Drylands – an Economic Asset for Rural Livelihoods and Economic Growth

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Foreword

This Draft Challenge Paper with the working title Drylands – an Economic Asset for Rural Livelihoods and Economic Growth1 will be part of the Dryland Challenge Paper Series of the Global Drylands Imperative1 spearheaded by UNDP/DDC. This Draft Challenge Paper is a joint effort of IUCN, IIED and UNDP/DDC with the aim to

1. Demonstrate the importance of dryland ecosystem services for the sustainable and effective development of the world’s drylands
2. Foster improved understanding of the specific characteristics of dryland ecosystems and the wealth of knowledge and institutional capacity of dryland dwellers
3. Discuss the cornerstones of a sustainable investments framework in drylands

Developing such a Challenge Paper reflecting and representing global dryland issues and the diversity of dryland ecosystems and people is as such a challenge. We hope that making available this Draft document will allow the numerous dryland experts worldwide to provide feedback and contribute with examples and facts that allow for an improved representativeness as well as global ownership.

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1 The Global Drylands Imperative (GDI) brings together people and institutions interested in promoting sustainable development in drylands. It is an informal group of international organizations, donors, NGOs and individuals interested or actively involved in dryland development. This partnership is dedicated to increasing awareness on the importance of drylands among policy makers and within relevant international forums, with special focus on the United Nations Convention to Combat Desertification (UNCCD) Conference of the Parties (COP). The Challenge Papers Series aims to reach decision makers who determine important developments on drylands.
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IUCN CHALLENGE PAPER ON DRYLANDS

1: Why drylands?

Among the world's major ecosystems, those of the drylands receive the least attention in proportion to their size, their population, and their importance for global sustainability. They are 'investment deserts' in the struggle for wealth creation. They are inadequately understood by the world's policy makers and even by those of dryland countries. In a few areas, severe and persistent conflict has been allowed to recur. Because of their relative neglect, the world's drylands offer a fresh opportunity to develop a global strategy that integrates ecosystem health with human well-being; this in the context of environmental, climatic, and economic change. But the knowledge base requires strengthening. This Challenge Paper aims to contribute to such an understanding.

Where and what are drylands?
Drylands are arid or semi-arid regions where rainfall is scarce, highly variable or confined to short seasons of the year. A majority of them have tropical or sub-tropical climates. But very extensive drylands are also found in temperate regions and in high mountains. Temperature extremes are very common. Tropical drylands may have very hot summers and temperate ones, very cold winters. Most soils in drylands have low fertility and together with moisture limitations, their capacity to support woodland, grassland or crops is quite limited. Notwithstanding these constraints, the world's drylands (not including deserts) are home to more than 32 percent of the world's population, which includes many 'million cities', and cover more than 34 percent of the world's land surface (Fig. 1).

Figure 1: Distribution of the World's drylands according to aridity zones (based on UNEP, 1992)

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2 Poor drylands, predominantly in Africa and South Asia, are the focus of this Paper. Drylands in developed countries (e.g., Argentina, Australia, Israel, USA), sub-Arctic and high mountains are excluded from its scope.
Therefore, uncertainty and risk characterise primary production systems in drylands, and indirectly affect other economic activities too. This has always been so. Now, however, this uncertainty is increasing under conditions of global climate change. Furthermore it is compounded by other environmental changes which are linked with land transformation under human use, driven in turn by rapidly growing demand for access to land resources, increasing market demand for commodities, new technologies, and mistakes in policy or in land management. In sum, and compared with the rest of the world, the drylands are highly sensitive to changes from climatic or human pressures.

**Ecosystems and poverty – the myths**

Achieving sustainability in the drylands is essential to achieving sustainability in the world as a whole. And because average poverty is high in their great and growing populations, its reduction in the drylands is essential to achieving the Millennium Development Goals for the world as a whole. In particular, Goals 1 and 7 are highly relevant (Box 1).

Understanding the challenge of sustainable development in drylands has long been impeded by a number of commonly held assumptions (or myths).\(^3\) It is the aim of this Challenge Paper to dispel these. They are summarised as follows:

1. **The drylands of the world are minor, remote areas where few people live.** Fig. 1 effectively dispels this myth. Besides the major dryland countries (such as Egypt and Iran), drylands occupy large regions within many others (such as China and Nigeria).
2. **Poverty is an inevitable consequence of low biological productivity and high rainfall variability.** Drylands are marginal to national prosperity; public sector investments do not pay. Dryland countries were not poor in ancient or mediaeval times. In Chapter 4 evidence is presented to suggest the importance of drylands to national economies, and in Chapter 5 it is shown that investments can pay in rural drylands.
3. **Local adaptive capacity is weak (victim images) and dependency on external assistance is high.** Indigenous knowledge has little to contribute (paternalistic images). Adaptive capacity is based on diverse economic strategies which are highly flexible and informed by local knowledge. Indigenous or local knowledge is no longer despised and plays an essential role in development.
4. **Drylands are too remote to participate on equal terms in domestic or export markets.** Some drylands are coastal (such as Mauritania, Pakistan) and some contain major cities (such as Dakar in Senegal, Hyderabad in India). Cotton exports are maintained from Mali and Burkina Faso, both of them landlocked. Complex long-distance commodity trade links markets with producers (such as Kano, Nigeria). Market participation is increasing with urbanization.
5. **Opportunities for technological advancement (a green revolution) are few on account of productivity constraints.** Hunger results inevitably from supply failures in the local agricultural sector. While a green revolution on the scale of South and East Asia’s humid and irrigated regions is still awaited in the drylands, success stories (such as the expansion of maize production in Nigeria) suggest that technical and demand factors are more influential than supply-side constraints.

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\(^3\) UNDP, 2005 The Global Drylands Imperative. Achieving the Millennium Development Goals in the drylands of the world
6. *There are too many people in drylands in relation to their population supporting capacity. Over-use is the prime cause of natural resource degradation.* In fact the most densely populated drylands are the more sustainably managed by small-scale farmers and it is extensive cultivation by sparse populations that is linked with degradation.

7. *Poor countries cannot afford or sustain effective drought relief programmes.* When major droughts reduce crop output, internal responses are ignored by media in favour of publicised international food aid. India largely overcame its famine problem between the 1960s and the 1990s. Niger (a persistent importer of food grains) improved its production significantly between the 1980s and 2000 during the same period despite declining average rainfall.

8. *Desertification is a large-scale process of land degradation associated with climatic changes.* The effects of desertification will not be reversed unless efforts are made to rehabilitate the land to the state it was in previously. Rather than an ‘advancing desert’, land degradation in drylands is patchy, variable, and (for the most part) reversible. However restoration to virgin conditions is not realistic. A sensible target is to set degraded lands on course towards improved productivity, by intensifying agriculture with better fertility management.

9. *Desertification is associated with inevitable increases in deforestation and most rangelands are degraded as a result of pastoral overgrazing.* Deforestation for cultivation has occurred widely, but evidence from West Africa shows that when trees become scarce, they are re-valued by local people who both protect natural vegetation and plant useful trees on their farms. Studies of pastoral management show that livestock losses which are borne during drought ensure the survival of the rangeland ecosystems, which are well adapted to intermittent rainfall.

10. *Drylands ecosystems are in a state of equilibrium before desertification sets in and optimum management should retain that equilibrium.* Equilibrial concepts such as plant succession and animal carrying capacity have been questioned and alternative models based on resilience under variable conditions provide a superior understanding of change.

11. *Extensive areas of degraded drylands have little ecological value and do not merit investment for rehabilitation.* Dramatic restoration has been achieved on eroded soils in West Africa through soil moisture conservation techniques based mainly on local labour and skills.

Informed by such assumptions as these, it is easy for policy makers and international donors to neglect the drylands, despite their demographic and territorial importance. They may prefer investing in high potential areas. In the geo-politics of development, played out within nations, dryland peoples (and especially mobile livestock keepers) lacked advocates and empowerment to stake their claim for equity in sharing out the nation’s resources, including the inward flow of international assistance. Moreover, some dryland peoples were (and still are) politically restive with central governments whom they consider biased and unrepresentative.

**Key questions**

This Challenge Paper is part of the UNDP/DDC series, builds on its predecessors by making the case that successful sustainable drylands development needs to fully recognise the links between poverty reduction with sustainable ecosystem services. This aim reflects IUCN’s interest in the status, trends, restoration and conservation of ecosystems, in which poverty reduction has been accepted as a necessary coordinate. We intend to address the following questions:

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4 UNDP Drylands Development Centre (list of Challenge Papers)
5 IUCN Drylands Programme Strategy
• How endangered are dryland ecosystems under present conditions; what is a balanced view (Chapter 2)?
• Given that the defining property of drylands is scarce and variable rainfall, what will be the impact of climate change and how can adaptation be optimised (Chapter 3)?
• What is the value of dryland ecosystem services to local peoples’ livelihoods and their contribution to national economies (Chapter 4)?
• Can investments in drylands yield a satisfactory return without endangering future ecosystem services (Chapter 5)?
• What should be the role of markets in dryland development, and how can they be made to work for poor people (Chapter 6)?
• What kinds of institutions are required to manage high levels of livelihood risk and share contested ecosystem services (Chapter 7)?
• What opportunities are there for dryland peoples and their ecosystems? [In what ways do policies and attitudes need to change?] What should a sustainable development framework look like (Chapter 8)?

Dryland systems are not static but dynamic. In the chapters that follow, in which these questions are addressed, key elements of change emerge. Rather than final solutions, our search must be for the right directions and for adaptive capacity in policies and interventions, as for dryland peoples themselves, their management of ecosystems and of their livelihoods.

The background to this paper
The framework for prescribing dryland policies has changed dramatically. The UN Conference on Desertification (1977) gave birth to a multi-national and interventionist approach – spearheaded by UNEP’s Plan of Action to Combat Desertification - that drew its inspiration from science-based technologies for ‘reversing desert advance’, conceived as correctives to land use mismanagement by poor, conservative, and myopic farmers and herders, especially in Africa which felt the full force of the droughts of the early 1970s. Such a conceptualisation of the problem made it inevitable that interventions would be seen as necessary and that their mode would be top-down, driven by international agendas, and judged in terms of their impact on the health of dryland ecosystems rather than on the well-being of dryland peoples. The institution of the UNCCD in 1992 did not challenge this approach fundamentally, though later acknowledging a need for a livelihood and poverty reduction perspective and participatory approaches, and most of its energies have been dispersed on promoting Environmental Action Plans at national level – a strategy that still struggles to achieve credibility and impact.

Meanwhile, the adoption of the MDGs in 2000 moved poverty reduction to the top of a rights-based development agenda. However, only two of the MDGs (1 and 7) are explicitly relevant to the environment. Equally important for our present purpose is the Millennium Ecosystem Assessment (2000-2005) which accepts human well-being as inseparable from ecosystem health. In its Chapter 22 (Dryland Systems), it recognises that human agency has had positive as well as negative impact on ecosystem management and that local communities must continue to be principal actors in striving for ecological sustainability. IUCN, in parallel, has recognised and vigorously developed the Ecosystem Approach, which was initially formulated in the 12 principles of the Convention on Biodiversity. Other international agencies (e.g., the Global Environment Facility of the World Bank) now use Integrated Ecosystem Management as a guiding approach.

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7 Endorsed by CBO Decision V/6
A satisfactory integration between ecosystem health and human well-being has not yet been achieved, however, either in theory or in practice (except on a small scale). There is a dilemma in facing up to the need for an integrated approach while much science is divided between natural and social science disciplines and development practice tends to reflect the traditional professions of agriculture, forestry, economic planning, etc. This Challenge Paper recognises that a way forward will not be easy, but that its direction is set. Development in drylands will continue for a long time to depend directly on natural resources, through the maintenance and restoration of ecosystem services. At the same time, human well-being is a necessary condition for ecosystem health because research shows that livelihood improvement does not or need not be achieved at the price of degradation; rather, it enables farmers, herdsmen and others to advance the sustainability of their production systems in their best long-term interests and those of their heirs.
2: Degradation drylands?

In popular perception, the terms ‘dryland’ and ‘desertification’ have become almost synonymous, with the consequence that land degradation (the term which we prefer) is assumed to characterise drylands everywhere. Yet there are no global data sets that permit its measurement in objective terms; early mapping was based only on expert opinions, and estimates based on this work claimed that 20% of drylands were degraded; a fresh desk study commissioned by the Millennium Ecosystem Assessment estimated that only 10% were degraded; the MEA itself guessed that the true figure lay between 10 and 20%. The term has been used by various authors to refer to soil nutrient depletion, soil erosion, salinisation, deforestation, declining biomass productivity or net primary productivity, and hydrological desiccation on the surface or underground.

According to the MEA, existing water shortages in the drylands are projected to increase owing to population growth, land cover change and global climate change; meanwhile, the conversion of forest or grassland to cultivation is leading to persistent decreases in plant productivity; ecosystem services are being lost as rural population densities increase; and dryland populations continue to lag behind the rest of the world on human development indicators. However, this ‘desertification paradigm’ of degradation, proceeding remorselessly via anthropogenic drivers, is disputed by a ‘counter-paradigm’ that takes account of the non-equilibrial nature of dryland ecosystems and the adaptive capacities of human groups to live with uncertainty and reverse degradation in favour of more sustainable and intensive land use.

If the jury remains out on the ‘desertification paradigm’, are there alternative methods to reliance on in-depth but circumscribed and localised field studies?

Earth satellite data are globally compatible and have been analysed for the period 1981-2003. They offer an alternative method to earlier projections based on localised sampling, opinion surveys and inferences. However, the reflectance values in key parts of the spectrum are essentially proxy indicators lacking systematic ground truth correlation and needing correction for distortions caused, for example, by dust or cloud. The most promising line of enquiry is the use of the Normalised Difference Vegetation Index (NDVI) to derive estimated plant biomass on a monthly or annual basis. The application of this methodology to the African Sahel produced surprising counter-evidence to the orthodox view of progressive degradation, calling into question the methods on which the orthodoxy was based. A strongly significant relationship with rainfall confirmed earlier findings and lends weight to the ‘counter-paradigm’ of non-equilibrial ecosystems in drylands.

A new study uses global NDVI data adjusted for efficiency of rainfall use, to show ‘degrading’ areas (having negative trends in NDVI over the 23-year period). The data have a spatial resolution of 8 km². Table 1 shows these trends in selected dryland countries, together with total loss of net primary productivity. But such data need to be interpreted with care. For the earth as a whole, degrading areas are 19.8% of the territory, a larger

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9 Oldeman et al., 1991
10 Thomas and Middleton, 1992
11 Lepers, 2003
12 MEA, Chapter 25: 637
13 MEA, Chapter 25: 645-6
14 Eklundh, Herrmann
15 Tucker
16 Rainfall Use Efficiency (RUE) is the ratio between annual rainfall (measured at stations) and the annual sum of monthly NDVI.
17 Bai et al
fraction than is found in all but ten of the selected dryland countries, and all of these have extensive non-dryland areas. So what the data are telling us is the rate of deforestation and land use conversion to agriculture, which usually involves a loss of NPP, and this is proceeding fastest outside the drylands. Another important qualification highlighted by the authors is that degradation is cumulative: i.e., areas degraded before 1981 (for example since ancient times in the Middle East and Mediterranean) have stabilised at low levels of productivity, while the series data show additional degradation since 1981. Moreover, many dryland countries have hyper-arid or desert regions included in the national territory, and the percentage of territory degrading is therefore less significant than the percentage of the population affected.

<table>
<thead>
<tr>
<th>Country</th>
<th>% territory degrading</th>
<th>Total NPP loss (tonne C/23 yr)</th>
<th>% population affected</th>
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Source: Bai et al, 2008
Total plant biomass is, of course, a poor proxy for the use-value of dryland farms or pastures. Some invasive plant communities, such as *Prosopis juliflora* and *P.chilensis*, are useless for grazing or indicate the abandonment of economic production on farmland. Fallowing between cultivation cycles will be treated as degradation when the land is returned to cultivation at the peak of its productivity. Timber volumes on wooded farmland in Nigeria may exceed those of secondary woodland nearby. Measurements on the ground show that farmers can produce useful biomass (crops, fodder, fuel, compost) in a short growing season at a level that compares favourably with that of natural vegetation under the same average rainfall.

A better indicator of degradation than the managed vegetation is the status of the soils. Unfortunately, ambiguity is present here also. In Africa, the dominant narrative of degradation and erosion is especially popular with regard to drylands, and is blamed on farming, grazing and deforestation. Early surveys claimed that 332 million ha (25.8% of the surface of Africa) are affected by soil degradation in the arid, semi-arid and dry sub-humid agro-ecological zones. Estimates were published of the annual depletion of chemical nutrients which were upgraded and promoted by the World Bank and international fertilizer interests. These put net combined N, P and K losses at 60-100 kg/yr and increasing. This narrative continues to guide policy makers, for example at the Abuja Fertilizer Summit, notwithstanding its critics.

A degradation narrative does not account for the long term persistence of some smallholder farming systems in Africa’s drylands, their capacity to support populations that have doubled in about 30 years, their use of livestock in integrated crop-livestock systems, the evidence of intensification driven by labour, skills and organic inputs, and increasing participation in markets. Moreover, this process of incremental intensification is spreading rapidly in response to growing scarcities of land. Even at the national scale, long term data (1960-2000) do not support theories of agricultural collapse. Rather, the intricate interactions of policy with production and yield from year to year suggest that the role of demand factors has been under-estimated. These interactions are difficult to unravel because the primary determinant of yield in any year is the rainfall.

There is no doubt that nutrient levels are low on repeatedly cultivated soils in drylands unless compensated by inputs. But chemical fertilizers are only a part of the answer, and it is now recognised that integrated fertilizer management requires cycling of organic matter, together with attention to the biological properties of the soils. In extensive semi-arid farming systems, organic matter is transferred from rangeland to farmland by grazing animals. The amount of rangeland available would therefore appear to determine the numbers of animals and the supply of organic matter. However, in more intensive systems (possibly benefitting from higher average rainfall), crop residues can support higher stocking densities even without rangeland.

As for the polemic of ‘overgrazing’ and degradation in rangelands, based on the concept of a theoretical ‘carrying capacity’ which argues for stocking levels to be controlled at the highest that can be reliably supported in the driest years, a major movement has occurred towards a

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18 Cline-Cole et al, 1990
19 Mortimore et al
20 Oldemand and Hakkeling, 1990; Soorvogel and Smaling, 1990
21 World Bank, 2003; Henao and Banaante, 1999
22 Abuja Fertilizer Summit, ref
23 Scoones and Toulmin, 1998; Mortimore and Harris, 2005; Faerle and Majid,
24 Mortimore, 1998
25 Mortimore IIED; Djurfeldt et al
26 Uphoff
27 Turner or Schlecht
28 Harris
new paradigm of ‘opportunistic stocking’. It is more productive and profitable to increase livestock holdings in good years and carry losses in bad ones. This paradigm in turn is now being refined by fresh insights on the breeding strategies of mobile herders.

So the debate on degradation in dryland ecosystems is by no means closed. The circumstantial evidence of continuing viability, adaptation, and resilience demands that existing systems are taken more seriously by those who wish to transform them. In the following chapters, an ideology of degradation is rejected as a basis for policy, in favour of a more nuanced approach that is specific to time and place.

29 Sandford, Benkhe and Scoones
30 Kratli
3: What climate futures?

Observed effects to date
Long-term changes in dryland climates have already been observed. The IPCC Working Group 1 notes in its Summary for Policy Makers: “Long-term trends from 1900 to 2005 have been observed in precipitation amount over many large regions….Drying has been observed in the Sahel, the Mediterranean, southern Africa and parts of southern Asia.”\(^{31}\) Working Group 1 also reports downward trends in rainfall over the period 1900-2005 or some more recent sub-period within it, in northwest Mexico, southern Africa, northwest India and especially the Sahel.\(^{32}\)

IPCC Working Group 2 notes that in the Sahel warming plus reduced rainfall has reduced the length of the vegetative period “no longer allowing present varieties [of millet] to complete their cycle.”\(^{33}\) However, fortunately Sahelian farmers usually cultivate both long and short cycle millets with the aim of spreading risk. This means that they have been able to adapt their cropping patterns to shifts in rainfall over recent decades.\(^{34}\)

IPCC Working Group 1 states that there is an increased risk of drought in certain dryland areas of Africa coherent with observed climate change trends. Uncertainty exists as to whether specific drought events and drought cycles are attributable to global warming. Take for example, the example of the West African Sahel, which has experienced multi-decadal periods of wetter and drier climate, interspersed with periodic harsh drought events, as can be seen from Figure 1 below. Whether the current drier period is the result of a cyclical pattern or of global warming is not known. It is probably due to a combination of factors including the effects of climate change, changes in sea surface temperature, land degradation, and biomass burning. Whatever the cause, global warming is likely to exacerbate such droughts and other natural extremes.

Available evidence suggests that Africa is warming faster than the global average and is likely to continue to do so. Some African dryland areas are seeing even greater warming than elsewhere. Southern and Western Africa have seen an increase in the number of warm spells and a decrease in the number of extremely cold days. In East Africa temperatures have fallen close to the coasts and major inland lakes.\(^{35}\)

Future climate change in drylands
The historic records of dryland climates have been examined, with the fluctuations in African lakes,\(^{36}\) seeking a guide as to what is likely to happen in future. However, although palaeodata provide valuable information about past changes in the vegetation-climate system, the history of the world’s drylands can only be an imperfect guide to the future, given the greater human pressures now at work.

Arid regions are expected to undergo significant changes under global warming, but there is considerable variability and uncertainty between different scenarios. The complexities of rainfall changes, vegetation-climate feedbacks, and direct physiological effects of CO\(_2\) on

Figure 1: Variability in West African Rainfall, 1941-2001

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\(^{31}\) Inter-governmental Panel on Climate Change, 2007: 6. The more detailed text of AR4 chapter 3 refers to long-term drying over northwest Mexico. Within southern Asia, northwest India is specifically referred to.

\(^{32}\) Trenberth et al., 2007: 255-6.

\(^{33}\) Ben Mohammed et al., 2002 (for millet); van Duivenbooden et al., 2002 (for groundnut); both cited in Rosenzweig et al., 2007.

\(^{34}\) Toulmin, 1992; Brock and Coulibaly, 1997.

\(^{35}\) Boko et al., 2007.

vegetation present particular challenges for modelling climate change in arid regions. Great uncertainties exist in the prediction of how these arid ecosystems will respond to elevated CO$_2$ and global warming. Projections from the theory-based biophysical models tend to disagree most where the complexity of weather systems is greatest. Some dryland areas of Africa and some monsoon affected areas fall into this category. In addition there are areas where a lack of weather station data makes it very difficult to use statistical downscaling from General Circulation Models. Many dryland areas in developing countries fall into this category.

The IPCC 4AR assesses various future trends based on climate projections using different emissions-related scenarios. They report that it is likely and in some cases virtually certain that there will be fewer cold days and nights over most land areas, and there will be warmer and more frequent hot days and nights over most land areas. In addition, the frequency of warm spells/heat waves will increase, as will the frequency of heavy precipitation events. Also likely is an increase in areas affected by drought, the intensity of tropical cyclone activity and the incidence of extreme high sea-levels.

Regional projections of climate change are made in Chapter 11 of the Report of IPCC Working Group 1. In particular, the report presents a synthesis of projections for different regions for the period 2080-2099 from 21 global models using the SRES A1B scenario. A summary of projections is presented in Table 1 for the African and Asian regions, which contain significant developing country dryland regions, and for which drylands account for a significant proportion of total area.

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37 Christensen et al. 2007: 854. This scenario is based on global integration with an economic, rather than environmental emphasis, but with a balance of fossil fuels and other energy sources.

38 The regions used in this analysis contain significant areas that are not drylands and this should be noted. Central and South America are not included here. There is a considerable amount of technical detail on, and qualifications to, the original table in IPCC (2007), to which reference should be made.
Table 1. IPCC reported climate change projections in drylands regions of Africa and Asia, comparing current climate with projection for 2080-2099

<table>
<thead>
<tr>
<th>Region</th>
<th>Median projected temperature increase (°C)</th>
<th>Median projected precipitation increase (%)</th>
<th>Agreement on precipitation among models</th>
<th>Projected frequency of extreme warm years (%)</th>
<th>Projected frequency of extreme wet years (%)</th>
<th>Projected frequency of extreme dry years (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Africa</td>
<td>3.3</td>
<td>+2</td>
<td>Not strong</td>
<td>100</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>East Africa</td>
<td>3.2</td>
<td>+7</td>
<td>Strong for increase in DJF, MAM, SON</td>
<td>100</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Southern Africa</td>
<td>3.4</td>
<td>-4</td>
<td>Strong for decrease in JJA, SON</td>
<td>100</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Sahara</td>
<td>3.6</td>
<td>-6</td>
<td>Strong for decrease in DJF, MAM</td>
<td>100</td>
<td>See footnote 43</td>
<td></td>
</tr>
<tr>
<td>Southern Europe and Mediterranean</td>
<td>3.5</td>
<td>-12</td>
<td>Strong for decrease in all seasons</td>
<td>100</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Central Asia</td>
<td>3.7</td>
<td>-3</td>
<td>Strong for decrease in MAM and JJA</td>
<td>100</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Southern Asia</td>
<td>3.3</td>
<td>+11</td>
<td>Strong for increase in JJA, SON</td>
<td>100</td>
<td>39</td>
<td>3</td>
</tr>
</tbody>
</table>

Besides a global pattern of warming (which is important for evapotranspiration from soil and crops and effects on human and animal health), this table shows, at a highly aggregated geographical level and across seasons, that Southern Africa, the Sahara, North Africa and Central Asia (which are also the regions used by the IPCC that most closely coincide with drylands) are projected to receive smaller average rainfall, and more seasons and years that would be considered extremely dry relative to 1980-1999. East Africa and South Asia (each of which include significant non-dryland areas) are projected to receive higher rainfall and more seasons and years that would be considered extremely wet relative to 1980-1999. West Africa presents considerable uncertainty, and disagreement among models, as regards future trends in rainfall. An average of the major models suggests a modest increase in rainfall for the Sahel with little change on the Guinean coast, although there are some models which project strong drying, and others that predict an increase in rainfall.

Few studies so far have attempted to map out the implications of climate change projections for livelihoods. Thornton et al (2006) use climate impacts on crop and forage growth as proxies for likely impacts on rural livelihoods. This work shows impacts of rainfall and temperature changes on the length of growing seasons across Africa. GCM outputs for changes to rainfall and temperature are used in crop and forage models to identify climate effects on farming systems (as a proxy for rural livelihoods). The implications of climate change for farming systems are overlaid on socio-economic vulnerability information to identify climate and poverty ‘hot spots’. Many of these are in dryland areas. Figures 2 and 3 show predicted changes in rainy season failure and predicted changes in length of the crop and forage growing period. Table 2 summarises climate and poverty ‘hotspots’.

39 The original disaggregates median response by the four quarters of the year; the figure given here is the annual average as given in the original
40 As for temperature
41 Agreement is “strong” (current authors’ terminology), when the 25th percentile and the 75th percentile of the distribution of models were of the same sign; this is shown in the original by brown shading for agreement on decrease, and blue shading for agreement on increase.
42 Essentially, years warmer than the warmest between 1980 and 1999; similar definitions apply for wet and dry years. The original further presents projections of warm/wet/dry seasons
43 No aggregate figure for years, but significant frequency of dry DJF and MAM seasons
This work shows that changes in marginal areas – such as drylands – may be non-linear. For example, in east Africa higher rainfall (quantity and length of season) in the short to medium term could be cancelled out by increased temperatures, with increased evapo-transpiration. Non-linear effects will make climate adaptation an even more difficult task, liable to pitch stakeholders into competition for resources – whether the climate change makes natural resources more scarce or more abundant, for example, conflict arising from the movement of crop farmers into previously pastoral areas under increasing rainfall. The distribution of costs and benefits of such encroachments between farmers and pastoralists need careful negotiation.

Failure is defined as length of growing period falling below the minimum required for maize grain to be set. The shortening growing period comes about as a result of the modelled increase in temperature not being offset by increased rainfall.

Eriksen et al., 2005; Mworia and Kinyamario, 2008.
Table 2. Climate change and poverty hotspots across Africa (Source: Thornton et al 2006)

Synthesis of hot-spots

<table>
<thead>
<tr>
<th>Scenario A1F1</th>
<th>Highest vulnerability quartile</th>
<th>Second-highest vulnerability quartile</th>
</tr>
</thead>
</table>
| Possibly severe length of growing period loss (>20% to 2050) | * Some arid/semi-arid systems in Sahel*  
* Mixed rainfed and highland perennial systems in Great Lakes region of E Africa*  
* Arid/semi-arid systems in parts of E Africa*  | * Arid/semi-arid systems in large parts of Sahel*  
* Livestock systems and some mixed systems in parts of E and southern Africa*  
* Coastal systems in E and parts of southern Africa* |
| Possibly moderate length of growing period loss (5-20% to 2050) | * Mixed systems in parts of E Africa*  | * Coastal systems of parts of W Africa*  
* Tree crop systems in parts of W Africa*  
* Forest-based systems in central Africa*  
* Root-based and root-mixed systems in south central Africa* |

Interactions of climate and non-climate stressors of environmental change

Non-climatic stressors can increase vulnerability to climate change by reducing resilience, for example, habitat change, invasive species and pollution are all having increasing impacts, in many cases rapidly, across the different dryland ecosystems.\(^{46}\) Table 3 provides examples relevant to dryland areas. All of the non-climate stressors listed on the left-hand side of the Table are likely to affect poorer individuals and households more than the better-off. In addition, the interactions with climate change effects are also likely to be felt more keenly by the poor, increasing their vulnerability.

Rapid demographic changes in response to climate impacts make resource management more problematic. For example, populations that migrate between or into new dryland areas can be a source of additional pressure on environments and resource management when, for example, livestock temporarily concentrate at key resources, such as water points.

Table 3. Interactions of non-climate stressors with climate change effects

<table>
<thead>
<tr>
<th>Non-climate stressors</th>
<th>Examples of interactions of non-climate stressors with climate change effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land scarcity driving the diminution or fragmentation of landholdings (Sadik, 1991)</td>
<td>Reduced agricultural productivity due to rainfall and temperature changes exacerbates effects by reducing per area yields (MA, 2005)</td>
</tr>
<tr>
<td>Environmental degradation caused by population, poverty and ill-defined and insecure property rights (Vosti and Reardon, 1997), including widespread soil degradation (Lal, 2000)</td>
<td>Migration as a climate adaptation strategy increases population pressure, balance of poor and non-poor and destabilizes property rights systems. Eriksen et al., 2007</td>
</tr>
<tr>
<td>Regionalised and globalised markets, and regulatory regimes, increasingly concerned with issues of food quality and food safety (Reardon et al., 2003)</td>
<td>Concern over carbon emissions and food miles increases downward pressure on food imports affecting agriculture-dependent economies.</td>
</tr>
</tbody>
</table>

\(^{46}\) Easterling et al., 2007; Safriel and Adeel, 2005; Millennium Ecosystem Assessment, 2005.
HIV/AIDS pandemic, reducing household labour supply, eroding household assets, disrupting knowledge transmission and agricultural services (Barnett and Whiteside, 2002)

Distribution and spread of climate-sensitive diseases alters with precipitation and temperature changes, leading to new disease burdens in high HIV/AIDS regions (IRI, 2006)

Threats of panzootics (e.g. avian influenza) attacking livelihoods and constraining trade (ILRI, 2005)

Increased frequency of extreme weather events increases probability of disease outbreaks

State fragility and armed conflict in some regions (FAO, 2005)

Climate change effects of both fast and slow onset represent increased hazards that fragile states are ill-equipped to deal with, and are likely to fuel conflicts. Both types of effects can cause decreasing resource availability or equity of access (Eriksen et al., 2007)

How should we rate adaptive capacity at community and state levels, based on past experience?

Adaptation (as opposed to coping), whether individual or collective, “can be severely constrained by market distortions or by a lack of resources to implement any transformation” (IPCC).\(^\text{47}\) As well as failure to adapt adequately, this may give rise to inappropriate adaptation or “maladaptation”, defined in this source as “changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli.”

**Adaptive capacity** may be defined as “the ability of countries, communities, households and individuals to adjust in order to reduce vulnerability to climate change, moderate potential damage, cope with, and recover from the consequences” (Tyndall Centre).\(^\text{48}\) The IPCC distinguishes between four scales of adaptive capacity:

- mega (global – e.g international agreements);
- macro (national);
- meso (at the community or population-group scale); and
- micro (at the scale of the household or company).

Adaptation, and hence adaptive capacity, at each of the lower scales depends critically on the scales above. If it is to be successful, appropriate and effective adaptation (and therefore adaptive capacity) is therefore required at all these scales.

Of particular importance in the present context is the relationship between adaptive capacity at the macro, meso and micro scales. The state plays a key role, not only through its direct role in collective adaptation – services, infrastructure, etc. - but also in the enabling environment and incentives its policies create for individual and voluntary collective adaptation. Governance issues, both in government and in other collective fora, are therefore critical.

In the absence of effective, accountable and equitable decision-making processes, as Adger et al. observe, “many collective adaptation decisions made at local levels end up protecting vested interests and the interests of the less vulnerable”\(^\text{49}\). Adaptation that is truly ‘pro-poor’ requires creative approaches to the traditionally hierarchical structures of government and donor-supported intervention.

**Determinants of Adaptive Capacity**

Since the direct measurement of adaptive capacity *per se* is problematic, it is necessary to assess it on the basis of other indicators which exhibit a strong statistical relationship with successful responses to climate-related events. On this basis, Adger et al. identify 18 indicators as statistically significant:

\(^{47}\) IPCC, 2001b: 133.

\(^{48}\) Tyndall Centre, 2006.

\(^{49}\) Adger et al., 2006.
• Population with access to sanitation;
• Literacy rate, 15-24 year olds;
• Maternal mortality;
• Literacy rate, over 15 years;
• Calorific intake;
• Voice and accountability;
• Civil liberties;
• Political rights;
• Life expectancy at birth;
• Government effectiveness;
• Literacy ratio (female to male ratio);
• GDP per capita;
• Gini coefficient;
• Regulatory quality;
• Rule of law;
• Health expenditure per capita;
• Educational expenditure as a percentage of GDP; and
• Percentage of population employed in agriculture.50

These indicators can be broadly summarised as encapsulating four closely interrelated variables:
1. adequate incomes (GDP per capita, Gini coefficient);
2. high levels of health, health-related services and social determinants of health (calorie intakes, sanitation, maternal mortality, life expectancy, health expenditure);
3. basic education and educational provision (literacy rate indicators, education expenditure); and
4. good governance (voice and accountability, civil liberties, government effectiveness, regulatory quality, rule of law).

These priorities underline the convergence of adaptive capacity building with development in the climate change context, an area that demands attention from research and practice.

Channels for adaptation
Adaptation through policy mainstreaming, social transfers, adaptation projects, civil society or private sector actions are not alternative or competing channels or means of addressing climate adaptation. They are options with differing comparative advantages that will need to be used in combination to achieve the main objective which should be supporting and enhancing climate adaptive capacity of the poorest.

However, there is the tendency – sometimes born out of political expediency – to over-emphasise one option to the neglect of the others. This in part is because information on the relative effectiveness and complementarity of these channels under different circumstances is not available. IIED’s work on adaptation channels has derived headline findings as shown in Table 4.

50 Adger et al., 2005
### Table 3. Summary findings from IIED’s work on adaptation channels

<table>
<thead>
<tr>
<th>Channel</th>
<th>Summary findings from evidence</th>
</tr>
</thead>
</table>
| Adaptation in national planning | • The willingness of governments to engage with the adaptation problematic determines the effectiveness of this channel.  
• Willingness can be increased through capacity development and by providing the right incentives.  
• This channel tends to limit downward accountability.  
• A culture of local collective action, rather than ‘participation’, is therefore very important for success. |
| Social transfers for building adaptive capacity | • A demand-side strategy that has been largely overlooked in the adaptation debate.  
• Public awareness levels are crucial for adaptation by the poorest (ABTP) to happen.  
• A strengthening climate signal will push up demand for adaptation relevant services. |
| Multi- and bi-lateral funded adaptation projects | • A good project is still a project and it ends - politics, upper limits on scale and well documented ‘projectisation’ maladies thwart this channel.  
• Adaptation can be characterised as a growing need that does not fit with the project format - uncertainty resists structures.  
• Environmental GPGs are undifferentiated and do not necessarily (or often) address the adaptation needs of the poor, and environmental protection is not central to ABTP.  
• The Global Environmental Facility (GEF) is not tooled up for supporting ABTP – the best it can offer is a UNDP or World Bank project.  
• GEF targeting has not been towards countries that have high demand for ABTP |
| Inter- and national NGO managed adaptation | • Environmental international Non-Governmental Organisations (NGOs) are not appropriate for ABTP – it is too difficult for them to resolve complex trade-offs between environment and people in ways that benefit the poorest.  
• Linking to national policy and planning is critical for channel success in all but failing states. This linking is critical for the accountability of the NGOs and the processes they manage  
• This channel is appropriate for situations where current climate signal is weak and where there is high uncertainty around the severity of future climate impacts – NGOs have the contacts, engagement and communications skills to raise awareness and build collective action. |
| Private sector provision of adaptation goods and services | • Relevance, accessibility and affordability of products crucial to address poor sector in meaningful way – repeat business is a key indicator.  
• Although financial return is always the key determinant for interest of the private sector, there is over-optimism about the level of transaction costs in targeting the poorest.  
• In both technology and insurance sectors a social enterprise business model is required if these transaction costs are to be absorbed, making them less accessible and relevant for the poorest.  
• Market segmentation currently excludes the poorest (and will continue to do so) – insurance products are both out of reach and often not relevant to needs (owing to low asset base) – while increased climate change risks will lead to increased insurance premiums  
• Weather index insurance has high start-up costs, e.g., who pays for weather stations?  
• Companies may seek to mainstream insurance for climate change to offset the high costs of addressing the wider market and to maintain profitability. |

### Conclusion

This chapter has addressed five questions:

- What effects of climate change have been observed to date?
- What is known of future climates?
- What interactions are expected between climate and non-climate stressors?
- What is the adaptive capacity of dryland systems?
- What channels for adaptation are available?

All of these are key research and action areas. They set the stage for the development and conservation efforts which are addressed in the following chapters.
4: What price for dryland ecosystem services?

‘A critical requirement of a one-planet economy is that economic calculations of all kinds take proper account of biodiversity and ecosystem services’.\(^{51}\)

Dryland ecosystems have two characteristics that assist human communities not only to survive but to learn from nature. Ecological *adaptations* allow dryland plants and animals to reproduce, grow and survive in extreme conditions. These include many species used by local people as part of their livelihoods. Indigenous trees of southern Africa, for example, have dozens of uses (food, beverage, medicinal, utilitarian, spiritual and cultural).\(^{52}\) Domestic animals have also been bred from locally adapted species, for example *Nguni* cattle (Box 1). Dryland ecosystems and species also have a dynamic *ability to respond* to low and variable rainfall and recurring drought in uniquely productive ways. Dryland systems may be said to be ecologically resilient.

Box 1: *Nguni cattle in South Africa*

After being almost eliminated, the *Nguni cattle* breed is being revitalized for use by communal farmers in Eastern Cape Province. This hardy breed is known for an ability to withstand the environmental limitations, pests and cultural practices in this arid region. Unlike exotic breeds introduced during colonial times, *Nguni* are disease-resistant and productive in low-maintenance and low-input systems, such as those typical of poor communal farmers. They are highly prized for their beef and milk, skins and hides, draught power and manure which contribute to an integrated food security and livelihood strategy at a household level.

*Sources: Bester et al, 2001; Musemwa et al., 2008*

It is important that sustainable use strategies are informed by an understanding of these adaptations and dynamics. This type of *knowledge* results from regular interaction between people and their environment. Research has shown that success can be attributed to social mechanisms embedded within communities for the transfer of knowledge and responses to environmental cues.\(^{53}\) This knowledge also has a value, measurable not in monetary terms but in the success or failure of household livelihood strategies over time.

Recognition of the full value of ecosystem services, and of the opportunities they offer, will enable better planning and realization of the full economic potential of dryland ecosystems, rebutting the common perception that drylands are ‘economic wastelands’.\(^{54}\)

Dryland ecosystems support crop, livestock and other forms of production (‘supporting’ and ‘provisioning’ services’) for vast numbers of people. Additionally there are many lesser known commodities whose values are hidden in national economic planning because they serve local and informal markets. Although not intensively produced, they are harvested from the ecosystem and traded, thus contributing to the livelihoods of rural people. Still less recognised are the values of ecosystems in sustaining human life – biodiversity, and the ‘regulating’ and ‘cultural’ services of ecosystems. These also have values, for which estimates are available.

**Supporting services for crops, livestock and trees**

Dryland ecosystems provide supporting services to agricultural crop and livestock production and tree plantations. Although national statistics do not report separately on dryland regions, but merge data with that from more humid areas,\(^{55}\) the contribution of drylands to national economies can be inferred from measures such as sector contributions to gross domestic product (GDP), per capita income, employment, public revenues, and export earnings. For

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\(^{51}\) Adams and Jeanrenaud, 2008  
\(^{52}\) Sullivan and O’Regan, 2003  
\(^{53}\) Berkes et al., 2000  
\(^{54}\) Dobie, 2001  
\(^{55}\) Exceptions are those countries that fall entirely within the drylands (e.g., Mauritania, Egypt, the Yemen).
example, agriculture contributed more than 30% of GDP in dryland countries such as Afghanistan, Burkina Faso, Kenya and Sudan in 2005, and over 20% in Chad and Pakistan.\footnote{World Resources Institute, http://earthtrends.wri.org} In India, the arid and semi-arid tracts contribute over 45% of agricultural production, 53% of the total cropped area, 48% of the area under food crops and 68% of that under non-food crops; drylands account for nearly 80% of output of coarse cereals, 50% of maize, 65% of chickpea and pigeon pea, 81% of groundnut, 88% of soybeans and 50% of cotton.\footnote{Shah et al., 1998 ref to be supplied (KF)} Moreover, because of the large extent of the drylands, a small rise in agricultural productivity has a large impact on the country as a whole.

These figures are direct values in terms of market prices, however. Valuations may be made using other methods, which may take better account of the direct values of subsistence production to farming households, as well as indirect values such as those associated with family farming and aesthetic considerations. These add to the total economic value of crop production by dryland smallholders.

Similarly, direct values may be cited for livestock. The Chinese drylands are home to 78 million cashmere goats which supply 65-75% of the world’s cashmere fibre; and in Mongolia, pastoralism may provide 30% of GDP.\footnote{Davies and Hatfield, 2008} In Kenya, 50% of the national territory is too dry for farming but suitable for livestock. Over 60% of the national livestock herd is found there, providing 67% of the red meat consumed, 10% of GDP and 50% of agricultural GDP. The livestock sub-sector employs about 50% of the agricultural labour force.\footnote{Republic of Kenya, 2000, 2001, 2002} Livestock provide 20-25% of agricultural GDP in Africa, and 25-30% in Asia;\footnote{Davies and Hatfield, 2008: 12} in individual countries, the contribution may be much larger, for example 80% in the Sudan. In five West African countries, notwithstanding a doubling of the human population, FAO statistics show that the numbers of livestock units per capita remained constant or increased between 1961 and 2001.\footnote{Mortimore, 2003.} In countries that depend on livestock for a large proportion of national income, such as Niger, the value of supporting rangeland ecosystems can easily be inferred. In the Sahel Region of Niger, on the border of the Sahara, livestock production contributes 46% of local household income.\footnote{Zonon, 2007}

Again, official statistics based on direct market values do not fully reflect the value of pastoralism, which is usually the most profitable use of marginal lands. Nor do they admit that the productivity of pastoral systems is often higher than that of alternatives – in Africa, 2-10 times higher per hectare than ranching systems.\footnote{Scoones, 1995} The indirect values of livestock production, particularly mobile pastoralism, such as the social coherence and values associated with keeping animals, are not factored into such valuations.

Dryland ecosystems have low and variable rainfall and low biological productivity, and food production must keep up with high population growth rates. Despite these challenges, which require innovative and ingenious solutions to food insecurity, many dryland countries succeeded in maintaining food production per capita at constant or improving levels during the period 2000-2005 (Table 4.1).
<table>
<thead>
<tr>
<th>Country</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolivia</td>
<td>104.2</td>
<td>99.4</td>
<td>104.7</td>
<td>109.3</td>
<td>107.5</td>
<td>105.8</td>
</tr>
<tr>
<td>Botswana</td>
<td>98.8</td>
<td>106</td>
<td>105.4</td>
<td>98.4</td>
<td>99.6</td>
<td>99.3</td>
</tr>
<tr>
<td>China</td>
<td>100.2</td>
<td>102.7</td>
<td>107.4</td>
<td>110.1</td>
<td>114.8</td>
<td>117.8</td>
</tr>
<tr>
<td>Egypt</td>
<td>102.7</td>
<td>97.4</td>
<td>100.4</td>
<td>104.8</td>
<td>106.2</td>
<td>106</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>98.4</td>
<td>105.6</td>
<td>106</td>
<td>100.5</td>
<td>101.6</td>
<td>100.1</td>
</tr>
<tr>
<td>India</td>
<td>99.1</td>
<td>100.8</td>
<td>94.9</td>
<td>100</td>
<td>99</td>
<td>97.8</td>
</tr>
<tr>
<td>Kenya</td>
<td>97.1</td>
<td>100.9</td>
<td>102</td>
<td>103.9</td>
<td>98.6</td>
<td>97.8</td>
</tr>
<tr>
<td>Namibia</td>
<td>95.8</td>
<td>103.7</td>
<td>109.1</td>
<td>123</td>
<td>122.2</td>
<td>121</td>
</tr>
<tr>
<td>Peru</td>
<td>101.3</td>
<td>101.5</td>
<td>106.1</td>
<td>107</td>
<td>104.3</td>
<td>106.2</td>
</tr>
<tr>
<td>Senegal</td>
<td>101.3</td>
<td>92.9</td>
<td>57.7</td>
<td>76.6</td>
<td>76.4</td>
<td>87.9</td>
</tr>
<tr>
<td>Tanzania</td>
<td>100.5</td>
<td>99.8</td>
<td>100.7</td>
<td>98.3</td>
<td>99.4</td>
<td>98.1</td>
</tr>
</tbody>
</table>

Source: FAO 2006 Statistical yearbook

In six West African countries, having significantly large dryland regions, food production per capita showed positive trends from 1977 to 1999, though with much inter-annual variability. The cereal crops maize, millet, and sorghum dominate food production in these drylands, with rice in irrigated areas. Some of this additional output was achieved through extending the cultivated area, but it is significant that maize and millet yields per hectare remained stable (though low by world standards) or slowly improved. In Burkina Faso, yields of all four crops more than doubled over the period 1960-1999. Rainfall was the primary determinant of yields from year to year. However the long term trend was driven by growing demand from a doubling of the population between 1960 and 2000 and rapid urbanization. Structural adjustment policies introduced during the 1980s reversed an earlier declining trend. In an eight-country study including six eastern African countries, food production was found to have increased throughout the period 1961-2002, albeit at a slow pace.

This evidence demonstrates that drylands play a critical role in ensuring national food sufficiency, and that the long-term trends are complex. Demand and policy factors are important determinants, though hidden by annual variability in the rainfall. Although they fluctuate widely, values of output per ha show rising trends in several of the West African countries.

Where dryland ecosystems support woody vegetation (especially in Africa, where open savanna predominates), they contribute to national economies by providing fuelwood and charcoal for energy (for example, 70% of national energy in the Sudan; 74% of total energy consumption in Kenya, where charcoal is equal in value to horticultural products and only second to tea among marketed agricultural products). A great part of this is

**Box 2: Tree regeneration on farms in Niger**

When farmers migrated northwards during the early and mid-twentieth century, in response to growing population and new markets, they cleared the natural woodlands to make way for crops of millet, groundnuts and cowpeas. Assisted by frequent wet years, the cultivated area increased from <35% in the 1950s to 59% in 1975 and 73% in 1996. By the 1980s, trees were sparsely distributed, and soil fertility loss, wind erosion and increased risk from droughts were reported. A scarcity of fuelwood, timber and valuable NTFPs had developed as forests became degraded. Food security was low and food aid was required often. Development interventions based on tree-planting (often exotic species) had disappointing impact. But beginning in the 1980s, an NGO-led programme promoted on-farm protection of naturally regenerating indigenous trees – an activity already well established in long-settled areas of the Sahel (such as Kano, Nigeria and the basin arachide of Senegal). This was taken up by a state- and donor-sponsored development programme and soon became accepted as good practice in Maradi and Zinder Regions. A recent survey claims that 5 million ha of land and 4.5 million people are now enjoying the new trees and their beneficial effects on soil fertility, erosion control, and risk reduction. Sources: Raynaut et al., 1988; Mahamane, 2001; Jouet et al., 1996; WRI, 2008

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66 Mazzucato and Niemeijer, 2000
67 Holmén, 2005
68 ILRI, 2007: 95
consumed by rural populations, but urbanization and the growth of ‘million cities’ (Dakar, Khartoum, Kano) have generated growing markets and extended supply chains from remote sources. Fuelwood or charcoal use by poor households (in the absence of affordable alternative sources of energy) has often been blamed for deforestation, but on privately owned land, trees are normally harvested for dead or branch wood only, and protected for their valuable non-timber forest products (NFTPs). Such transitions to sustainable tree management on private farms are driven by increasing land and product values and have been assisted by some development projects. Trees add value to farmland and alternative incomes to livelihoods. (Box 2)

Dry forests also provide browse for livestock (an estimated 33% of the Sudan’s feedstock requirements), and timber for construction, tool-making and carving. Non-timber forest products are considered in the next section.

**Provisioning services: wild resources**

If the values of ecosystem services are reliably estimated, they can be integrated into national accounts, policy frameworks and local decision making. They can also point to policy choices available, and provide valuation guidance for assessing corporate performance and ecological footprints.70

Table 4.2 summarises the findings of a study in the Kgalagadi South District of Botswana, using valuation methods to quantify the benefits of selected products at the household and community levels. Here - in a district where many live on less than a dollar a day – plant- and livestock-based activities are valued at USD 1,394 per year at the household level, and community enterprises achieved on average USD 3,590 from hunting and USD 8,735 from tourism per year. Total estimated value to the District is USD 191,260, and estimated asset values are USD984,200.

Table 4.2. **Values of ecosystem services in Kgalagadi South District, Botswana (in USD)**

<table>
<thead>
<tr>
<th></th>
<th>Direct Use: Annual profits of enterprise¹</th>
<th>Direct Use: District total²</th>
<th>Asset Value³</th>
<th>Indirect Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Use</td>
<td>270⁴</td>
<td>91,870</td>
<td>604,280</td>
<td>-</td>
</tr>
<tr>
<td>Livestock Use</td>
<td>1,124⁴</td>
<td>68,211</td>
<td>Nil/</td>
<td>-</td>
</tr>
<tr>
<td>Trophy Hunting</td>
<td>3,590⁵</td>
<td>7,739</td>
<td>27,030</td>
<td>-</td>
</tr>
<tr>
<td>Tourism</td>
<td>8,735⁶</td>
<td>23,427</td>
<td>365,700</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
<td><strong>191,260</strong></td>
<td><strong>984,200</strong></td>
<td>-</td>
</tr>
<tr>
<td>Carbon Sequestration</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>111,300</td>
</tr>
<tr>
<td>Erosion Protection</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>68,400</td>
</tr>
</tbody>
</table>

(Adapted from Madzwamuse et. al 2007)

¹Private values (turnovers, net profits and returns to investment realised by households or enterprises), as expressed in monetary or in-kind transactions.
²Economic values or estimated contribution to national income (outputs less the costs of production).
³Present value of expected future contribution
⁴Per household
⁵Per community fund

In Senegal, the sales of NTFPs (harvested fruit, leaves, seeds, gum, roots, bark, honey) in Kolda and Tambacounda Regions of Senegal in the year 2000 were worth USD 2 million, and the value added along the supply chain averaged 48%; the value added to game byproducts reached 63% (Ba et al, 17, 23). Extrapolated to national level, including value added to urban markets, a median estimate of the annual economic contribution of NTFPs was USD 6.3 million. This is equivalent to an addition of 14% to conventional estimates of value added in the forest sector (timber, fuelwood and charcoal). Fresh water fisheries,
based on studies in two of the three major river basins, were estimated to be worth USD 14.5-19.6 million in value added in the country as a whole. These values were 19-26% of the value of marine fisheries, the primary sector by value in the Senegalese economy (Ba et al, 44). If recent movements in the value of the USD are taken into account, the national estimates increase to USD 8.4 million for NTFPs, and USD 19-26 million for freshwater fisheries. In sum, between 19 and 35 million USD of value added from wild products are currently excluded from national accounts. At a minimum, this would represent 10% of the annual Gross Domestic Product recorded for Senegal (approximately 20.6 billion USD) in 2007. Similarly, the Sudanese forests are famous for Gum Arabic, which earns 13.6% of annual export income.

African studies point to an under-valuation of ecosystem goods and services in national accounts which impedes planning on the basis of the true potentials of drylands. Given prevailing attitudes of governments and donors, the problem may likely extend beyond Africa.

Cultural services: tourism
Tourists are attracted to drylands by wildlife, scenic beauty, and cultural artifacts including ways of life of pastoralists in particular. Some indication of the importance of tourism to some drylands is given in Table 4.3, which reports the numbers of tourists and tourist revenues for selected African countries.

Table 4.3: Numbers of tourists and value of tourism in African countries with drylands

<table>
<thead>
<tr>
<th>Country</th>
<th>Thousands</th>
<th>$ millions</th>
<th>% of Exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Africa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Botswana</td>
<td>845</td>
<td>1675</td>
<td>98</td>
</tr>
<tr>
<td>Namibia</td>
<td>614</td>
<td>833</td>
<td>36</td>
</tr>
<tr>
<td>West Africa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senegal</td>
<td>369</td>
<td>769</td>
<td>108</td>
</tr>
<tr>
<td>Eastern Africa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kenya</td>
<td>943</td>
<td>1536</td>
<td>63</td>
</tr>
<tr>
<td>Tanzania</td>
<td>459</td>
<td>622</td>
<td>36</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>125</td>
<td>290</td>
<td>132</td>
</tr>
</tbody>
</table>


Tourists’ interest in wildlife has led to parks, reservations and conservation projects having conflicts of interest with rapidly expanding agricultural or ranching interests. Although tourism brings substantial revenues to the national economies of many dryland countries (Kenya,

Box 3: Wild harvesting by pastoralists
In Ethiopia the estimated value of goods collected from pastoralist areas is < USD 390,000/ year. However, there are big distributive differences between households in the collection of wild fruits, firewood, construction material and fodder. In Botswana, the largest share of the income of the poor is largely derived from the collection of wild fruits, vegetables and firewood, while the richest appropriate more of the grassland resources because of the higher returns to livestock compared with alternatives, and inequity in livestock ownership, and thus in environmental income, the use of natural resources and in pathways to the accumulation of wealth.

Sources: Ellis, 2000; Kerapeltsew and Lovett 2001.

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71 Based on the exchange rate of USD 1.00=F CFA 463.446 (10/09/08).
72 CIA, 2007
73 IUCN, 2006
where tourism accounts for 13% of GDP, is, however, exceptional\(^{74}\), the benefits do not necessarily flow to dryland farming or pastoral households displaced or constrained by parks. To capture a larger fraction of the USD 6 million tourism industry, Tanzanian pastoralists are now starting locally owned facilities with donor’s help.

Despite a move away from militant approaches to conservation ('fortress conservation'),\(^{75}\) approaches based on the engagement and participation of local communities in co-managing protected areas (e.g., CAMPFIRE in southern Africa) have made slow (though significant) progress. The clash of interests is exemplified in Kenya, where between 1977-78 and 1994-96, wildlife decreased by 61%, only increasing in one of 24 districts, while livestock also decreased, but only by 30%. Cultivated land, on the other hand, increased from 1985 to 2003 – that planted to maize from 1.2 million ha to 1.6 million ha, and that with beans from 0.6 to 0.9 million ha.\(^{76}\) The result is a mosaic of landscapes, those transformed by land use change and those energetically protected for tourists.

Tourist receipts are vulnerable to events that undermine perceptions of personal security. Before the recent onset of armed conflict in the Sahel Region of Niger, the Air and Ténéré nature and biosphere reserves were estimated to generate tourism revenues worth about USD 6 million.\(^{77}\) Tourists tend to converge on established attractions and famous countries or regions, and so the benefits of tourism are unevenly distributed in space as well as fragile. It is not a developmental strategy that is replicable in all drylands.

**Regulating services**

The regulating services provided by dryland ecosystems are critical for their management by dryland communities.

**Biodiversity.** Grazing management can improve or reduce biodiversity and degradation. Although formerly blamed for desertification, grazing and animal impact can stimulate pasture growth, reduce invasive weeds and may improve mulching, and mineral and water cycling.\(^{78}\) However, rangeland health and integrity are better where mobile pastoralism is practised.\(^{79}\) This allows recovery after grazing cycles and seed propagation.

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74 Davies and Hatfield, 2008: 21
75 Brockington
76 ILRI, 2007: 3, 74
77 At today’s rate (see Note 13).
78 Davies and Hatfield, 2008: 22
79 Niamir Fuller, 1999

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**Box 4: Controlled grazing schemes in Senegal**

In the early 80’s, the German GTZ collaborated with the Senegalese Forest and Water Service to create a model to test a new way of managing rangeland and herds around the borehole of Widou Thiengoli in northern Senegal. The model was based on trying to find the right balance between the number of cattle and amount of fodder available. In order to do this, the project provided special benefits to those few families who were allowed to use the pasture and water enclosed and protected by barbed wire fencing. But selling off animals soon after weaning (as planned) was not profitable enough. Animals which had gained advantage in good years within the enclosure were at a disadvantage in years of poor rainfall. In wet years, insufficient trampling of forage and soils led to the disappearance of preferred grasses. Fencing some families in, and others out, of what had once been a common resource enabled the elite to capture the benefits. Families who benefited within in good years found themselves rejected by others in the bad years when they had no choice but to cut the wire and let their animals venture out onto the common range.

Extensive farming has been assumed to reduce biodiversity. However, as farming intensifies, greater value is attached to biodiversity as trees, shrubs and herbs have food, fodder, medicinal and other values. In one village in the western Sahel, 135 useful species were recorded, and attitudes among the population were found to be strongly conservationist. In another village, a nursery set up for propagating threatened tree species was prioritised by the community.

**Water holding.** There are claims that effective pasture management can improve infiltration of water, reduce run off, and thereby raise water tables. If each millimetre of additional rainfall captured represents 1 litre more usable water per m², or 1,000,000 litres more water per km², it is worth investigating the role of pastoralism. Dry farming and irrigation both have an impact on sub-surface water, the first through infiltration effects and the second through withdrawal. The values of water services are immediately apparent when mismanagement leads to soil desiccation or salinization.

**Soil fertility.** Nutrients, biological organisms and physical properties of soils are critical to providing supporting ecosystem services for farming and grazing. Pastoralism does not necessarily generate overgrazing and land degradation, because collective action or institutions regulating access, such as those in the inland Niger delta, can ensure sustainable use. Pastoralism can play an important role in maintaining ecosystem health and resilience, promoting water and mineral cycling, and protecting biodiversity. Paradoxically, under-grazing can lead to encroachment by unwanted trees and shrubs. In monetary terms, based on GIS data, soil loss models and assumed net income of stock raising, a study in the grasslands of China estimated the value of soil maintenance at USD 3 /ha/yr.

Farmers in the Kano region of Nigeria have stabilised soil fertility, though at rather low levels, even under annual cropping regimes. Fertility is now a function of management. Organic matter recycles chemical nutrients and biological organisms and the fertility varies sharply between and within plots, depending on a farmers’ access to animals, compost, weeds and chemical fertilizers if affordable. In such a densely-populated farming system, there is a close tie between poverty reduction and the capacity to manage ecosystems sustainably.

**Carbon.** Estimations of Carbon stocks, sequestration and values vary from one ecosystem to another, as would be expected. Grasslands store approximately 34% of the global stock of CO₂, with an annual value of USD 7 assigned to their function in regulating CO₂. If the sink values of major biomes are estimated separately, the tropical savanna and grasslands average 0.14 tC/ha/yr, compared to only 0.01 tC/ha/yr for cropland (assumed to include tropical and temperate). The corresponding values for Net Primary Productivity are 7.2 and 3.1 tC/ha/yr. However it is possible that the tropical savanna and grassland includes some tropical cropland, so that the assumed difference is invalid.

With Carbon sequestration, erosion limitation, water storage (and purification), nutrient (including carbon) cycling, and radiation absorption in grasslands can mitigate the effects of drought or erratic weather patterns, and may be promoted by sound management. In Table 4.2 (above), for example, ‘indirect’ economic values are assigned to carbon sequestration and erosion protection services in the Kalahari. In Box 5, dispersed trees in pasture

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80 Salisu Mohammed, in: Mortimore et al, 2008
81 Davies and Hatfield, 2008: 22
82 Mearns, 1996; Davies and Hatfield, 2008: 22
83 Yu et al., 2005
84 Harris and Yusuf, Mortimore, 2006
85 Davies and Harfield, 2008: 22
86 Costanza et al. 1997, cited in Davies and Hatfield, 2008: 22
increased sequestration rates without adverse effects on the pasture. Of course, the costs of sequestration vary according to management practice.

Regulating services enhance livelihood opportunities and reduce vulnerability to the impact of climate change, notwithstanding the extreme and unpredictable elements of these landscapes and their limited access to water. Management makes a difference to what the regulating services can deliver.

Re-evaluating ecosystem management

In the drylands of poor countries the dominant systems of land use may be simplified as follows:

a. Mobile herding of livestock (‘nomadic pastoralism’)
b1. Extensive rain-fed farming with semi-sedentary livestock herding
b2. Intensifying rain-fed farming with integrated livestock keeping
b3. Small-scale irrigated farming in river valleys and local depressions

Herders and farmers have been accused of causing land degradation through over-grazing, over-cultivation, and deforestation. However, decades of unsuccessful attempts to transform them have forced a re-evaluation of these systems. Development agencies have scaled down their expectations and field studies have improved scientific understanding of their adaptive strengths as well as their vulnerabilities.

The mobile livestock herding systems (a, above) were once a target for cattle ranching or ‘controlled grazing’ schemes. These were tied to the idea of ‘carrying capacity’ – the largest number of weighted animal units supportable through low rainfall years – in a bounded, enclosed area. However, it was shown conclusively that mobile herding is more productive than ranching because it permits better use to be made of feed resources that are highly variable in time and space. African evidence indicates that such opportunistic grazing systems give better economic returns per ha than livestock reared under ranching conditions. Controlled grazing cannot adjust adequately to this variability (Box 4).

In the northern (drier) Sahel, although they are less abundant than those in the south, pastures have been shown to be more nutritious. This is well known to pastoral communities, who regularly move their animals north during the rainy season to fatten their livestock in preparation for the difficult dry season. Such transhumance is rewarded. In Niger, nomadic cattle are 20% more productive than sedentary cattle in terms of annual reproduction, levels of calf mortality, and annual milk production.

Commercial crop farming has remained secondary to small family farms in most drylands. Even on land formerly reserved for cattle ranching, small-scale cultivation has recently been introduced (e.g., in Kenya). Such farming is risky and livelihoods need backing up with income diversification strategies. The primary charge levied at small-scale farming in drylands is the destruction of soil fertility, either through exposure to erosion, or through

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88 Burton, 2001
89 Sandford, 1983; Behnke and Scoones, 1993; Ellis, 1994
90 Western, 1982; Scoones (1994)
91 Western 1982; Breman and de Wit (1983)
92 De Verdière (1995)
nutrient and organic matter depletion from repeated cropping with inadequate replacement inputs. As fallow periods become shorter (under conditions of increasing demand for land and divisible inheritance), their full vegetative recovery is frustrated, and the redistribution of nutrients from fallow to field via grazing livestock is reduced.

The wisdom of rotating and mixing crops (including nitrogen-fixing legumes), recycling crop residues and weeds as highly nutritious fodder, and maintaining livestock on farms as natural rangeland diminishes, is now recognised and the thrust of agricultural extension is towards supporting intensifying systems rather than transforming them into commercial models. Food security is given official recognition rather than being dismissed as mere ‘subsistence’ – an early stage in development. Nevertheless, fertility maintenance is a major issue despite the remarkable persistence of resource-poor farming systems, for example, maintaining 100 years or more of annual cropping in the Kano Close-Settled Zone of Nigeria.\footnote{Mortimore, 1993 a, 1993b}

In reality, the systems 2a and 2b (above) merge imperceptibly as a growing scarcity of land forces an increase in labour and other inputs. Financial resources are increasingly critical as inorganic fertilizers come to be seen (and are promoted as) a solution.

Also in the Sahel, ambitious re-afforestation programmes were supported by governments and donors as a solution to ‘indiscriminate deforestation’ and the degradation observed in farming areas during the drought cycles of the 1970s and 1980s. Based on exotic, fast-growing species, they were largely unsuccessful, and public investments in nurseries, water supply, distribution and planting were lost. Meanwhile, farmers in intensifying systems have long practised tree planting and the protection of natural regeneration on their farms.\footnote{Cline-Cole et al., 1990} The promotion of such practice (called *défrichement amélioré*) in southern Niger in the 1990s accelerated a transition driven by the increasing value of multi-purpose trees. Five million ha are reported to have benefited (Box 2).\footnote{WRI, 2007}

Some reasons why existing practice was systematically under-valued for so long in Africa include the following:

- Smallholders’ motivation to maintain viable farms or herds for their heirs was underestimated, in face of the myth that poor people always have short-term planning horizons.
- Local knowledge was not adequately appreciated by development agents, and nor was local capacity to evaluate new (external) knowledge, exchange from farmer to farmer, and experiment.
- Livelihood goals – which include health, education, welfare, income diversification and migration – complicate the uptake of new practices in natural resources management.
- Development practice was based on an equilibrium model, whereas local practice sought to adapt to uncertainty (or non-equilibrium).\footnote{Scoones ed 1994}

Some of this diagnosis may apply also to drylands outside Africa. Now, however, the values of low external input production systems in drylands are potentially transformed by the crisis in global sustainability and climate change.\footnote{Adams and Jeanrenaud 2008} Having for long been an ‘investment desert’ the drylands should now profit from having among the lowest carbon footprints in the inhabited world. We can no longer afford to treat local knowledge and practice as ‘conservative’,
‘backward’, outside the market, and necessarily destructive. Not only can rural drylands boast low Carbon emissions, but the world needs their help in mitigating global warming. The trends towards agricultural intensification (based on labour, skills, and organic cycling), and tree protection and planting on private farmland, in the African Sahel not only reverse degradation but also sequester Carbon. Payments for these environmental services may become a part of household budgets.

**Conclusion**

Evidence has been given to support a re-evaluation of ecosystem services and management in drylands. This will enable governments and donors to include dryland goods and services in national accounts. In conjunction, a re-evaluation of local management systems should involve a change in the attitudes reflected in public policy. These re-evaluations make a case for increasing public investment in drylands and improving incentives for engagement by the private sector. Markets are central. These issues are taken up in the next chapter.
5: Will dryland investments pay?

Drylands, especially in tropical Africa, have long failed to attract inward investments on the scale needed, mainly because national and international actors have misconceived or misunderstood their potentials. Given the historical relationship between development and investment, it is tempting to see drylands – in poor countries – as ‘investment deserts’, incapable of yielding an economic return when compared with high potential areas. Such a characterisation defines the prevailing poverty of drylands just as moisture constraints define their bio-productivity. But this is not the whole picture – and need not be.

Drylands in Argentina, Australia, Israel, Mexico and the USA have enjoyed relatively high capital investments and their advanced development, including in rural areas, provides the strongest evidence that drylands need not be poor. 98 Drylands in poor countries however have been treated as ‘investment deserts’, except where valuable minerals have attracted inward (and short-term) investment. Investors have favoured instead the high potential regions.

Landscape investments

The behaviour of small-scale farmers in some African drylands challenges the stereotype of unacceptably low returns to investment. Recent studies show that their long-term investment strategies, unrecorded and so usually ignored in macro-economic planning, have gradually transformed some densely-populated farming landscapes. Often constrained by poverty, smallholders invest incrementally, and many of their investments are created by labour. Finance is sourced from off-farm incomes as well as agricultural profits. It is highly significant that many of their strategies are designed to conserve the productive capacity of their land, rather than ‘mining’ it as often alleged by outsiders. Among well-documented cases is Machakos District in Kenya (see Box 1). 99

While some of these improvements were promoted through government and donor funded project interventions and credit schemes, it is notable that these were short-lived whereas the landscape transformation is long-term. Its sustained momentum is due to a positive social and economic evaluation of sustainable ecosystem management driving the development process. However, such incremental investment is an untidy process from an economist’s perspective. Taken forward in years of prosperity, it may regress in years when food is scarce and resources must be diverted to consumption. At all times, land management investments compete with other livelihood priorities. Farming households try to access incomes outside agriculture to boost their resources. Nevertheless, productivity per

98 They are excluded from the present discussion, along with high mountain drylands whose circumstances are different.
99 Tiffen et al, 1994

Box 1: Smallholder investments in Machakos/Makueni Districts, Kenya

In a study of landscape management, 1930-1990, the following investments were made by virtually 100% of farmers in the districts:

- Clearance and enclosure of farm land
- Improved management of enclosed pastures
- Building of soil and water conservation structures
- Adoption of new technologies
- Integration of crop and livestock production
- Planting and protecting economic trees on farms
- Purchase of organic and inorganic fertilizers
- Purchase of improved seeds
- Erection of grain stores, poultry houses, and livestock bomas
- Acquisition and hire of farm transport vehicles
- Building, improving and extending farm houses.
- Purchase of animals, equipment, immunisation, salt cures

Source: Tiffen et al, 1994
hectare of farmland has been increased (or its decline averted), land values have risen, and markets for land, labour and skills have grown. New crops and new livestock activities (e.g., fattening) have developed.

Landscape transformation is a condition of agricultural intensification. This is based on labour, local knowledge, efficient nutrient cycling, and the use of organic inputs in combination with an affordable minimum of chemical fertilizers. Such landscapes are spreading rapidly outwards from their original nuclei (often in the vicinity of towns). Growing rural populations, together with new markets, force up the demand for, and value of, land. Such expansion has been found to have a beneficial impact on the ecosystems, tending towards more sustainable trajectories, in northern Nigeria and southern Niger. But the diversity of livelihood circumstances and priorities from family to family militates against conforming to predetermined investment targets, as preferred by donor-funded projects.

In other parts of dryland Africa, increasing pressure of demand on natural resources likewise pushes production systems towards maximising the efficiency of the scarcest factor. In the pastoral zone where rainfed farming is impossible, labour may be limiting. There may be less opportunity to invest in pastoral systems, where little effort has gone into researching new breeds or technologies compared with that spent on crop breeding and agronomy for farming systems. Where large-scale management is the norm, or where out-migration has significantly reduced the labour force, investments of financial capital must substitute for labour. Because capital is easily moved elsewhere, there is a greater risk of unsustainable practices damaging the ecosystems.

Public investments
Evidence from India and China indicates that economic rates of return to public investments may be higher in rainfed dryland regions than in irrigated and more humid regions. In India, rural districts were classified into predominantly irrigated or rainfed, and the rainfed areas were subdivided into agro-ecological zones, including semi-arid. Five categories of public investment were analysed: research on high-yielding crops, rural roads, canal irrigation, electricity provision, and education. There is considerable variability among the rainfed zones, but in roads, electricity and education, the semi-arid zones performed better on average than the irrigated areas, and the investments had a greater impact in reducing the numbers of poor people. Comparable results were obtained in China. Drylands are often (though not always) remote from central government and their scattered populations impede effective service provision. But governments, whether assisted by donors or not, cannot improve on performing their essential functions efficiently.

A history of failed project interventions has deterred governments and donors from making fresh initiatives in African drylands. However, satisfactory economic rates of return (from 12 to 40%) have been cited for a number of projects, including soil and water conservation (Niger), farmer-managed irrigation (Mali)(see Box 2), forest management (Tanzania), and farmer-to-farmer extension (Ethiopia). Returns of over 40% are on record for small-scale valley bottom irrigation in northern Nigeria and Niger. Where financial data are not available, the impact of project interventions can be evaluated from uptake, especially in

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100 Mortimore, Ariyo et al 2008
101 Hazell et al
102 Reij and Steeds

Box 2: Farmer management of irrigation, Office du Mali, Niger
Set up in 1932, this large government-controlled irrigation scheme was best with problems: poor maintenance, insecure tenure, inefficient water management, land degradation and marketing. Rice yields were only 1.5 t/ha in the 1980s. However, with the transfer of maintenance and water management to farmers’ committees after 1986, yields increased to 5.5 t/ha; crops were diversified; 30,000 ha were rehabilitated, and 30,000 ha were newly irrigated. Rice income increased from USD 450 per ha on degraded land to USD 1,000 per ha on rehabilitated land, and the economic rate of return was 30%

Source: Reij and Steeds, 2005
the post-project period. Such evaluations are infrequent, however. These examples draw attention to a need for better ex-post monitoring of projects, which tend to be forgotten as soon as donor interest drifts elsewhere.

Livestock investments
With regard to investment, pastoralism (extensive livestock production in the rangelands, distinguished from ranching systems in this paper by the practice of herd mobility) differs from farming in two important respects. First, all available and suitable rangeland is already in use, so no investment in extending pastoral territories is possible. This applies to virtually all of the world’s drylands. Indeed, the major challenge is the loss of land to competing uses (farming and urbanization). Second, pastoral production systems are already labour-intensive. For example, the WoDaaBe cattle herders of Niger practise intensive breeding based on deep local knowledge and on caring for each individual animal and its progeny (see Box 3). Grazing systems are equally carefully managed, balancing fodder and water availability with the capacity of animals and often arduous daily journeys. It is well known that such systems, despite the hardships imposed on their users, are more efficient in their use of natural resources than alternatives.103 This fact is unfortunately lost by those who advocate ‘modernization’ in the form of large-scale ranching, a type of investment once favoured by donors who took their lead from capital-intensive systems in developed countries.

Pastoralism has substantial economic value and is fundamental to the wellbeing of millions of drylands people. The contribution of pastoralism to agricultural GDP is substantial in many dryland countries, and it contributes to export earnings. For example, the global market for camel milk is estimated at USD 10 billion,104 and in Ethiopia, leather exports provide 12% of national earnings. Given the low cost of inputs in rangeland systems (compared to farming in high potential areas), this suggests that economic returns for some livestock products can be high.105 Other products include milk, meat and wool. In farming areas, livestock also provide farm energy and transport, which can both earn income, a substantive return to livestock investments. In Kenya, a pilot project in Isiolo District implemented with a government investment of Kshs. 2.5 million resulted in earnings of Kshs. 18 million, derived from livestock marketing.106

Tree products
The major use of wood in drylands is for fuel and this is followed by construction and craft timber. Because woodland is often viewed as an open access resource, fuelwood cutting has been blamed for deforestation. This is only partly true. When private rights are asserted over farmland, trees may come under protection, as in many African drylands, not only for

Box 3: WoDaaBe breeding and grazing systems, Niger
The WoDaaBe production strategy involves a management system informed by studying cattle in their environment, capable of controlling stress and facilitating the rapid regeneration and transmission of functional behavioural patterns within the herd (learning, feeding competence and social organisation). The breeding population of cattle is organised into matrilineal lineages, the genealogies of which are carefully memorised. Cattle reproduction is strictly controlled with almost 100% of dam-sire matching and less than 3% of the bulls being systematically used for reproduction. Animal variability is fostered. Selected sires are intensively circulated within the breeding network. Cows are rarely sired twice by the same bull. Culling of females focuses on reproductive capacity, with marketing of poorly performing animals. Selection is carried out within but not between lineages. Long-lasting lineages are sought after and protected from non-strategic marketing in case of economic pressure.

Source: Kratli, 2007/8

103 Western; refs cited by Kratli
104 FAO, 2006
105 Gabre-Madhin and Haggblade 2001
106 Reij and Steeds 2005
their timber, but even more for the marketable ‘non-timber forest products’ (NTFPs) such as edible fruit, animal browse, medicinal products, and fibres. Contrary to claims of extensive treeless ‘deserts’ appearing in the vicinity of major fuelwood markets in Africa, commercial demand for fuelwood may actually be displaced to areas of easily accessible woodland up to 200 km away.\(^{107}\) Markets for cutting rights, dead or branchwood encourage farmers to produce wood as a subsistence activity or as a commercial proposition. Labour inputs on protection and management are small enough to ensure a good rate of return.

Gum production (especially Gum Arabic, derived from *Acacia Senegal*) is better documented than most non-timber forest products as it enters international trade. In the Sudan (the world’s major exporter), because it is obtained from naturally regenerating trees on fallow fields, producers stand to gain most of its market value in profits, though transport to ports from inland locations reduces net returns. In another exporting country (Ethiopia), gum collection and sale are important to producers’ livelihoods. [Box 4]

**Box 4: Returns from Gum Resin, Ethiopia**
In South-East Ethiopia, the average annual cash income generated per household from sales of gum resins was estimated at USD 80. This contributes 32.6% of annual household subsistence costs and ranks second after livestock in the overall household budget. Crop farming only contributed 12%. In 1988, 663 tons of gum resins were exported from Ethiopia with a total value of USD 1.23 million. More recently, between 1996 and 2003, Ethiopia exported 16,019 tons of gum resins per year, worth USD 20.5 million. Sources: Lemenih et al., 2003; Tadesse et al., 2007; Tilahun, 1997

Another tree product of commercial importance is frankincense, also exported from Ethiopia [Box 5]. Although investment or input data are not available for a calculation of economic returns, the profitability of such NTFPs to rural livelihoods may be reasonably inferred.

In East and Central Africa, the continuing importance to household incomes, nutritional and food security of the fruit of *Adansonia digitata*, *Tamarindus indica*, *Zizyphus mauritiana*, *Sclerocarya birrea*, and *Mangifera indica* has been noted.\(^{108}\) Dryland horticulture producing high-value fruit and vegetables can stand transport costs to market and still yield a good return, for example, in Machakos District of Kenya.\(^{109}\)

**Commercial investments**
Private commercial investments are not easily attracted to drylands, and a negative stereotype is prevalent in many countries, which is due to:
- A lack of physical infrastructure (safe water, electricity, solar energy, transport network, markets, telecommunications, schools, health centres and shelter) that promote human capital and private sector development.
- Poor access to financial resources and services such as banking and credit facilities.
- Little information on exploitable ecosystem resources, costs and values.
- Insecurity
- Distrust of local populations
- High tariffs on long market routes
- Insecure tenure

An important issue with private commercial investment is the difficulty of taking proper account of the social and environmental costs and benefits of new developments. Both are likely to be higher than in urban or more humid locations. The best way forward may be through partnerships between public and private interests.

\(^{107}\) Cline-Cole et al., 1990
\(^{108}\) Jama et al., 2008
\(^{109}\) Tiffen et al, 1994
Investment incentives
Poor dryland producers are not necessarily too poor to invest in the long term. Private investments were keys to each of the landscape investment stories (above), even where public-sector agencies also played a role. The context of the decisions of small investors is critical. There are opportunities and constraints facing the individual investor that reflect the enabling incentives present in the economic environment, macroeconomic policies and the risk of external shocks such as drought. Resources are allocated to meet livelihood objectives (which include other elements besides agriculture), taking account of the costs and expected benefits (e.g. to present or future income, leisure, inheritance). Many considerations, in addition to financial returns, have a bearing on these decisions. Among the considerations are consumption requirements, social obligations and off-farm income opportunities. Many constraints, however, impede investment, including risk, lack of funds, soil infertility and ignorance of markets or off-farm alternatives. Thus, natural resources are embedded in a livelihood investment framework.

Private commercial investments have failed to play the role expected of them, for example in service provision. Higher returns are needed than those acceptable to smallholders, who tend to discount labour costs. Attention is needed to incentive structures if the private sector is to fill the gaps created by a retreating public sector under policies of structural adjustment, or to share the burden of meeting the MDGs. Private investment can be stimulated by public-sector investments and policy.

All the evidence accords a critical role to market incentives. Dryland peoples attach much importance to market participation. For most, the risks associated with isolation from markets (cash and food scarcity, unemployment, knowledge deprivation) now outweigh the risks of closer involvement (for example, dependence on highly priced food in times of scarcity). Closer involvement is seen to have many benefits (sales of produce; supplies of food and consumables, inputs and technologies; labour exchange; information; education-based careers; remittances; and investment funds). An example is the Karakoram highway that opened up rangelands in Pakistan and allowed pastoralists to stop farming grain, and instead buy grain on the market at lower prices, converting their land for fodder production, and thereby boosting the more lucrative livestock sector.

Alternatively, policy can work through enabling incentives. Among the critical institutions whose relevance is clear from experience are land tenure, common pool resources, credit institutions, decentralized government services, and research and extension systems. The scope for influencing investment depends on the architecture of a particular country’s institutions, for as we have stressed, dryland countries are not all the same.

Risk management in drylands
Policies to promote dryland investment face a major challenge in the form of high perceived levels of risk. The biggest source of risk is a variable climate, which may directly cause losses of livestock or crops from droughts or floods, with ramifications throughout the local economy.

Vulnerability to market failure compounds the plight of pastoralists: factors contributing to high transaction costs include poor information flow to producers, a lack of competition in the supply of goods and services, and an inability to choose the best time of sale. Such failures disadvantage pastoralists when they want to convert their livestock wealth in times of

Box 5: Returns to production of frankincense in Metema District in Ethiopia
Frankincense is a resin extracted from Boswellia species. Local people have traded in it as a means of diversifying their incomes. Between 1996 and 2003, Ethiopia exported 13,299 tons per year of gum resins (90% frankincense), earning USD 18 million. In Ethiopia, drylands constitute 70% of the landmass and livelihood options are few given the harsh environmental conditions. Thus, promotion of production and marketing of frankincense and other commercial plant gums is essential for sustainable development. Gum trees also contribute to the conservation of dryland ecosystems.
 Managing risk calls for risk identification, quantification and the design of suitable instruments, taking account of such factors as location, season, weather, disease, marketing, civil order or others.

Traditional drought-coping mechanisms have become weaker for pastoralists. However, in African countries at least, they have effective customary loaning and insurance arrangements and working institutions for redress and debt collection. These assist individual households to survive in bad times and to rebuild after losses. Such institutions may be enhanced through policies to broaden micro-credit and investment opportunities, and to enable access to financial services such as banking and insurance. However, if poorly executed, they could have the opposite effect.

Farmers who are resource-poor require a range of coping strategies to help them adapt to variable rainfall. For example, in Central and West Asia and North Africa, recommended strategies include changing cropping systems and patterns, switching from cereal-based systems to cereal–legume mixtures, introduction of drought and heat resistant varieties, use of more water-efficient irrigation practices, adopting existing or new water harvesting technologies. Some of the opportunities for diversification in drylands that have been suggested are: value addition in livestock products through rural based processing industries, mining, fishing, eco-tourism and cottage industries, apiculture, bio-fuels, natural products, and the genetic improvement of livestock to improve productivity and marketing.

Crop insurance, as a strategy to reduce the risk of crop failure from adverse weather, and avoid prematurely committing farm resources, has not yet been extensively tested in drylands. Contracts would be written based on the mean local rainfall. If rainfall is below this value at a critical time of the cropping season, then all who have purchased insurance receive compensation. Such schemes have been piloted in Malawi, India and Ethiopia, but it may too early to conclude on their efficacy. In Mongolia, index-linked insurance schemes are in operation.

All insurance schemes, whether customary and local or modern and more extensive, face the constraint of co-variance in climatic events across wide regions. If all livestock producers, or all farmers, or worse still, both - suffer losses simultaneously, compensation schemes may collapse locally or become entirely dependent on external assistance. This, in effect, is what international food aid already does, and rising food prices make it an increasingly cost-ineffective option.

Another option for the public sector is better seasonal rainfall forecasting to minimise losses from committing resources before rainfall outcomes are known. Progress has been made in the technical development of forecasting in Africa, and in providing simple messages that farmers can use in making decisions about their inputs.

Conclusion

There is a fundamental tension between high levels of environmental risk in drylands and a need for returns from investment. If assets are protected through droughts, investments can be cumulative; if not, divestment in food emergencies frustrates growth. Insurance probably holds the key to an upward cycle of cumulative investment. Both investment and financial forms of insurance link dryland peoples more closely with markets. This theme is taken up in Chapter 6.

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110 WISP 2006
111 Thomas, 2008
112 Hazell, 2004
113 Cooper et al paper
6: Markets for poor people?

Drylands in North and Tropical Africa and Asia have deep historical ties with markets, cities, and distant places. Central Asia and the Sahara were criss-crossed by trading routes linking East with West, and tropical environments with temperate. High value commodities, new knowledge, slaves and conquering armies traversed them; silk and printing technology travelled from China to Europe, and in West African history, the savannas lent themselves to the passage of horse-borne empire builders. Nomadic populations of the deserts and steppes played intermediary roles in these exchanges; and Arabic culture was created in and exported from drylands to the humid biomes of the Old World.

It is a myth that drylands – at least in recorded history, if not earlier – always acted as barriers to economic, social or political intercourse, and only had a history of remoteness and isolation. It is important to bear this in mind when confronting the relative marginalisation of many dryland peoples in the contemporary world. Globally, markets have a central place today both in the ideology of development (the ‘Washington Consensus’) and in the everyday life of dryland communities. Participation in markets is increasing, but many would say that it is failing to bring development on the scale expected. We shall offer a brief analysis of the ways in which market participation is changing, and the opportunities that sound investment and policy can exploit.

The demise of colonial export agriculture. The promotion of cotton, groundnuts, and tobacco were central to agricultural policy in many African drylands from the beginning of colonial rule. A symbiosis between growing demand for fibres, vegetable oils and stimulants in the industrial countries on the one hand and, on the other, land-surplus economies with a need for monetary rewards (with which to pay taxes and to finance rising consumer expectations), created new opportunities. Governments installed transport and port infrastructure, financed the introduction of new varieties, set up agricultural extension systems, and facilitated processing plants (cotton ginneries, oil mills, tobacco factories). This system peaked in the 1960s (the decade of independence). Thereafter, cotton exports became less remunerative as world prices stagnated and the demand from local textile mills escalated; groundnut exports were decimated by rosette disease, drought and falling world prices; and tobacco production was also diverted to local markets even as Northern producers came under pressure from anti-smoking lobbies. Under the impact of falling world prices, the state-driven systems of marketing, processing, credit provision and technical support failed (e.g., in Senegal).

This model helps to explain the diminishing share of African countries in world trade; though it does not apply equally to all export crops nor to all drylands. It is reinforced by the refusal of the USA and Europe to terminate agricultural subsidies and market barriers; while the EU’s preferential trade agreements originating in bilateral colonial relations have been dismantled in favour of EU policy to impose ‘free trade’ agreements in the name of development. American subsidies to its cotton farmers are believed to exceed the national income of Burkina Faso, a dryland country that still depends on cotton exports. Dryland futures appear insecure if built on export agriculture.

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114 The Australian drylands perhaps come uniquely close to the stereotype, but on account of oceanic, not desertic barriers.

115 Faye et al., 2001

116
New commodities for growing and urbanizing populations. Concurrently with the decline of colonial trade relations, population growth was approaching a 30-year doubling time in some African countries and urbanization was accelerating rapidly throughout the world’s drylands, with accompanying currents of short- and long-term migration. And while concern was (and is) being expressed about the growth of urban poverty and the deterioration of urban environmental quality, less attention was given to the implications of this demographic transformation for commodity markets. Urban dwellers buy rather than produce food and other rural products, and their low average incomes notwithstanding, generate significant growth in aggregate demand. In an absence of state provision, this demand is translated into expanding informal market systems, privately owned public transport, and extending urban hinterlands. For example, in West Africa’s drylands, between 1960 and 1990, market growth correlated with population density and output per ha and per rural inhabitant, indicating a strong coherence between these variables. (Box 1)

At Kano, one of the major cities of the region, food commodity markets, followed through the period 1960-1999, demonstrated their flexibility and a capacity to supply growing numbers of consumers with staple cereal grains and livestock products at prices that tended downwards in real terms, despite the vicissitudes of policy changes and climatic variability. The West African experience suggests that development policy should aim to build on what is already happening, rather than distort the status quo in favour of what policy makers may consider ideal.

Niche markets – a return to exports?
Dryland ecosystem wealth extends to a range of existing and emerging high value natural products whose development can be facilitated by globalization and premium prices. Eco-friendly products, using trademarks, can earn niche products premiums for positive environmental externalities. There is an increasing demand for innovative, unique or specialty products aimed at niche markets, worth globally about USD 65 billion per annum, which features strongly in some dryland country economies. A significant proportion of this demand is for medicinal and cosmetic products. Global trade (including industrial production) in Aloe, a skincare product traditionally used in and originally sourced from drylands, is valued at about USD 80 billion. Other examples are Devil’s Claw, an arthritic medicinal plant from Namibia and Botswana, valued at over 31 million in EU markets; Gum Arabic (see Chapter 4), and crocodile skin, an emerging opportunity for Zambia, generating up to USD 2 million after an initial investment in 2005.

In southern Africa, the current natural product trade is estimated at USD 12 million per annum, with potential to grow to USD 3.5 billion, half the value of current agricultural exports from the Southern African Development Community (SADC) Region. A growing sector of commercial natural products employs up to nine million casual, largely female, workers (see Box 2).

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117 Ariyo et al., 2001
118 Bennett 2006
Biofuel production and markets

An altogether new dimension in market horizons in the cultivable drylands is the potential for producing biofuels and *jatropha* in particular, either to meet internal demand or for export. This is being energetically advocated by fuel supplying interests and from the point of view of the national economy, is particularly relevant in fuel-importing countries, especially those where major centres of economic activity and urbanization incur heavy transport costs on moving it in from the coast. Such a country is Kenya. The possibility of even a partial relaxation of the economic stranglehold exerted by fuel bills may prove irresistible to planners. However, there are serious objections to biofuels as a strategy for drylands. First, the amount of cultivable but unused land available is already limited, after more than a century of agricultural expansion. This is especially applicable to Kenya, where most of the rural population lives on about 15% of the territory. This means that biofuel production will compete with food production on existing cultivated land. If the price advantage offered by *Jatropha* is sufficient incentive to clear new land, it will be the more likely to displace food production on existing farms. Second, the producers who will be attracted to biofuel production are unlikely to be the poor, who value their subsistence production most highly, but rather the better off, who can risk capital and afford to buy food. Third, new pressure on uncultivated land will threaten biodiversity. In Kenya, most wildlife is now concentrated into reserves, and is diminishing outside as agriculture expands.

These and other questions indicate that a ‘biofuel revolution’ must be supported by adequate research and planning and its social and ecological consequences anticipated.

Livestock markets

Given the importance of pastoral production systems in the drylands, and the role of livestock producers in meeting a globally rising demand for meat, milk and other livestock products (the ‘livestock revolution’), it is necessary to take special account of the modes of engagement with markets that are found in different dryland regions. Rather than producing animals to supply markets, as in commercial ranching systems (where the most financially efficient off-take levels are sought), pastoralists seek to use the market as an instrument in achieving their wider livelihood objectives, in particular building up and maintaining high quality herds in an environment that can be dangerously variable. Thus among the WoDaaBe of Niger, buying and selling animals is intimately embedded in selection and breeding strategies. In the Ferlo of Senegal,
the Fulani embody their awareness of risk in their engagement with markets (see Box 3).

In Northern Nigeria, the marketing decisions taken by owners of livestock have tended to increase, in aggregate, the percentage offtake from herds over the longer term. In the range 9-11%/year, this level probably indicates a maximum, given the risks inherent in drylands. In Maasai land in Kenya, agriculture has advanced but livestock numbers have remained fairly static, and livestock marketing rates have risen greatly. Any study of market behaviour gives the lie to the myth that in Africa, animals are kept only for status, and the more the better. In addition to livestock specialists, farmers in drylands keep very large numbers of livestock, especially sheep or goats, and buy and sell according to circumstances (e.g., buying after harvest and selling at price peaks before religious festivals). A capability for such flexible responses to variability make livestock a prime instrument in building livelihoods.

Labour markets and financial flows
Collaborative or communal work on farms or with livestock, based on principles of reciprocity, was a characteristic feature of many dryland production systems. It enabled a flexible response to urgent, time-constrained, large-scale or emergency tasks and represented a form of adaptation to a rapidly changing and uncertain environment. Labour markets, however, developed in response to the growth of the commodity and service markets which permit the monetization of inputs. In some West African drylands, an important social distinction between richer and poorer farmers came to be reflected as ‘labour hiring’ versus ‘labour selling’. In other social groups, people would both hire others’ and sell their own labour at different times in the year. This resulted from the decline of communal arrangements owing to the permeation of a cash economy. Livestock producers too engage others’ labour to help with watering or herding animals. In the past, this was sometimes accomplished by maintaining a lower caste of servants. Today, money changes hands more often, though the resilience of labour-sharing institutions tends to be greater among pastoralists than among farmers.

Diversification of livelihoods is a strongly established and increasingly popular strategy for managing risk. Employment in cities or areas of commercial agriculture, often in the informal sector, provides incomes that may be taken home or sent as remittances to support consumption or investment by the family. Because income diversification usually calls for travel over long distances, the family must agree on the distribution of responsibilities. Because the drylands have long dry seasons, farmers may circulate between home farm and workplace on a seasonal basis. For livestock producers, on the other hand, labour for lifting water and conducting animals between wells and grazing fields may be at a premium during the dry season.

Labour markets, the migrations associated with them, the financial flows which they make possible from urbanised or wealthier regions to the rural drylands, and the adjustment of customary labour sharing institutions represent key developmental opportunities for dryland households and rural communities. Yet rather than facilitate such spontaneous adaptations, the state has often obstructed free movements, deplored the arrival of migrants in urban areas, ignored their contributions to urban economies and markets, and even forcibly driven them home, especially if they came from across an international frontier. New policy thinking could reverse this failure by adopting a new approach to the necessary symbiosis between drylands and core economic regions.

Land and NR markets
With the monetization of labour sharing and diversification of incomes has come the emergence of land markets, and to a lesser extent of markets in other natural resources such as trees, woodland, and water. Valuable ‘point’ or ‘patch’ resources such as land, water and trees in oases were exchanged through markets in history, or allocated as political

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122 Norton Griffiths
favours, with potential for disputes or actual conflicts. What is new is a huge increase in the incidence of market exchanges of rights to farmland, valuable trees, cutting rights in woodland, fishing rights, etc.

There are two reasons. First is a slow evolution of land use rights from customary towards private holdings as pressures (from the market) drive right-holders to devise new forms of contract for temporary loans and benefits, to assert more enduring private rights to farmland, to block access to trees previously browsed by other peoples’ livestock, or to livestock tracks leading through farmland to water, within the framework of customary tenure. This evolution has been studied in depth in West Africa and in particular, the growth of secondary or ‘derivative’ rights.123

The second reason is the intervention of the state in customary resource tenure and its administration. This began (in Africa) with colonial assertions of state ownership, asserted over feudal-style kingdoms and family land alike. Statutory tenure was enacted for purposes of government, planned city growth and economic, infrastructural and educational projects.124 State interventions continued after independence, with new legal frameworks enacted that were intended to unify customary and statutory law. But as the frequency of statutory allocations increased with the pace of economic change and urbanization, and political power was devolved from the centre, the manipulation of statutory rights became a prime target for corruption.

Meanwhile, grazing rights remain reliant on a weak form of customary recognition that was formerly enjoyed by mobile pastoralists and does not prevent the appropriation of land for farming. In areas too dry for farming, this does not threaten pastoralists, but where crop production is possible, the deprivation of grazing resources is at the centre of the marginalisation process that afflicts specialist livestock herders. The principle ‘land to the tiller’ adopted in some Sahelian countries has been discriminatory in effect. However, beyond the farming frontier, state appropriations for ranching or other activities may still occur, and of course, more humid rangelands needed during dry weather may become less accessible.

Given the observed pressures of rising demand, dryland natural resources will be driven increasingly by market values in future. Development policy needs to obtain a better understanding of the stakeholders and their interests and should aim for a regulatory role for the state that is even-handed and transparent. Greater empowerment of dryland resource users is a necessary first step in the inevitable negotiations.

**Input, service and knowledge markets**

With the withdrawal of many states from production and service delivery in the agricultural sector, which characterised structural adjustment programmes in many dryland countries from the early 1980s, a gap appeared which has not yet been filled by the private sector. Drylands stood to lose because they include extensive sparsely inhabited areas, under-supplied with public investment, infrastructure, service providers and access to new knowledge. Given low levels of bio-productivity and high levels of risk, incoming investment will prefer cities.

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123 Toulmin and Lavigne Delville
124 Mortimore IIED

**Box 4: Carbon capture on the Tibetan Plateau**

Alpine meadow covers more than 58 Mha on the Tibetan Plateau, and contains between 25-53 tC/ha, more than 90% of which is in soils. 18-year grazing studies show that continuous heavy grazing leads to a halving of soil C stocks. Official figures suggest these grasslands are overstocked by 30-40%. Carbon finance could play a role in providing herders with an incentive to reduce stocking rates. A policy of contracting grassland to households has been implemented in most areas. The average household has clear user rights to more than 110 ha of grassland. Average incomes are below US$1 per day. If reductions in stocking rates could increase soil C sequestration by just 0.5 tC/ha/year, then at current carbon prices a herd household might be able to receive payments of over $7000 per year, more than twice their current annual income, while also preventing the loss of important ecosystem services in this critical region.

*Source: Wilkes (2008)*
irrigation or other high value opportunities, unless motivated by social or kinship links. New approaches linking decentralised governance of natural resources with knowledge sharing partnerships are being tried in some drylands.\textsuperscript{125} This approach combines new or adapted institutional structures with greater respect for local knowledge. Local knowledge is indigenous knowledge adapted to current experience and messages from external sources. In the new partnership, science-based knowledge is ideally put at the disposal of local users who themselves choose directions for natural resource management.

The role of markets in such developments remains to be seen. However, it is clear that the state may prefer to remain detached unless in a still centrally planned economy. If so, new forms of partnership between the public and private sectors are urgently needed in drylands.

Supply/value chains, how to make them work for poor people
Commodity-based value chains (filières) linking producers with markets through intermediaries are inadequately understood in many drylands. Along these chains are found all of the opportunities to regulate or intervene in support of poor producers of crops, livestock, natural products or others. They are specific not only to commodity but to time and place. Local perceptions of developmental barriers often highlight one or more ‘market failures’ along the chain – such as illegal rent-seeking, taxation on transactions, fuel prices – whose complexity should force policy makers to look politics in the eye. Mere technocratic solutions, or single-commodity solutions, are insufficient. A major objective of applied research should be to uncover this complexity, systematise knowledge, negotiate with stakeholders, and identify measures to reduce costs and losses in marketing dryland products.

Carbon markets
Payments for Environmental Services (PES) recognise the existence of external interests in dryland ecosystem management. At the local level, this principle has long been used to provide incentives for land use decisions, for example, in upper river catchments that benefit downstream users. Carbon markets link dryland resource users with global interests in mitigating climate change through reducing greenhouse gas emissions. The capacity of dryland vegetation to sequester Carbon is less than in many other biomes (e.g., the tropical rain forest), but the areas of dry woodland and grassland in the tropics are vast and are capable of making a significant contribution to mitigation as well as bringing a new source of income to dryland peoples.

Conclusion
Economic diversification is driving poor people into greater participation in markets – and not only in drylands.\textsuperscript{126} Strategic investments of time (labour) as well as savings in alternative livelihood options have provided more than an escape from the potentially dire consequences of extreme events, but also a development pathway that deserves far more recognition from governments and donors. Users of natural products in Southern Africa, for example, have found ways to shift investment strategies while minimizing risk.\textsuperscript{127} There is evidence that ‘populations are not passive victims of their environment, but have excellent coping capacities, are innovative and extremely responsive to economic signals and activities’.\textsuperscript{128}

Markets need stable and enabling institutions. In the next Chapter we turn to some institutional questions.

\textsuperscript{125} NNJC Project
\textsuperscript{126} Ellis and Allison 2004
\textsuperscript{127} Hort 1976, IUCN 2007
\textsuperscript{128} Dobie, 2001
7: Can risk be contained?

What institutional arrangements are required in order to release the full potential of dryland people to adapt to risk and change, to improve their livelihoods, and to manage their natural resources sustainably? Environmental variability lies at the root of the development challenge in drylands. Therefore institutions that promote investment and sustainable resource use, while also building resilience to external shocks, are critical for sustainable livelihoods and wider economic development. Given a specific dryland ecology, an institution must enable people to cope with seasonal and inter-annual variability, and with expected but unpredictable natural shocks such as droughts, floods or disease. They must also support adjustment to economic, political or social shocks, protect assets and enable diversification and mobility. Secure rights over land and natural resources are critical. They must provide mechanisms for dealing with conflicting interests, particularly where competition has increased as a result of demographic growth, socio-economic change or investment inflows.

NRM institutions that respond to environmental variability

Dryland peoples have evolved customary systems of rights to the use of natural resources. For example, the rights of pastoralists in Niger were governed by reciprocity (Box 1). Across dryland Africa, however, land legislation tends to emphasise state ownership or control, with much of the population only enjoying use rights. The lack of a clear definition of what constitutes “productive use” creates opportunities for abuse, and undermines the security of land rights.

In rural areas, particularly in West Africa, continuously reinvented and adapted ‘customary’ tenure systems are often applied even where they are inconsistent with legislation, because they tend to be more accessible to rural people. As a result, several tenure systems – state, customary and combinations of both – may coexist over the same territory, resulting in overlapping rights, contradictory rules and competing authorities. This situation creates confusion and fosters tenure insecurity, which has been shown to discourage agricultural investment, undermine incentives for sustainable land management, and enable elites to grab common lands. On the other hand, privatization leading to individual, clearly bounded ownership is ill-suited to regulate the flexible, overlapping and reciprocal relations that characterize pastoral land use.

Box 1: Reciprocity in pastoral livelihoods

Pastoral institutions offer many lessons to address dryland challenges. Managing natural resources through a mix of common property and private regimes, where access to pastures and water are negotiated and often depend on reciprocal arrangements, allows pastoralists to respond in a flexible and opportunistic manner to resources that are highly dispersed in time and space. Offers of reciprocity, investments in maintaining close ties with “host families” in distant lands, and careful organisation of livestock mobility, allow herdsmen to negotiate access to a wide range of resources in any given year. Therefore, besides secure resource rights over their home areas, pastoralists need flexible institutional arrangements enabling herd mobility, as well as secure access to distant water and dry-season grazing. Such flexibility enables livestock to be driven to where the most nutritious and abundant pastures exist, thereby optimising weight gain and milk production in the wet season, and limiting weight loss in the dry season.

Sources: Thébaud 2002; Turner 1999, Lane 1998

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129 Cotula, 2007
130 République du Niger, 1997
131 Hesse & Thébaud, 2006
132 Toulmin and Quan, 2000; Cotula et al, 2006; Lo and Dione, 2000; Fay, 2008.
In the following sections, institutional responses to these challenges are set out.

**Securing local land rights**

Giving full legal recognition to local (including “customary”) land rights, through which most people gain access to rural land, is a key step to improved security. Land registration may (but need not) be a component of a broader strategy, if customary systems have collapsed, or land disputes are widespread, and in newly settled areas. Registration may also be useful in areas of high land values, such as urban and peri-urban areas and irrigated lands. A wealth of experience on how to secure local land rights is being developed in several countries, for example in the Ethiopian state of Tigray (Box 2).

Registering collective land rights may also be a cost-effective way to provide adequate tenure security, provided that group members enjoy clear rights over their plots. In Mozambique, for instance, while all land belongs to the state, “local communities” can register a collective, long-term interest and manage land rights according to customary or other local practices. Several countries have made explicit efforts to protect customary land rights and provide for their registration (e.g. Uganda, Mozambique, Tanzania, Niger and Namibia).

Enabling access to appropriate systems of land dispute resolution can provide greater returns in terms of certainty and security than investing in comprehensive exercises to document land rights. Increasing the security of land transactions, particularly land rentals (fixed-rent or sharecropping contracts), is also critically important, requiring simple local documentation systems. New technologies such as computerized land information systems and GPS can help put in place efficient and publicly accessible land records, but are no substitute for a locally legitimate process to adjudicate competing claims.

**Decentralising natural resource management**

Devolving responsibilities to local government bodies can strengthen local control over natural resources, and provide real as well as perceived security of resource rights, provided that the bodies are truly representative. Devolution proceeds at different speeds and to different extent in the Sahel and in certain East African countries (for example, local governments have long enjoyed powers in natural resource management, but in Mali the policy is not yet operational). It provides opportunities for legal recognition of community-based management rules that are better adapted to local environmental, social and political context. However, it can also bring new opportunities for rent seeking and resource grabbing by local elites.

Devolution of powers to local communities needs to be distinguished from “deconcentration” or mere transfer of responsibilities to field units of the same administrative department. However, this can also improve local responsiveness and oversight of decision-making. Examples are the Land Commissions in Niger, the Land Boards in Uganda, and the Communal Land Boards in Namibia. Botswana’s longstanding Land Boards have been explicitly or implicitly used as a model (e.g., in Namibia). Slow implementation of these provisions has been mainly due to a lack of human and financial capacity.

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Box 2: Land registration in Tigray, Ethiopia

Simple, low-cost and accessible local land records are handled by the lowest level of local government; fees tend to be very low, the technology is very simple and the language used is accessible to most rural land users. As a result, the process is transparent and accessible for most land users. However, the simple technology used does not enable documentation of the size, boundaries and location of the plots, which limits the use of the records in solving border disputes. *Source: Haile et al, 2005.*

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133 Chilundo et al, 2005
134 Cotula et al, 2006
135 Vogt and Vogt, 2000
136 Djire, 2004
Facilitating pastoral mobility in the Sahel

The past decade has seen a promising shift by several governments to recognize and regulate access and tenure rights over pastoral resources—first with Niger’s Rural Code (1993) and then with the pastoral laws passed in Guinea (1995), Mauritania (2000), Mali (2001) and Burkina Faso (2002). Although the approaches taken by legislators vary considerably across countries, this pastoral legislation tends to recognise mobility as the key strategy for pastoral resource management—contrary to much previous legislation, which was traditionally hostile to herd mobility (Table 7.1).\(^{137}\)

In order to maintain or enable mobility, pastoral legislation seeks to protect grazing lands and cattle corridors from agricultural encroachment and to secure herders’ access to strategic seasonal resources. The tools used range from the delimitation of pastoral lands to innovative legal concepts like the *terroir d’attache* in Niger.\(^{138}\) Pastoral laws also regulate multiple and sequential use of resources by different actors (e.g., herders’ access to cultivated fields after harvest), and determine the role which pastoral people can play in local conflict management.

While these laws constitute a major step forward, some problems remain. First, pastoral legislation has been scarcely implemented. Secondly, although some laws now recognize pastoralism as a legitimate form of productive land use (*mise en valeur, a prior condition for protection of land rights*), the pastoral application of the concept (*mise en valeur pastorale*) remains ill-defined, and generally involves investments in infrastructure (wells, fences, etc.) that are not required in the agricultural application. Finally, in most countries, other laws and institutions affect rangelands. (Cotula et al., 2006).\(^{139}\)

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**Box 3: Programme d’Appui à la Gestion de la Réserve Nationale de l’Air et du Ténéré**

PAGRNAT developed an approach to sustainable rangeland management based on customary practice that promoted livestock mobility and thereby the opportunistic tracking of resources in a highly unpredictable environment. Using the Tuareg concept of *echiwel*, the project identified up to twenty *terrain de parcours*, socially defined areas regularly used by a group of families and their livestock with priority rights of access over key resources (e.g., dry season water, grazing). The overlapping and fluid nature of these areas’ boundaries as well as the practice of negotiated access by the inhabitants of the different *terrain de parcours* enabled the local population to make optimal use of the available resources and match livestock numbers to available forage in most years. The project’s decision to base its operational approach on the notion of *terrain de parcours* ensured a high degree of appropriation by the local community as well as a strong basis for the design of a “model” for decentralised natural resource management and local development within the Aïr-Ténéré reserve.

*Source: PAGRNAT 2001; 2002.*

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\(^{137}\) Hesse and Thébaud, 2006

\(^{138}\) Under Niger’s Rural Code and its implementing regulations, the *terroir d’attache* is the area where herders spend most of the year (usually a strategic area, such as a *bas-fond* or the land around a water point), and over which they have priority use rights. Outsiders may gain access to these resources on the basis of negotiations with the right holders.

\(^{139}\) Cotula et al., 2006
### Table 7.1 Key features of pastoral laws in West Africa

<table>
<thead>
<tr>
<th>1. Recognition and protection of mobility: Pastoral Charter (Mali)</th>
<th>“Throughout the country, livestock may be moved for sedentary livestock keeping, transhumant livestock keeping or nomadic livestock keeping” (Art 14).</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Livestock mobility takes place on livestock corridors. These are local corridors and transhumant corridors (Art 15).</td>
<td>• “Livestock mobility takes place on livestock corridors. These are local corridors and transhumant corridors” (Art 15).</td>
</tr>
<tr>
<td>• Local government is responsible for managing livestock corridors with the help of pastoral organisations and in collaboration with all concerned stakeholders” (Art 16).</td>
<td>• “Local government is responsible for managing livestock corridors with the help of pastoral organisations and in collaboration with all concerned stakeholders” (Art 16).</td>
</tr>
<tr>
<td>• Any form of occupation, blockage or use of a livestock corridor or any infringement whatsoever is strictly forbidden” (Art 17).</td>
<td>• “Any form of occupation, blockage or use of a livestock corridor or any infringement whatsoever is strictly forbidden” (Art 17).</td>
</tr>
<tr>
<td>Pastoral Law (Mauritania)</td>
<td>“Pastoral mobility is protected under all circumstances and can only be limited temporarily and for reasons of the safety of animals and crops, and this in accordance with the provisions of the law” (Art 10).</td>
</tr>
<tr>
<td>2. Recognition of priority use rights over resources Rural Code (Niger)</td>
<td>“Priority use rights over natural resources situated in those zones defined as “home areas” (Art 28).</td>
</tr>
<tr>
<td>3. Recognition of “productive” pastoral land use Pastoral Charter (Mali)</td>
<td>Productive pastoral land use is defined as “the regular and long-standing use of an area for pastoral activities on public land involving customary or modern improvements and/or activities seeking to protect or restore the environment” (Art 49).</td>
</tr>
</tbody>
</table>

Projects such as Programme d’Appui à la Gestion de la Réserve Nationale de l’Aïr et du Ténéré (PAGRATN, Box 3) Projet Appui à la Gestion Conjointe des Ressources Sylvopastorales (PAGCRSP) and Appui à la Sécurisation Foncière (ASEF II) in Niger have experimented with some success in promoting livestock mobility either within pastoral areas (PAGRATN) or between the pastoral zone and more southerly areas (PAGCRSP, ASEF II), while securing pastoral access to and control over strategic resources, particularly in the dry season (water, grazing lands) both in the pastoral and agricultural zones on Niger. All projects have also sought to institutionalise decentralised management within the context of Niger’s local government reform programme.

### 3. Local conventions for NRM in the Sahel

The experience with “local conventions” for natural resource management, developed in the Sahel over the past few years, provides a promising example for managing conflict among multiple resource uses. Local conventions are community-based agreements concerning the management of shared natural resources, negotiated by natural resource users, often but not necessarily with support from development projects, and sometimes formalised through local government byelaws. In the Takiéta forest (Niger), for instance, local users with support from an NGO established a set of rules and institutions that enable sustainable resource use on the one hand, and peaceful coexistence between competing resource users on the other (Box 4).

**Box 4: Local Convention at Takiéta, Niger**

“Local conventions” for natural resource management provide promise for managing conflict among multiple resource uses. They can be valuable in regulating pastoral mobility and access to water points, dry season pastures and post-harvest field residues. They are community-based agreements negotiated by users, often but not necessarily with support from development projects, and sometimes formalised through local government byelaws. In the Takiéta forest (Niger), local users with support from an NGO and government established a set of rules and institutions that enable sustainable resource use, and peaceful coexistence among competing resource users. Takiéta is still being managed by local people today and the experience has led to four other forests being put under management, positively affecting the lives of an estimated 80,000 people.

*Sources: Vogt and Vogt, 2000; Vogt and Amadou, 2007*
In agro-pastoral contexts, local conventions may be particularly valuable in reconciling the competing resource interests of herders, farmers and agro-pastoralists, for instance in regulating issues like pastoral mobility and access to water points, dry-season pastures and post-harvest fields.

**Institutions for asset protection**

In a variable climate, institutions are needed to protect, or to limit the loss of, critical productive assets such as livestock, ploughs or land during bad years, while enabling communities to rebuild their capital and productive livelihoods once the crises have passed. Such institutions minimise chronic destitution and the costs of lost production. Providing institutional incentives to manage expected but unpredictable cycles of “boom and bust” requires considerable innovation and capacity. This principle is illustrated below by two examples: first, insurance for herders, and second, for farmers.

**Insurance for herders**

WoDaaBe herders in Niger, as well as using mobility to insure themselves against rainfall and pasture variability, also seek to maximise their herds and returns from them in good years. The size of herd thus represents the risk profile of a pastoral family. Families with larger herds spread risk by splitting them into smaller management units, and can make loans to kin or friends, thereby building social capital. In a larger herd there is likely to be greater diversity in age and sex distribution, which determines how quickly the herd will recover after losing animals in a drought (Box 5). Such institutions – embedded in the community and its knowledge of natural resources – perform an essential function in drylands and should never be put under threat by development innovations.

The introduction of financial insurance schemes provides an opportunity to involve the private sector in dryland development. In several schemes that now operating, a Weather Index is used to trigger payouts, or a related index such as animal mortality. In Mongolia, two insurance products can now protect herders. The base insurance product is a commercial policy sold and serviced by insurance companies. The product pays out when the mortality rates in their region exceed a specified trigger. The maximum payment is at an agreed level. If losses in the region exceed this level, the government’s Disaster Response Product (DRP) compensates all herders (including those who don’t buy the private insurance). Micro-credit can be used to flatten out seasonal fluctuations in the prices of food and livestock, and especially for reducing the impact of drought on women who (in several Sahelian countries) bear much of the responsibility for feeding children.

**Insurance for farmers**

Farmers also maintain webs of social claims and obligations at the community level. The difference with herders is that the social fabric is proving weaker in the face of new...

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opportunities to pursue wealth through markets by individualist strategies. Moreover, dependence on annual crops rather than livestock increases vulnerability to food insecurity in the short term for claimants and benefactors alike. During the Sahel drought of the early 1970s, farmers in severely affected areas in northern Nigeria bewailed the inability or unwillingness of local patrons to offer assistance to their poor clients; instead they appealed to the government. Wisely unwilling to wait, however, they set about an elaborate framework of strategies for finding alternative incomes.\textsuperscript{141}

While the utility of seasonal weather forecasting and early warning has provided a natural focus for experiments in insurance provision, crop failures may extend over large geographical areas and call for backstopping by government, regional or international organisations. The Ethiopian government, in partnership with the World Food Programme, has introduced a scheme whereby the government pays an annual premium to a private sector company which undertakes to pay compensation to farmers in the event of drought, as measured by a weather index.\textsuperscript{142} A scheme for groundnut farmers is being tried in Malawi (Box 6). Groundnut is a market crop, and food crop production will not benefit directly; however, as markets become more pervasive in drylands (see Chapter 6), the benefits of insuring market production will impact more widely on livelihoods.

**Box 6: Groundnut insurance in Malawi**

Opportunity International Bank of Malawi and Malawi Rural Finance Corporation give groundnut farmers loans for high-yielding certified seed, as long as they buy weather insurance (provided by the Insurance Association of Malawi). If there is a drought that triggers a payout, that money will be paid directly to the bank in order to pay off the farmer’s loan. If there is no drought the farmer will benefit from selling the higher value production. This arrangement has allowed farmers in the pilot area to access new finance. Reducing risk exposure can give producers confidence to invest in inputs and strategies for higher returns in other years.

*Source: Weather Index Insurance Malawi. www.microinsurancecentre.org*

**Diversification**

To treat livelihood diversification solely as a risk-spreading strategy would be to ignore the multiple benefits it offers to a diversity of individuals and families, as a way of escaping poverty, for women as well as for men. Diversity characterises not only the sources of alternative incomes and the market systems in which they are sought, but also the age, gender, skills, education, and motivation of participants, the places, seasons and times of participation, the entry costs or barriers, remuneration or profits, and sharing of benefits. Two generalisations may be suggested, however.

First is the commonly observed intensification of the search for alternative incomes when drought destroys incomes from crops or livestock. Examples from West Africa include investment by farmers in livestock (taking advantage of depressed prices) and increased agro-pastoralism; accelerated off-farm employment and short- or long-term migration; and investments in small-scale irrigation. Second is a tendency for governments to ignore this ‘informal’ but market-based sector in policy making, or to obstruct it through controls on movement by rural people to cities.

Dryland communities are highly differentiated – some are heavily dependent on natural resources, other less so, but maintaining a diverse portfolio of income generating activities; while some require alternative options, which do not end in destitution. Environmental variability coupled with rising population levels and increasing competition for access to natural resources, adds urgency to the need for institutions that can promote viable alternative incomes and investment options. As argued in Chapter 6, new market

\textsuperscript{141} Watts, 1983; Mortimore, 1989

\textsuperscript{142} Christopher Barrett et al. (2007) *Financing Poverty Traps and Climate Risk.*
opportunities both for natural resource products and for other activities offer alternative development pathways for dryland communities. Targeted interventions, such as micro-credit provision for women’s income-generating activities (e.g., CARE-Niger), are practicable and appropriate.

**Conclusion**

There is scope for adaptive institutional development in drylands to reduce the risks of a variable environment. New partnerships between communities, governments and NGOs making the best use of both local and external knowledge are already being tried in a number of countries. Experience gained from pilot and innovative schemes must be shared, tested and modified to suit other situations. However all work on institutions necessarily takes place under an umbrella of policy (and not only natural resources policy). Policy is formed and contested at national level, with varying degrees of involvement and support from donors and international organizations. It is to these priorities that we turn in Chapter 8.
8: What opportunities for drylands?

The foregoing chapters have first set the stage in terms of what is known of climate change and degradation in the world’s drylands (Chapters 2 and 3), and then proposed a case for better valuation of dryland resources (Chapter 4), a new positive approach to dryland investment (Chapter 5), a more effective use of markets (Chapter 6), and a serious assault on the problem of managing risk especially by the poor (Chapter 7). Many commonly held assumptions about drylands, identified in Chapter 1, have been challenged. A new landscape for a dryland paradigm has been sketched. It follows from the nature of the opportunities identified that development should be built on the resources and capacities of dryland peoples and that interventions should be sensitive to the positive changes already taking place. Evolution rather than revolution is the key to the transformations sought. At the same time, the best science and inward investment are needed which will engage external actors in achieving a vision for drylands that is now a global (not a local) responsibility. And national policies will need to recognise this.

Given the warnings and the uncertainties on climate change and degradation scenarios, what opportunities are there for dryland peoples and ecosystems?

Opportunities for dryland peoples and ecosystems

It is an imperative for the global community to have a strategy to enhance the well-being of dryland communities, help them to sustain their ecosystem services, and strengthen their adaptive capacity to environmental (including climate) change. Five building blocks for sustainable development are now proposed as foundations of an integrated strategy for dryland peoples and their ecosystems.

1. Upgrading the knowledge base.

The simplistic assumptions used to support some dryland development interventions and conservation efforts in the past need to give way to more accurate, complex and risk-aware models and strategies. Ongoing research on both climate change and degradation, and the adaptations and responses observed and needed in future, needs to be incorporated into the policy processes and carry greater weight against narrow institutional and other stakeholder interests. ‘Knowledge partnerships’ are needed in developmental contexts such as GEF environmental interventions. Although this looks like a cliché, drylands suffer from an exceptionally wide gulf between knowledge and policy or practice, as shown in the numbers of interventions that have not succeeded. Action is urgently needed at both international and national levels.

2. Valuing dryland ecosystem services.

There is evidence that dryland contributions to national economies and local livelihoods are often under-estimated to the neglect of drylands in economic planning and service provision.

- The supporting services provided to agriculture, livestock and forestry production by the ecosystem (soil fertility and soil moisture in particular) are normally ignored while input costs are always factored in to agricultural economic analysis. This means that nature’s contribution to these basic activities is under-estimated.
- Wetlands in drylands provide supporting services for irrigated agricultural production, livestock management, fishing and wild resource harvesting.
- Food sufficiency – or a lack of it - is an outcome of these productive activities (Chapter 4). The costs of failing to achieve national food sufficiency in bad years must be paid in imported food. The value of ecosystem services provided to food production is not, however, included in national accounts, though it could be inferred from the savings on imports in good years.
- Trees are grown both on farms and in natural woodland. In both modes, fuelwood, charcoal and timber may be harvested. These provisioning services are
fundamentally important in poor dryland countries, where fuelwood and charcoal may provide up to 80% of energy needs.

- Non-timber forest products (NTFPs) include a huge range of useful products that are harvested from trees and shrubs both in natural woodland and on farms. In addition to their value at home, wild products are finding new and sometimes little known markets. Recent studies in Africa have begun to provide estimates of the value of these provisioning services.

- Solar energy in drylands is second only to that in the hyper-arid (desert) biome.

- Tourism in drylands is based on the cultural services provided by the ecosystem. In countries with a large tourism sector, most tourist revenues are earned in the drylands (e.g., Kenya).

- The regulating services of dryland ecosystems include water filtration and subsurface storage, all the more valuable in a seasonal regime with no rainfall for half or more months in a year.

- Dryland ecosystems are adaptable and resilient in variable and uncertain environments. This has direct value for local communities, for example in providing repertoires of famine foods when droughts destroy food crops. The biodiversity of dryland ecosystems is greater than commonly supposed, threatened by hunting (of animals) and land use change (for plants), but valued by local communities.

The major cause of partial or under-valuation of these resources in policy and planning is a knowledge gap, which can be corrected through participatory approaches to development and more effective sharing of knowledge in partnerships between stakeholders. These values play critical roles in first, the rationales that underlie land use systems such as mobile livestock herding and extensive farming, second in local knowledge and innovation, and third in adaptive capacity to changing environments. These should be better understood as resources on which to build, rather than impediments to remove, in the furtherance of sustainable development.

3. Promoting public and private investment in drylands.

At a global scale, if not in every dryland country, there is incongruence between a relative under-investment by the public sector on the one hand and, on the other, a willingness on the part of poor resource users to invest their own small resources in sustainable management of privately owned land and other natural resources. Yet there is positive evidence of benefits from investment (Chapter 5), such as:

- Positive impacts on poverty of public investments in infrastructure and services in India and China.

- Satisfactory economic rates of return at the project level (several projects in African drylands).

- Successful and growing marketing of wild resources, locally, nationally and overseas (e.g., South Africa).

- Poor people's investments of their labour and skills (where finance is scarce), to maximise the productivity of farms, herds or farm trees. Large-scale, commercial, private sector investments are problematic in the uncertain environments of drylands; but small-scale producers can reap benefits from intermittent, incremental micro-investments (Box 4.1).

The question of investment needs to be scrutinised from a poor resource-user’s perspective, and a livelihoods standpoint, and not solely through a standard economist’s eyes. It is critical to the success of wealth-building strategies, which have been under-estimated because most forms of micro-investment (other than those financed by development programmes) have been officially ignored. This is where policy incentives and facilitation through markets and institutions can make a lasting contribution, supported by improved physical and social infrastructure.
4. Developing equitable markets.
Markets are undergoing a long-term transformation in many drylands. In place of an under-developed and dualistic market sector, based on export production of specialist commodities on the one hand and local exchange by subsistence producers on the other, rapidly expanding internal or regional markets are now focusing on provisioning growing and urbanizing populations who depend on markets (Chapter 6).

- Subsistence activities have not ceased, but subsistence and market objectives can be subtly interwoven—for example, in the management of livestock holdings, and indeed, of farms.
- New global markets for niche products are being sought and found, bringing significant benefits to a few dryland countries, and with potentials for further growth.
- Markets for labour, natural resources, finance, inputs, knowledge and services are evolving in response to the monetization of economies and (perhaps) a global climate of trade liberalisation.

There are many opportunities to improve the efficiency and equity of markets and commodity value chains, for example, through regulation, infrastructure, information provision, and institutions.

5. Facilitating institutional changes to manage risk.
A principal hazard for livelihoods that depend on ecosystem services, in the uncertain environment of the drylands, is risk (Chapter 7). Indigenous institutions—for example, among pastoral communities—are often designed to manage risk at the family or community level. By sharing mechanisms, short-term losses can be compensated and assets protected. Owing to the growth and penetration of markets, the state’s assumption of powers over natural resources, contesting demands for ecosystem services, and variable development policies, new sources of risk have been added to those of climatic origin, and institutional development needs help in order to cope. Ways of helping reduce such vulnerability to risk may include:

- Securing land rights,
- decentralising natural resource governance,
- supporting pastoral mobility,
- facilitating local management conventions,
- insuring assets against loss, and
- supporting diversification.

Institutional routes to sustainable ecosystem management are a focus of interest among NGOs, which are often in better positions to win the trust of local people than government officials, and (as neutral outsiders) can facilitate equitable stakeholder dialogues.
**Technological change**

Traditionally at the heart of proposals for dryland development, technological change assumes a different priority from the present perspective. Many technology-driven interventions in drylands have failed to reverse environmental degradation. International donors and governments are presently renewing their commitments to agricultural research.\(^{143}\) Agricultural production is still central to achieving food security policy objectives in most dryland countries, as import dependency is risky in unstable global markets. Much has been written about the failure of Africa to emulate the green revolution of South Asia. However, in South Asia, the green revolution package of new varieties and inputs did not have the same impact on the rain-fed drylands as it had in irrigated areas. For Africa, a green revolution must adapt to very diverse conditions and a blueprint approach is inappropriate. It can be safely assumed that in other drylands account must also be taken of locally specific conditions.

The focus of this Challenge Paper is on the management of dryland ecosystems, which in turn provide supporting services for crops and livestock. New technologies, and especially crop production technologies, have implications for sustainable ecosystems. In particular, moving from low-input, low-output systems of crop production to high yielding systems must be supported by soil nutrient replenishment and appropriate attention to its biological and physical properties. A fundamental barrier in drylands is the high cost of fertilizers in relation to the value of output and the resources of small-scale farmers. It is therefore essential for research to be conducted on-farm and within the production system in order to address its systemic implications. For example:

- New crops and varieties (e.g., of millet) for rain-fed dryland systems, developing acceptable varieties that are early-maturing or can withstand drought during the growth cycle. Significant successes are reported, most in South Asia.
- Micro-dosing (the application of ‘three finger’ doses of fertilizer to individual crop stands) has been successful in raising yields in controlled trials in West Africa, but it has not yet been proved over extensive areas or populations.
- Water-harvesting techniques developed in dryland countries (e.g., Tanzania) have been found successful in the right conditions of topography and surface run-off, and offer scope for wider replication, as yet in progress.
- Soil and water conservation with terraces and drains has seen dramatic success in some hilly areas in drylands (below). As this method had ancient predecessors (e.g., in Africa and India), its promotion has been easier than that of newer, less well understood, technologies.
- No-tillage systems are advocated for the better preservation of soil structure, moisture, and humus, but their testing in African or Indian drylands is not yet advanced.

A variety of approaches to improving the productivity of dryland crop production systems is thus in evidence. The achievement of productivity improvements within a framework of sustainable ecosystem management will take forms which are specific to local circumstances, given the diversity of dryland conditions and land use histories. The promotion of inorganic fertilizers through subsidies on a massive scale (as proposed in West Africa) may have unforeseen consequences for both ecological and economic sustainability.

Technological innovations may have to wait for economic conditions to change before significant uptake occurs. While it is true that sustainably managed ecosystems are a condition of well-being for dependent populations, it is equally true that poverty reduction is a condition of sustainable conservation and ecosystem management. The technologies required may already be known (though not always by the community that needs them). Thus an interactive model is needed to integrate conditions with outcomes in a ‘virtuous

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\(^{143}\) World Bank, 2008
circle’, as suggested in the ‘Machakos hypothesis’ (Box 1). A similar development is suggested to explain the adoption of protected tree regeneration in the Sahel (Chapter 4, Box 1). In most such ‘success stories’ community access to new (or newly relevant) knowledge – whether based on research or on local experimentation – also plays a key role.

The complexity and unpredictability that characterise dryland ecosystems provide ample justification for addressing the context and the conditions of technological change. The four building blocks suggested above provide a framework.

**Action is necessary**

Poverty reduction targets and sustainable ecosystem management cannot be achieved at the global level if the drylands are ignored, because of their large populations and great extent. Additional urgency arises because a new interlocking of climatic and geo-political factors means that drylands cannot be treated any longer as poor, remote, largely self-subsistent areas and left to their own devices. The new factors include the following:

- Land surface conditions (temperature, moisture) in vast dryland regions are a major driver of global climate systems, which affect rich ‘Northern’ countries as well as poor ‘Southern’ ones. The possible extension of processes of land degradation (or ‘desertification’) is no longer a local problem, but may be a threat to adjoining regions and countries.
- The costs of adaptation to climate change now are far exceeded by the costs of repairing the damage later, and as the drylands are already affected by climatic variability (both floods and droughts), a sound adaptation strategy is essential. Because adaptation is now a global priority, drylands are an international funding responsibility.
- The greater part of the costs of climate change are expected to be borne by poor people in poor countries. Development is the antidote to vulnerability. Within the framework of the MDGs, poor people’s rights to development are an international obligation, but many of the costs of providing these entitlements will eventually fall on rich countries. It is better to begin now.
- Drylands make a contribution to mitigating global warming. Dry forests, and to a lesser extent, grasslands, sequester significant amounts of atmospheric Carbon (when account is taken of their vast extent). Small-scale farming, such as may be observed in some dryland countries where irrigation or intensification has taken place, also sequesters Carbon. Participation in international Carbon markets through payments for environmental services has unforeseeable implications for drylands.
- Unfair global markets (exclusion, subsidies and dumping) may undermine the profitability of dryland production systems, depriving them of investment incentives (either public or private).
- Economic inequality between ‘Northern’ and ‘Southern’ countries (among which drylands tend to be poorest) is threatening to destabilise international relations, not least in growing flows of migrants trying to gain access to the wealth of rich nations.
- Internal conflict of a new, bitter and very long-term kind, and focused on the control of natural resources, is tearing some dryland countries apart, and has implications for international order.
- Global food security is more delicately poised than it has been since World War II, with rising food commodity, fuel and input prices. A few dryland countries are claimed to be chronically dependent on food aid. The cost of such aid is increasing daily for the donor countries, and far exceeds the cost of measures to improve local production.

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144 Stern Review, 2007
An integrative approach is essential
An important insight to ecosystem management in drylands is that the provision of ecosystem services ties people and nature together in relations that have both antiquity and continuity, and cannot sensibly be unravelled. A systems approach is essential. At a theoretical level, the human and ecological systems may be said to be ‘co-evolving’, and where this relationship breaks down, degradation occurs in the ecosystem, or impoverishment in the human system. Such an approach suggests a pivotal role for institutions of natural resource management.

At the practice level, an ecosystems approach has been formulated on the basis of principles identified by the Convention on Biodiversity. Such an approach, in the light of the argument presented in this Challenge Paper, demands fully participatory methods based on equality between stakeholders (including researchers) and between local and science-based knowledge. Within the science and professional communities, long-held simplifications (or distortions) of human-environmental relations between societies and ecosystems (such as neo-Malthusian dogma) are overdue for replacement. A litmus test for any scientific interpretation of dryland management is whether it makes sense on the ground through the perceptions of local people. Their ownership of action-research in their own context is anyway critical to the success of an intervention aimed at achieving positive change.

Drylands on a threatened planet
The values of low external input production systems in drylands are potentially transformed by the crisis in global sustainability and climate change. Having for long been an ‘investment desert’ the drylands should now profit from having among the lowest carbon footprints in the inhabited world. We can no longer afford to treat local knowledge and practice as ‘conservative’, ‘backward’, outside the market, and necessarily destructive. Not only can rural drylands boast low Carbon emissions, but the world wants their help in mitigating global warming. Very extensive woodlands and grasslands are being targeted by advocates of direct payments to dryland producers for guaranteeing desired land uses. Agricultural intensification (based on labour, skills, and organic cycling), and the protection and planting of trees on cultivated land (as observed in the African Sahel), can not only reverse degradation but also capture Carbon. There are huge social and ecological implications. The drylands stand poised for a new role in the global ecosystem. Their marginal status may soon be ripe for overturning.

145 MEA, Chapter 22
146 Reynolds et al, 2007
147 Shepherd
148 Mortimore, 1998
149 Adams and Jeanrenaud 2008
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