed treatment

188. In addition to planting selected seeds, some farmers soak the seeds in water. By this slight pre-germination treatment, the plants grow faster and develop an advantageous young growth, which gives them a head start over other plants. The wet seeds may also be mixed with ash. According to the farmers, the dark colour camouflages the seed to rodents and birds. Another method, less used, is to soak maize seeds in water mixed with botanicals such as neem tree leaves. The germinating seeds absorb some of the bitterness of this extract, which makes the seed unattractive for termites, birds and fowls.

E. Storage of foodstuffs

189. Techniques for processing food of plant and animal origin for an extended shelf life provide important food reserves for hard times. Dried vegetables, fish sun-dried or smoked, sour milk or butter converted into cheese or ghee, meat smoked or cooked, boiled in fat and dried, tubers pounded or allowed to grow some moulds and dried, and grains mixed with ash or sand stored in bins indoors maintain good condition for a long time and assure supplies through lean times.

190. Dryland communities possess a wide range of traditional biotechnology skills for food preservation and fermentation. In South America, fermented foods such as *chicha* and *aloja* are still popular.

191. An indigenous, low-input, food preservation technique is the production of *masi*, the local name for fermented foods made by Polynesians in the Solomon Islands. Foods most commonly used include breadfruit, cassava, unripe plantain or banana and *tenatu*, a popular forest fruit (*Burkella obovata*). After harvesting, the cassava is peeled, cut into large pieces and either placed in baskets and submerged in fresh water for three days or soaked in a plastic bucket, changing the water once or twice during the three days, (probably to drain off cyanide). Most other foods are prepared for fermentation without soaking. Once softened, the cassava is crumbled by hand into granules and is ready for fermentation in pits on the well-drained soils on higher ground. The pits range in size from 70 cm diameter / 70 cm deep for family use, to large communal pits used for storage in case of natural disaster and for use during feasts.

192. The prepared cassava is put into the pit and packed firmly to remove any air pockets. This is extremely important because it is an anaerobic fermentation process, and spoilage will occur around an air pocket. The pit is then sealed by covering the food with layers of *Heliconia* leaf and coconut-leaf panels on top,

similar to the pit lining. Clean rocks are piled on top of the covered food to press and seal it off.

193. Initially, food is kept in the pit for at least six weeks, during which fermentation occurs. After this period, the *masi* stabilizes and ages. The pit is periodically opened to remove *masi* for use, or to add additional food to ferment. The *masi* is eaten as a traditional island pudding by mixing it with coconut milk, wrapping it in banana leaves and baking it in a stone oven.

194. Like other fermented foods such as cheese and wine, flavour develops as the *masi* ages. Pits are maintained for many years. Periodically, when the leaves of the lining begin to deteriorate due to the weather and soil moisture levels, the *masi* must be removed and the pit relined. Islanders have added a final lining of polythene sheets in a recent innovation that extends the life of the lining.

195. Communities living in sub-temperate areas in South America use the first frost to convert potatoes to *cuno* for long storage.

F. Home gardens and backyard plots

196. Farmers generally build their houses outside the farming area, usually in a site considered to be of marginal agricultural productivity. Animals are kept in shelters close to the houses, with concomitant accumulation of manure and enhanced fertility in the site. The animal shelter is subsequently shifted to a new site near the house, leaving the fertilized site for gardening. Sometimes the oxen are fed inside the farms and the place for feeding is moved annually to in less fertile spots. The farmer gradually cultivates the fertilized land around the house, often starting with pioneer crops such as spices including garlic, basil, peppers, onions and vegetables like kales, cabbages, cucurbits, potatoes and medicinal plants. Soleri and Cleveland (1989) have observed that this assemblage of crops in time constitutes an important source of staples and cash crops for the family. Such household gardens have significant promise in bringing about sustainable development by improving family and community well-being and promoting environmental upkeep.

197. The home garden may be used for a few years but when the soil gains fertility, the house and the garden are shifted to a less fertile location while the original garden site reverts to cultivation of major field crops. This practice is particularly important for resource-poor communities as it recycles nutrients efficiently through application of manure and crop residues, crop rotation and inter-cropping.

G. Mixed crops and livestock farming

198. The agro-pastoral system has evolved as a twin system of cultivation and animal husbandry. Initially the two systems were separate, but later on their mutual support was understood, as animal power was found to be essential for cultivation and crop residues important as animal food.

199. The practice of traditional agroforestry makes the overall farming system a complex three-in-one system that may be referred to as the agro-pastoral-forestry complex. At the family level, there is complete integration between crop agriculture and livestock production, in which one is dependent on the other for various purposes. The resultant synergistic effect is quite considerable. The fields and gardens produce supplementary feed and support the animals while the latter in turn support the production potential of fields and gardens through manure production. The entire system is highly integrated, with mutual support for, and stimulation of increasing production, land fertility and biodiversity conservation.

H. Pests and diseases

200. Rats affect all crops particularly groundnuts at the planting stage. Locusts and grasshoppers, quelea birds, aphids, stem borers of cereals, etc. are all important pests in crop production areas. Diseases include fungal and viral infestations. Farmers know the relationship between the incidence of pests and diseases and the breeding cycles in relation to prevailing weather and the seasons.

201. Because late clearing of land gives more time for pests to breed in the fields, farmers clear their fields early but leave slash and crop residue to protect the soil from wind erosion. Some farmers practise direct sowing under zero tillage condition to capture any rainfall and repeat sowing if the first seed fails. This provides optimum crop germination and establishment and hence optimum crop yields and enables the crops to mature before the peak season of major pests such as quelea birds.

202. Different communities have elaborate indigenous pest control and plant protection measures such as careful field sanitation, replacing susceptible types by more resistant seed, and using only adaptable local crop species in mixtures rather than monocultures. Proper soil tillage, inter-cropping, altering planting dates, and balanced crop rotations are also used widely. In traditional farming systems, the burning of brushwood and branches kills large numbers of pest and disease organisms, while shifts in the cultivated fields, relay cropping and mixtures provide effective remedial cultural control. Other notable cultural practices include cultivating several widely separated fields, distributing cattle to relatives and friends, early and timely sowing of cereals to evade stock borers, bird damage and bad weather. Some communities use infusions of toxic plants to treat insect pests. These constitutes traditional, sophisticated and effective integrated pest management packages.

I. Grass-roots indicators

203. Traditional communities use calendars based on the major seasons similar to Western calendars. Knowledge and use of natural indicators enable prediction of seasonal events important for planning crop and animal management. Climatic indicators such as trends in the prevailing wind and fog conditions, astronomic features, such as shapes and tilts of the moon, and alignment of the stars, and

biological features, particularly the behaviour of plants and animals, enable local communities to predict changes, rain failure or arrival and other phenomena.

204. Traditional signposting of ecosystems with the life forms they support, including indicators of site quality, ecosystem dynamics and weather variations, that have guided communities for many years, are prime candidates for scientific validation. Traditional indicators such as systems used in soil classification, site quality and ecological assessment would provide useful building blocks to systems of early warning, drought preparedness and management, that are understood at local, national and international levels. Drawing on numerous eyes and ears would enhance local participation and greatly reduce the burden of monitoring the implementation of programmes to combat desertification.

J. Range reserves

205. The settled pastoralist communities have long adopted a simple method of resting a piece of grazing land for one or two seasons and grazing it in rotation in order to improve the range condition and avoid excessive degradation. Such practices of using communal rangelands on a rotational basis have been practised in isolation by some tribes and villages in many parts of Pakistan, the Sahel and eastern and southern Africa for a long time.

206. In other instances, the dry season grazing areas are kept closed during the wet season so that the vegetation can recover. The elders decide when to open and close the pastures, after a prior inspection. The closed areas are guarded, with fines imposed on offenders. This system does not only allow the pasture to rest, but also provides a reservoir of seed of the palatable species that are likely to be selectively depleted in the open areas. As the drought continues and people cannot find enough pasture in the common ground, decisions concerning pasture and herd management are made by herd owners. In instances where crops and livestock conflict, such as in Lesotho, management encourages an exodus of livestock from villages to high mountain ‘cattle post’ areas during the summer months. In Lesotho, grazing in the village during the summer is further prohibited under the *maboella* system.

207. These formal and informal rules are important in determining the principles that govern everyday decisions made by the herders and thereby avoid the ‘tragedy of the commons’ syndrome.

K. Human and animal health

208. Pastoralists recognize and avoid areas infested with pests such as the tsetse fly, which transmits trypanosomiasis, and resort to such vegetation only during the peak dry season when flies are fewer in number and when alternative pastures are impoverished. Riverine areas and wetlands are also avoided during the rainy season because of the risk of fungal foot diseases in the wet, heavy soil.

209. Pastoralists and farmers use a wide range of plants in treating themselves and their sick animals against common diseases, and have different levels of specialization in specific conditions, such as pregnancies, infant diseases and digestive diseases. Living in the remote corners of various countries, dryland communities rarely benefit from public medical and veterinary facilities, and hence rely on natural remedies.

L. Biodiversity management

210. Many traditional societies have developed wildlife conservation strategies that are deliberately aimed at the preservation of these resources for the benefit of present and future generations. Regulatory measures include prohibition of indiscriminate hunting, and promotion of selectivity in capturing wildlife. The Masai regard wildlife as a last resort resource, only to be used after livestock has gone. In southern Africa many cultural beliefs exhort abstinence from wanton killing of wild animals, especially those which society holds in contempt such as hyenas, monkeys, and the young of all species. Fish are also protected through regulated fishing patterns. Family totems, whereby some groups of people are prohibited from eating certain fish, animals or birds, also offer protection. There can be little doubt that these strategies emanated from people who had a concern for their environment and its ecosystems, an attitude which enabled societies to conserve their resources through oral policy “fences”, without written legislation or rangers.

211. In a few cases, rights over the resource may be specific if the resource is strategic or subject to very personal investments, such as the *Acacia senegal* gum-producing trees in the Sudan, and riverine *A. tortillas ekwar* along the Turkwell valley, Kenya, which are privately owned and used by families. Among the southern Somali, pasturage water and natural wild products occurring in the fields are communal property but the system of land use establishes prescriptive rights over territorially-bounded frankincense collection areas, locally known as incense fields, to a core of closely related agnostic families.

M. Dryland afforestation

212. Plenty of indigenous knowledge exists in the field of dryland forest techniques, which are being adopted widely, especially in sandy areas along the desert margins. Some of the local technologies that are employed for tree establishment to rehabilitate degraded ranges in drylands, using proven site amelioration treatments and adapted plant species, include:

- Earthen tubes: These are baked earthen tubes that have long been used in sandy deserts for planting seedlings of fodder and fuelwood trees. Small holes in the sides of the tubes provide aeration and drainage. Tree saplings are planted in these tubes and are irrigated with a little water at critical times. The earthen tubes keep the moisture for a long period of time and help root establishment and deep penetration into the moist soil.

• Pitcher planting: Locally made pitchers are used in this technique for establishing fodder trees in desert ranges. Round earthen pitchers are dug into a hole near the root zone of the newly planted sapling. The sides of the pitcher are covered with coaltar except the one pointing toward the sapling. The pitchers are filled with water every 15-20 days during summer and it helps the plant establish its root in the moist soil zone. After two to three seasons, watering is stopped and the plant is entirely rain-fed thereafter.

• Trench irrigation and related water harvesting techniques for tree planting: Trees or shrubs are planted in 50-75 cm deep channels with catchments almost 3 metres wide to collect water. These trenches can retain moisture for sufficiently long periods. Other techniques include a wide range of soil and water management technologies, depending on what is appropriate for a given site, such as *limans* common in the Middle East and flood-water spreading techniques.

N. <u>Knowledge of crafts and fittings</u>

213. Craft skills ranging from house building, thatching, furniture and farm tool making, wood carving, basketry and leather tanning to metalwork are well developed among dryland communities. The hoe, developed many years ago, continues to be an effective tool for land preparation that ensures even distribution of water over the land. But apart from a few areas where wood carving and basketry have found lucrative markets in the tourist industry, these potentials remain largely untapped.

O. <u>Training of animals</u>

214. Animals are widely used for draught purposes and for transportation, depending on the economic circumstances of the given area (see chapter VII. K). Knowledge of draught animals is particularly developed in Asia and Latin America. In Asia, farmers have astounding skills in handling elephants, oxen and water-buffaloes. In South America, camelids provide the bulk of draught power. In Africa, oxen, donkeys, mules and camels are used, while camels are also common in the Middle East. These skills deserve to be respected, incorporated in the development process and exploited to the maximum for development.

XI. COMMUNITY-BASED ORGANIZATIONS

215. Responsibility for development rests with communities, who stand to benefit from the fruits of development and/or suffer from the consequences of delayed development. Today the effects of land degradation are felt principally by the rural poor, particularly the landless and near-landless peasant farmers, pastoralists with lower status or smaller herds, and ethnic or religious groups who, while not necessarily constituting minorities, are subordinate and marginalized.

216. In all the regions under review, communities have established grass-roots welfare and development groups such as landowners’ associations and women’s self-help groups that constitute community-based organizations (CBOs). Ongoing drives to promote such informal movements, encouraged by leaders and aid agencies, have institutionalized grass-roots CBOs as important entry points for development intervention. Many such CBOs have also made substantial contributions to setting grass-roots development agendas, and drawing up strategies for achieving national development.

217. Communities are obviously anxious to assume control over their land and land-based resources, although their functions are still constrained by lack of legitimacy, positive policies and political support. In many instances, efforts to include community participation directed by donors have assumed that communities have decision-making powers and the authority to implement resource management programmes, a role which governments have continued to deny them. To have true, community-based, natural resource management requires ownership of the resources: sanctioned rights of access and the right to benefit fully from use and management. Such group ownership would allow communities to negotiate resource management arrangements with government agencies in a manner which takes advantage of multiple-use opportunities, with adequate benefit to the groups. Meaningful decentralization of power to grass-roots structures particularly requires that the state, donors and other interested parties devolve a substantial portion of authority and responsibility to concerned CBOs.

218. The CBOs are well placed to promote the application of traditional technologies in combating desertification because they are people-driven and therefore hold a positive appreciation of the role and potential of such technologies in development, which they know and understand well.

Non-governmental organization partners

219. These include non-profit-making bodies having development, training or extension functions in land use, environmental management and related fields of production. Local NGOs, including registered international bodies, their local counterparts, locally (country) registered and non-registered grass-roots, member-run, self-reliant bodies such as women’s self-help groups and community associations, have taken a central role in community development activities over the past few decades in all the regions covered by the Convention. The number is large and continues to grow by the day. The strength of these NGOs lies in their decentralized and modest structure, operating in close proximity to local communities with an administrative simplicity that allows pluralistic decision-making.

220. In a number of countries, some NGOs play a positive role in research and extension activities on dryland resources management, although many lack the capacity to respond to problems as they are perceived by the people as constraints to development and often act spontaneously on crises. Thus vulnerable groups

sometimes do not participate in setting the agenda and in subsequent programme administration. Moreover, many desertification control programmes and policies favour elite groups, with little attention being paid to the most vulnerable groups and to promoting real popular participation. Contradictory policies and institutions have been listed among prominent obstacles.

221. This notwithstanding, a number of local, regional and international NGOs working at different levels have exerted much influence in global policy development on biodiversity management, food security and hunger and human rights issues. Many local NGOs have accumulated much information on traditional knowledge and practices that would provide useful entry points.

222. A new crop of influential environmental NGOs is working with communities on new paradigms for sustainable development and enjoying good grass-roots contacts. In some situations such NGOs and or development agencies have catalysed the formation of local governance structures (CBOs) and strengthened existing ones. They are therefore well placed to disseminate information efficiently.

XII. RECOMMENDATIONS

223. Despite past neglect and active marginalization of traditional technologies, many dryland communities continue to respect and use a wide array of traditional and local technical knowledge, know-how and practices. Economic necessity and improper guidance may have forced the people to neglect their valuable traditional systems in the immediate past. Since many of these traditional systems are environment-friendly and sustainable, efforts should be made to restore them and back them up with modern approaches to enable their effective mainstreaming in local and national development agenda. Many traditional technologies, some of which have been discussed in this paper, offer promising entry points for building packages on community-based dryland resource management technologies. The following mode of implementation is proposed.

(a) Collection and documentation of traditional technologies

224. The first step should include raising the awareness of all stakeholders of the important role of traditional technologies and their potential in promoting sustainable development and combating desertification, in order to clear the existing prejudices. Collection and documentation of traditional technologies should be undertaken through a partnership between community CBOs, NGOs, government and where feasible the private sector. Participatory rapid appraisal (or related models) conducted through thematic workshops of peasants and pastoralists would provide appropriate forums for documentation. This would constitute a first level of the documentation/screening process. For ease of documentation, separate sessions should be conducted for plant and animal systems, their products, uses, nutritional and medicinal potentials, processing pathways, etc. Such structures should recognize technologies that are not used currently. These may be tapped from oral literature and report by earlier writers on management techniques, tools, and

practices and integral production systems practised by named communities under specified ecosystem and geographical entity.

(b) Screening and assessment

225. Screening and assessment should be undertaken by examining candidate traditional technologies agains application criteria, considering questions of economic, technological and socio-cultural sustainability as follows:

- Economic sustainability – capital input should be low, relying on local resources, e.g family labour and skills. Leading questions should include: Does it generate self-management opportunities? Does it use locally available resources ?

- Technological sustainability – it should be small-sized, low input based and energy efficient. Relevant questions are: Is it transformable locally, nationally, or regionally? Is it environment-friendly?

- Socio-cultural sustainability – does it satisfy the community's basic needs while incorporating their intrinsic values?

Such a screening and evaluation process would foster the rational capture and restoration of traditional practices and optimization of their uses.

(c) Analysis and evaluation

226. This step should examine the flexibility, adaptability and sustainability of traditional technologies in new situations and environments different from the original ones. It is anticipated that the proposed work will generate comprehensive databases of traditional technologies that highlight promising practices, their strengths and shortcomings for different production and livelihood systems, by communities, geographical areas, countries and regions. Teams of biological social scientists, and community partners would participate in the next level of work on traditional technologies, focusing on the validation and valorization of promising practices through modern methodologies, including taxonomic identification, screening of active principles, identifying nutritive values and related areas of knowledge. The work should particularly employ standard common methodologies to enable comparability of results at the national, regional and international levels. Thematic networks run by national liaison centres in participating countries and coordinated at subregional level (such as IGAD, SADC) and regional units (to be based in Africa, South America, West Africa, China, etc.), would provide a useful approach in tackling this momentous task. But such a network must incorporate safeguards for traditional technologies to avoid loss of proprietary rights of community owners.

(d) Training and capacity-building

227. To secure effective participation on the ground, involved NGOs, local populations, both women and men, particularly resource users, from the farming and pastoral communities and their representative organizations should be trained through short seminars, visits, etc. on policy issues, planning, decision-making, programme implementation and review of action plans. This would strengthen the civic societies and empower communities for meaningful decision-making by enabling them to act from positions of strength and knowledge.

228. A new programme of training for scientific and technical staff, embracing short refresher courses, reorientation seminars, study tours, and degree and certificate courses, should be developed to promote appropriation of methodology for interfacing local knowledge with modern technologies and other avenues to foster effective valorization. Such training opportunities would equip the graduate for promoting dialogue and exchange between the partners, endow traditional technologies with fresh values, and cultivate cultural identity for communities and their role in development.

229. Research and development on community organization, promising traditional technologies, and related policy and legal issues would provide an invaluable base for the process of learning and recreating the knowledge base on traditional techniques. But the informal experimental nature of traditional knowledge is extremely important and should be encouraged to run parallel under community management, to formal activities of the programmes.

230. The new initiative should further provide forums for the exchange of information and experience, to enable development of common or comparable methodologies and approaches. The need to recognize the roles of the church, the state, donors, universities, the private sector, women and the elderly, technicians and youth in a consolidated community-driven programme will continue to be a compelling task.

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