Coping with water scarcity

Implications of biomass strategy for communities and policies

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This article summarizes present knowledge of the vulnerability to water scarcity of semi-arid Third World countries. Their predicament is explained in terms of four parallel modes of water scarcity, superimposed on one another, two of natural origin and two human-induced. The authors conclude that long-term planning within the environmental constraints imposed by water scarcity is crucial, and calls for a new awareness among high-level experts and policy makers. Careful land and water use planning based on the water-balance method is a key component, but depends on expanding traditional water resources assessment methods developed in the temperate zone to incorporate root zone water storage, differences in groundwater recharge, and landscape zonation in water-producing v *water-consuming or evaporating areas.*

A growing uneasiness is noticeable within the international community about Africa's development problems (Meerman and Cochrane, 1984). Its population continues to grow rapidly and is predicted to quadruple before levelling off in the next century. Land fertility continues to decline, yields of the dominant crops remain low, and no high-yield packages are yet in view to accelerate yields for the main dryland crops, sorghum and millet. Governments are overburdened with tremendous financial debts and tend to turn their backs on poverty-prone rural areas. There is, in other words, a general inability to deal with the situation.

The possibility of improvement is probably strongly affected by the fact that different professions tend to have very different perceptions of the core of the problem. One dimension which has seldom been discussed in the past is the role of climate (Kamarck, 1976). Top-level experts and policy makers have generally been trained in the temperate zone and are not used to thinking of water as a constraint upon societal activities. Not even the World Commission on Environment and Development touched upon the problems emerging when a population grows while water remains scarce (WCED, 1987).

Ecologists tend to blame the problems on 'droughts and desertification', rather than examing the management of drylands where intermittent droughts are a basic feature. Hydrologists are interested in clarifying the role of water scarcity in creating basic vulnerability. A starting point is the distinction between four different modes of scarcity (Falkenmark, Lundqvist and Widstrand, 1989), explaining the predicament of semi-arid Africa with the explanatory model presented schematically in Table 1. In addition to the three modes of water scarcity shown in the table, there is a fourth type, manifested as water stress or chronic water scarcity and developing in areas where the population is high in relation to the number of flow units of water (water scarcity D). An interesting observation is that a correlation seems to exist in Ethiopia between famine-prone regional units (*awrajas*), earlier identified by Mesfin (1984), and areas with water scarcity of type D or type C. This confirms that difficulty of access to water by plants and by humans are both fundamental determinants of famine-proneness.

The general inability to deal with the situation and the widespread ignorance of the role played by water scarcity in generating basic vulnerability in a region

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suggest an ever-increasing risk of continued famine catastrophes. This alerted the Swedish Red Cross to convene an international seminar in February 1989 in Vadstena, Sweden, hosted by the Department for Water and Environmental Studies at Linköping University. The aim of the seminar was to clarify the particular vulnerability related to water scarcity in semi-arid developing countries. Special attention was paid to Africa and South Asia. This article summarizes our present understanding of the problems, integrating the social development potential at the village level with the opportunities provided by the physical environment, and incorporates the main contributions to and the basic outcome of the Vadstena seminar.

Root causes of food insecurity

Famine and reduction in yields

From time to time dreadful famines haunt the peoples of Third World countries. A few decades ago famines were mainly of concern to people in Asian countries, but now it is primarily the African continent which is affected (Kates *et al*, 1988). Apart from extreme food shortages associated with famine for a certain period, it is essential to pay attention to the steady decrease in per capita food production in Africa. Whereas per capita food production in Asia and Latin America has shown a steady upward trend since the beginning of the 1960s, in Africa south of the Sahara it has been declining (Harrison, 1987). Contrary to widespread belief, it is not only food production for subsistence which has shown a falling trend in Africa; per capita production of most cash crops has also shown a steep reduction (Harrison, 1987). Even costly irrigation schemes have shown poor performance (Moris, 1987).

Information about famines is, however, invariably scanty. Sensational treatment in the media has led to neglect of the root causes and processes leading to this extreme form of hunger.

Environmental degradation and reduced rainfall efficiency

The phenomenon of desertification, repeatedly referred to in discussions of the decreasing fertility of the semi-arid tropics, has tended to be widely misinterpreted due to an undefined use of the concept: it has covered everything from the spreading of sand dunes along desert borders to eroded slopes, crust-covered land, poorly managed irrigated land and salinization of drylands due to altered land cover (changing from woodland to pasture). 'Paradoxically, the term desertification itself has, in a way, become desertified' (Nelson, 1988). The term desertification should preferably be limited to dryland degradation. There has been a confusion between cause and symptom. Reduced land productivity is a *symptom*, manifested through processes at work during drought years. The *cause* is overexploitation of the ecosystem generated by human behaviour including increased population pressure on vulnerable drylands. The inevitable *result* is ecological collapse, famine and outmigration.

For farmers facing water scarcity problems the decreases in yield and general difficulty of obtaining safe yields are often interpreted as effects of decreasing precipitation. However, Olsen (1987), in a study of Rayalaseema in India, showed that the climate change so often referred to when explaining the advancing water shortage is a myth. The real reason for water scarcity in that area was rapidly increasing groundwater usage, drying out local wells.

In a recent study of West Africa Gornitz (1987) shows that precipitation there has not shown any apparent secular decrease linked to vegetation clearing, as earlier suggested. The change in albedo was assessed to be only 0.5% over the past 100 years. He concluded that devegetation may have led to *reductions in soil moisture*, placing plants under stress and producing similar effects to climatic desiccation. In other words he identified the problem as *a human-induced water scarcity* (type C in our classification). Jackson (1988) also refers to the explanation that the rains have become less efficacious as a result of intensified land use with a reduction in soil organic matter; ie the fraction of precipitation which is retained as soil moisture is being reduced. In combination with heavy usage of available water, scarcity becomes acute.

In fact the semi-arid tropics where fertility degradation has developed into a major problem contain a great versatility of hydroclimatic conditions and must be analysed with this in mind.

The hypothesis that crop yields fall as a result of a

Table 1. Three main water scarcity modes.

Vulnerability	Complication	Triggering	Result
Aridity, producing a limited growing season	Degraded soils disturbing the recharge of the root zone	Intermittent droughts	Disturbed water supply of plants
Water scarcity A	*Water scarcity C*	*Water scarcity B*	

decline in the efficacity of rainfall is also supported by a study of the development of surface crusts in the semi-arid zone of West Africa – evidently a main determinant in reducing soil moisture. Valentin and Casenave (1988) describe a multitude of structural and depositional crusts developing both on semi-arid croplands after tillage and on range lands. The severely crusted and eroded surface had increased 20-fold during a 25-year period (1960–84) in which the cultivated land had doubled and the fallow had halved. They ascribe this transformation of the landscape to population increase in combination with a sequence of drought years which forced farmers to expand their fields to compensate for declining crop yields.

Decreasing nutrient status of the soil may also contribute to decreasing dryland productivity. Breman and Uithol (1984), in a study of primary production in the Sahelian zone of Mali, arrived at the conclusion that soil poverty is at least as big a problem as water shortage. They found that the Sahara is not advancing to the south; the cause of decreased productivity is overexploitation related to increased land use intensity and increasing grazing pressure. Unfortunately, the solution is not simply to introduce nitrogen-fixing species because of climatic problems. Reduced fertility in the area can be remedied only by external inputs, according to this study.

Debt burden

Deteriorating performance in terms of agricultural output per capita and outbreaks of famine are evidently end results of a number of interrelated factors. Aside from disruptions in the ecological system, official policy is a major factor in shaping the agricultural sector. National policies are in turn affected by international relations. The tremendous financial debt of Third World countries and structural adjustments decreed by the IMF are hitting poor countries very hard. The situation is particularly severe in Africa. 'Africa's debt-servicing ratios are by far the highest in the world. Debt-servicing flows are now reported to run at $16 bn per year... its average debt service ratio has more than doubled from 15% in 1980 to 33% in 1987. In some countries the debt service ratio even exceeds 100%' (Hydén, 1988, pp 3–4).

In its latest annual report Unicef bluntly blames policies advocated by the International Bank for Reconstruction and Development and the IMF and pressed upon Third World countries as a direct cause of human suffering, particularly among children. 'The situation has reached a point where both African governments and international donors must rise above their day-to-day concerns and think not only in terms of single policy interventions but also of restructuring the whole policy and governance arena' (Hydén, 1988, p 25).

Government aloofness from drought-prone regions

Often, prevailing policies have meant governments standing aloof from the development problems of the traditional agricultural sector. At the Vadstena seminar Michael Ståhl pointed out that it should not be taken for granted that national governments will give priority to semi-arid areas in their investment allocations. In a situation characterized by adverse macroeconomic trends, it is likely that the priority allocation of capital resources, infrastructure and staff will be to areas considered to have the potential for quick economic returns, ie well-watered highlands, river valleys, etc. The semi-arid areas are left to international charity.

Ståhl mentioned Ethiopia as an example. Although impressive tree planting and terracing campaigns are underway in the drought-prone degraded highlands, this is almost totally financed by food-for-work and other types of international aid. Government resources for agricultural development are channelled to a number of districts which have been identified as 'surplus producing'. These are found on highland plains with deep soils and adequate rainfall. The strategy is to maximize production of cereal crops utilizing conventional seed-fertilizer packages. Extension staff and other inputs by the Ministry of Agriculture are concentrated there. As a consequence of this policy the number of extension staff in the drought-prone Wollo region has been reduced by more than 50% over the last two years.

The inability to deal with the situation is particularly worrisome in the face of rapid population growth. The prospects for Africa are alarming. Its current population of 600 million (in 1987) is projected to reach 880 million by the end of the century, and 1.6 billion by AD 2025 (Wahren, 1989). Apart from mounting pressure on the resource base, the high fertility rates create a situation where the ratio of young people to adults imposes a heavy burden upon adult males and females. The burden on women is particularly noticeable, and Wahren found that there is a great unmet need on the part of women for child-spacing methods.

Environmental opportunities

The current trends in African development present a gloomy and difficult picture. But trends are not destiny. As pointed out in the so-called 'Kericho' document (African Academy of Sciences, 1987) the troubled times may extend to the year 2000, when a renewal could commence. By AD 2057 per capita income, life expectancy and other socioeconomic characteristics may have improved considerably: 'it would be as densely populated, as wealthy, healthy and educated as Greece was in the early 1980s' (p 5). What is said to be needed in the short run to achieve this massive transformation is a change in perception to bring about and welcome 'surprises'. Such 'surprises' apparently cannot be generated through imported goods and models. They must rather be build upon and amalgamated with the indigenous cultural and social fabric in combination with the opportunities provided by the environment. This document is inspiring in its optimistic outlook. It is, however, remarkable for failing to incorporate a natural resource perspective.

The Kericho document's optimism is rooted in a trust in sociocultural dynamics, rapid advances in biotechnology and benefits derived from climatic changes. For the realization of such a vision it is, however, fundamental to pay attention to what Mageed described at the seminar as the 'environmental fabric', its relation to water scarcity and the processes by which it is naturally regulated. Soil characteristics, vegetation sequences, animal species and human socioeconomic patterns are all related to variations and degrees of water scarcity. Mageed also stressed that the prolonged drought hitting sub-Saharan Africa in the 1970s created panic among populations as well as governments, and that the stage had been set for the collapse of the ecosystem by continued soil degradation from overgrazing, tree felling and inadequate land use practices. The dilemma of this poverty-prone region is magnified by the combination of acute economic and financial problems with complex factors such as water scarcity, an increasing food gap and general poverty.

Mageed emphasized how important it is that relief and emergency efforts generated by this panic and the collapse of the ecosystem be integrated into a long-term rehabilitation and restoration programme for the environmental system. Otherwise there is an evident risk that the supply of drought-resistant seeds, for example, will encourage the spread of crop production into more marginal lands, and that emergency water supply projects or food aid will generate dependent attitudes among local populations. He proposed that water scarcity be recognized as central to the crisis. Land and water use maps, based on the opportunities afforded by the environment, are needed and they should be reinforced by legal land and water use instruments, providing effective non-structural means to mitigate the water-scarcity-related vulnerability of the region.

Maximized biomass production

The most obvious way of improving the quality of life in drought-prone areas which are far away from rivers bringing exogenous water for irrigation is to make use to the largest possible degree of local rainfall (UD, 1988). The strategy should be the 'best possible use of local rain', involving biomass production for multiple purposes: crop production to provide self-reliance in food, and trees and forestry to provide fodder, fuelwood and timber for sale.

At the seminar Datye argued that considerable rethinking is actually taking place in India in this direction. In the past, sustainability of livelihood in hydrologically vulnerable drought-prone regions was thought to be mainly dependent on exogenous water entering from distant catchment areas, and this often led to favouring cash income generated through market-oriented crop production. The new focus on production based on local rainfall has raised the question of the sustainability of a system where tree crops are integrated with seasonal crops for food and cash.

In areas where water is the scarcer resource, maximum biomass production per unit of water is a more evident goal than maximum production per unit of land, capital or other factor of production. A fundamental challenge in such areas is the simple fact that biomass production is equivalent to the returning of a large amount of water to the atmosphere. Studies of natural ecosystems indicate these overall 'losses' to amount to 1000 m^3/ton of biomass (Falkenmark, 1986).

Water balance components

In hydrologically marginal regions where a major part of the rain input to the area is returned to the atmosphere in a complex evapotranspiration process, only very limited amounts remain for the recharge of terrestrial water systems in rivers and aquifers. This is equivalent to competition for water between the return flow to the atmosphere, on the one hand, and human water demands on the other.

Figure 1a illustrates a simple water flow analysis of a land unit in a rainfed upstream landscape where the only source of water is local rainfall. The tremendous difference between the huge amount of water returning to the atmosphere and the minor amount remaining to recharge local water systems, typical in the semi-arid tropics, is clearly illustrated.

The return flow to the atmosphere has two components (Falkenmark, 1986): a productive part tied to the plant production process, and an unproductive part tied to evaporation from moist surfaces in the landscape. In order to minimize the latter, vegetation has to be as dense as possible under the circumstances. In addition, however, the foliage has to be as small as possible to minimize interception losses of rain adhering to leaf surfaces during rainfall and rapidly evaporating again after the rain. Moreover, there is an interception loss from the litter layer

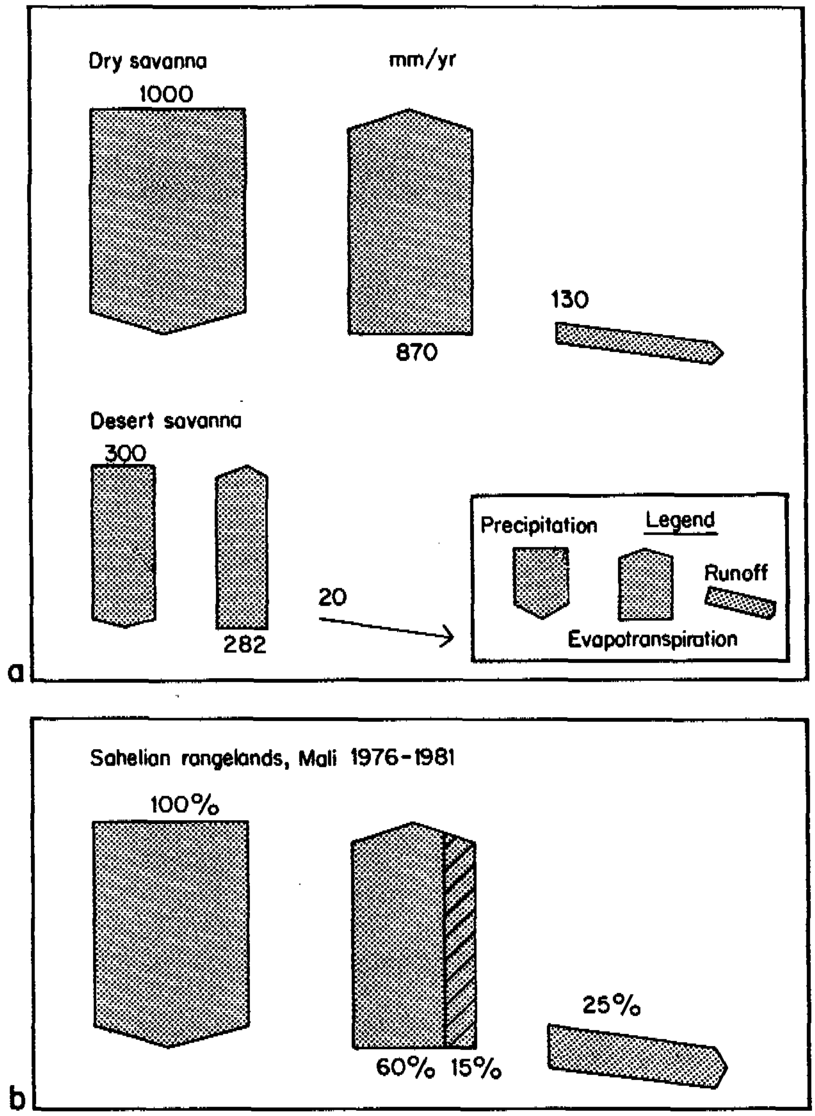

Figure 1. Water flow analysis of some typical semi-arid environments.

The upper figure (a) shows the relationship between return flow to the atmosphere and recharge of terrestrial water systems. Numbers indicate water flow in mm. *Source:* Lvovich (1979).
The lower figure (b) shows the relative proportions (%) between the productive part (striped) and non-productive part of the return flow. *Source:* Breman and Uithol (1984).

accumulating on the ground which has to be balanced against the need for mulching in order to avoid unnecessary erosion.

In order to achieve the best results, infiltration should be facilitated so that rainwater may rapidly enter the soil and recharge root zone water storage. Other measures to maximize productivity would include maximizing the amount of water that can be stored in the root zone. The water-holding capacity could be increased by adding organic material from crop residues to compensate for the rapid breakdown of such material characteristic of a tropical climate.

A typical water balance for the Sahelian rangelands (100–600 mm annual rainfall) is illustrated in Figure 1b, based on data from Breman and Uithol (1984). Under present conditions only 10–20% of the precipitation was productive in terms of plant production, whereas another 60% returned to the atmosphere as unproductive evaporation from the soil surface. Their study indicates that by improving access to nutrients the productive 'losses' could be increased to 50% of the rainfall, ie water used by vegetation could be more than doubled.

Practical solutions

Water scarcity modes

It was evident from the Vadstena seminar that there is ample information available on the various technical arrangements to mitigate different problems related to water scarcity, land degradation and risks of crop failure. Indian scientists have been particularly active in this area and energetic action is being taken in many of the Indian states to reduce vulnerability, based on an awareness of the constraints produced by limited water availability and related land management problems. Sivanappan gave a comprehensive overview of various techniques developed and increasingly brought into use in different restoration and land development projects in India in the last few decades. Table 2 presents an overview of the principal mitigation methods, related to the respective modes of water scarcity. Table 3 relates these different techniques to their basic scope as seen from a hydrological perspective and to the main water scarcity mode addressed, distinguishing between soil and water conservation techniques on the one hand and agronomic techniques on the other.

Various means for water harvesting have been identified as a way to mitigate poor conditions for plant production generated by low and erratic rainfall with particular reference to sub-Saharan Africa (Reij, Mulder and Begemann, 1988). Knowledge of indigenous systems in the region is scanty, however, and the acceptance of donor-supported techniques is low. Not surprisingly, the low or slow rates of adoption result from omitting to consider social factors and the way communities are organized. Techniques aimed at harvesting water in large watersheds make it difficult for individual farmers to identify their role and position, and the implications with regard to tenurial structure are not properly attended to.

Allocation of different water components

Because of the large interannual fluctuations in rainfall, the reliability of the rainfall and the fluctuations in water availability in terrestrial systems have to be taken into account. In ongoing experiments in Maharashtra in India aimed at developing realistic principles for achieving sustainable and stable income with the help of assured water and minimal use of external and cash inputs, Datye has developed a methodology based on compartmentalization of the local water into an assured and a variable component.

The assured component would have to be estimated from a baseline rainfall that could be available with a high degree of dependability, say 80%. Part of this water could be provided by water harvesting of rainwater over nearby non-cropped areas, storing it and making it accessible for protective irrigation of the land devoted to food security. Over and above the assured supply, a variable component would be available in many years with better-than-average rainfall. This water could be used for tree establishment and yield augmentation in tree plots or food plots, but also for commercial crops in good years. Obviously the

Table 2. Main measures for mitigating water scarcity.

Water scarcity mode	General scope	Measures		Principal measure
A	Get best out of short growing season	crop selection increased water use efficiency supply extra water (irrigation)	facilitate infiltration percol ponds agric techn farm ponds weed control	·water conservation ·tree crops
B	Preparedness for drought years	early warning crop storage from good years drought-resilient crops increased water use efficiency supply extra water overyear water storage	facilitate infiltration percol ponds agric techn farm ponds weed control	·use water efficiency even during good years ·avoid wastage
C	Renovation of degraded land, restoration of groundwater availability	improve infiltration land use policies groundwater policies improve water-holding capacity	soil conserv (bunding, terracing) afforestation agroforestry manure clay	·land development ·integrated soil and water conservation on watershed basis
D	Optimum allocation of available water	storage of wet season flow water use priorities administrative coordination sequential reuse – renovate urban sewage for irrigation		·crop selection ·drip/sprinkler (irrigated areas) ·supplementary irrigation (dryland areas)

Table 3. Dryland agriculture techniques.

Technique	Basic aim of technique Improve water-holding capacity	Facilitate infiltration	Improve ground-water recharge	Storage of surface runoff	Supply extra water = irrigation	Reduce erosion	Stop sediment flow	Reduce water loss	Effective water use	Nutrient supply	Addressed water scarcity mode
Soil and water conservation											
Soil conservation	X	X	X			X			X		ABC
Check dams			X	X			X		X		
Farm ponds				X	X				X		ABC
Percolation ponds			X						X		ABC
Irrigation tank				X	X						AB
Groundwater irrigation					X						AB
Sprinkler/drip irrigation					X			X	X		ABD
Agricultural techniques (broad beds and furrows)	X			X		X					ABD
Agronomic											
Rainfall analysis									X		AB
Dry seeding									X		AB
Crop selection									X		AB
Low-cost fertilizers									X	X	AB
Optimum plant population									X		AB
Weed control									X		AB
Cropping diversification									X	X	AB

assessment of assured water and requirements for basic needs has to be site-specific.

Datye suggested that the assured water be treated as a scarce resource, ie distributed equitably to attain a sustainable livelihood and food security for the local farming communities in vulnerable areas. The variable surplus, on the other hand, could be distributed as a free market good or a private priority right to be utilized for water-intensive commercial crops.

An agro-silvicultural strategy for livelihood security

Datye also reported on the approach and practical results of the ongoing experiments. The basic idea is to combine watershed management and development for the best possible use of local rainfall with sustainable biomass production providing stable agricultural yields and general livelihood security. Basically a family holding should be divided into two parts: a small part providing food security for the family, and the rest assigned to multiuse tree crop systems. The role of trees is thus multiple: to provide economic gains and security, and to contribute to the improvement of productivity in the area (see also Chambers and Leach, 1989). The silvicultural part should also provide biomass material to be used as organic input on the agricultural land to improve the water-holding capacity of the soil.

The immediate results have not necessarily been very dramatic. After the first two years of the five-year experiment period the results indicate that from a rainfall of 500 mm, of which 300 mm could be utilized for productive purposes, an overall production of 20 tons/ha of dry matter could be achieved in the forestry part and 3 tons/ha in the crop production part. Root zone water security was achieved by two or three protective waterings to fill interspell water shortages, in all 150 mm. Organic input was achieved from one cartload of dung per 100 m^2 of cropped area. Datye concluded that, with 5 tons/ha as a realistic yield goal for the coming years, 0.3 ha would be enough to provide one family with the 1.2–1.5 tons of grains needed annually for their food security.

Securing long-term productivity

In order to conserve the long-term fertility of the soil, nutrients have to be continuously added to compensate for the nutrient removed with the harvested biomass. But organic matter also has to be added intermittently to secure an adequate water-holding capacity over the years. At the seminar Lional Weerakoon reported on current experiments in the dry zone of Sri Lanka which address sustainable agriculture by developing a strategy aiming at *concurrent production and conservation.* A key component is the avoidance of unnecessary depletion of fertile soils by erosion. Therefore, no-tillage systems should be preferred, and the tillage benefits lost should be compensated for by crop residue mulches. The system has a number of components aimed at meeting a set of major criteria, notably soil fertility maintenance, biomass production, control of weeds and other pests, meeting firewood and fodder needs, avoiding high cost inputs, achieving farmer acceptance and compatibility with farming systems in the area (Weerakoon and Schall, 1987).

Implementation in the landscape

In Weerakoon's experiments landscape zonation plays an important role. The sustainable land use must be suited to different categories of land in what he calls a 'catenary sequence'. Components are a multi-storey home garden with nitrogen-fixing trees, erosion control barriers of hedgerows along the contour lines in the landscape, contour bunds on slopes, grass planted in buffer strips to minimize erosion and provide fodder for cattle, intercropping legumes with cereal crops instead of monocropping, in the lowlands line or double hedgerow planting or rice bunds for fertility maintenance, and plant mixtures for green manure purposes with fast biomass production (Weerakoon and Schall, 1987).

Constructed soil conservation measures such as conventional earth bunding systems are obviously expensive for the small farmer, but there are cheap do-it-yourself alternatives. Grimshaw (1987) describes in a World Bank pamphlet the use of vegetable systems for soil and moisture conservation. Suitable plants such as Vetiver grass are planted to form hedges along the contour lines. The result is both a yield increase and increased groundwater recharge as an effect of holding up the surface runoff.

In India, Sivanappan has already urged similar landscape arrangements in a number of papers (Sivanappan and Panchanatan, 1985; Sivanappan, 1989). Figure 2 provides a sketch of how to coordinate uphill, slope and downhill land use and the technological measures needed to support such land use (cf Table 3). The basic idea is to restore the forests in the upper catchments for resource purposes, for protection against soil erosion and to facilitate infiltration of rainwater, and therefore also to recharge groundwater aquifers, transporting surplus water to lower inhabited areas. The basic measures in uphill areas and hillslopes are contour trenching and contour walls or bunds to prevent erosion and to obstruct runoff; check dams to stop the silt in the streams; and afforestation to restore the forests. In the foothills *in situ* moisture conservation may be implemented by contour cultivation, furrows, broad-based ridges and furrows, and tie ridges, and local runoff can be stored in farm ponds to supply water for protective irrigation during critical vegetation periods. In the lowlands runoff arriving from upper parts of the catchments may be stored in tanks and desilted to improve their storage capacity. Water-saving irrigation techniques such as drip irrigation would increase productivity per unit of water.

Implementing concurrent production and conservation

Building on local knowledge and abilities

Not only are the poor people in rural communities the victims of rural stagnation and environmental disruption, but they also form the backbone of their countries' economies. A paternalistic attitude towards the rural poor is, however, noticeable. In the 'conventional wisdom' approach to the development of Third World countries, their needs and lacks have been highlighted rather than their potential. At the Vadstena seminar Peter Warshall described the situation with the help of a metaphor. There are two different ways to describe a cup which is half filled: we can look at it as half empty or as half full. The rural poor are conventionally looked upon from a 'half empty' perspective. The metaphor can be further tapped for symbolic significance. It is the bottom of the cup, not the top, which first and last has a content, and it is through the top that the craving for the contents at the bottom of the cup is expressed.

At the seminar there was unanimous support for the idea that a better future must to a much larger degree than is currently the case build upon the resources and abilities of local communities. The knowledge of the environment that can be found in local communities must be recognized, mobilized, supported, upgraded and put to use. Datye emphasized that identification and implementation of the biomass strategy discussed above was largely done *with* and *through* people in the communities concerned.

In a number of articles and books Robert Chambers has elaborated on the need for and benefits desirable from accomodating the experience and abilities of the millions of resource-poor farmers in efforts to improve livelihood security in rural areas in Third World countries (Chambers and Ghidyal, 1985; Chambers and Jiggens, 1986). The challenge is basically to identify practices which fit the total environment, social and ecological, rather than trying to make farmers adopt 'miracles'. 'Scientists project "first" values – industrial, capital intensive, dependent on cash inputs – into "last" environments – impoverished, labour intensive, dependent on local inputs – where they often make no sense or are otherwise unadoptable' by resource-poor farmers (Chambers and Jiggens, 1986, p 20).

This has nothing to do with a romantic image of the role that people in rural communities can play. 'A sentimental belief in "trad values" and a gut feeling that the "people know best" without knowing why and under what circumstances, will be unhelpful and damaging to the prospects of rural development in the long run' (Richards, 1980, quoted in Niamir, 1989, p 2).

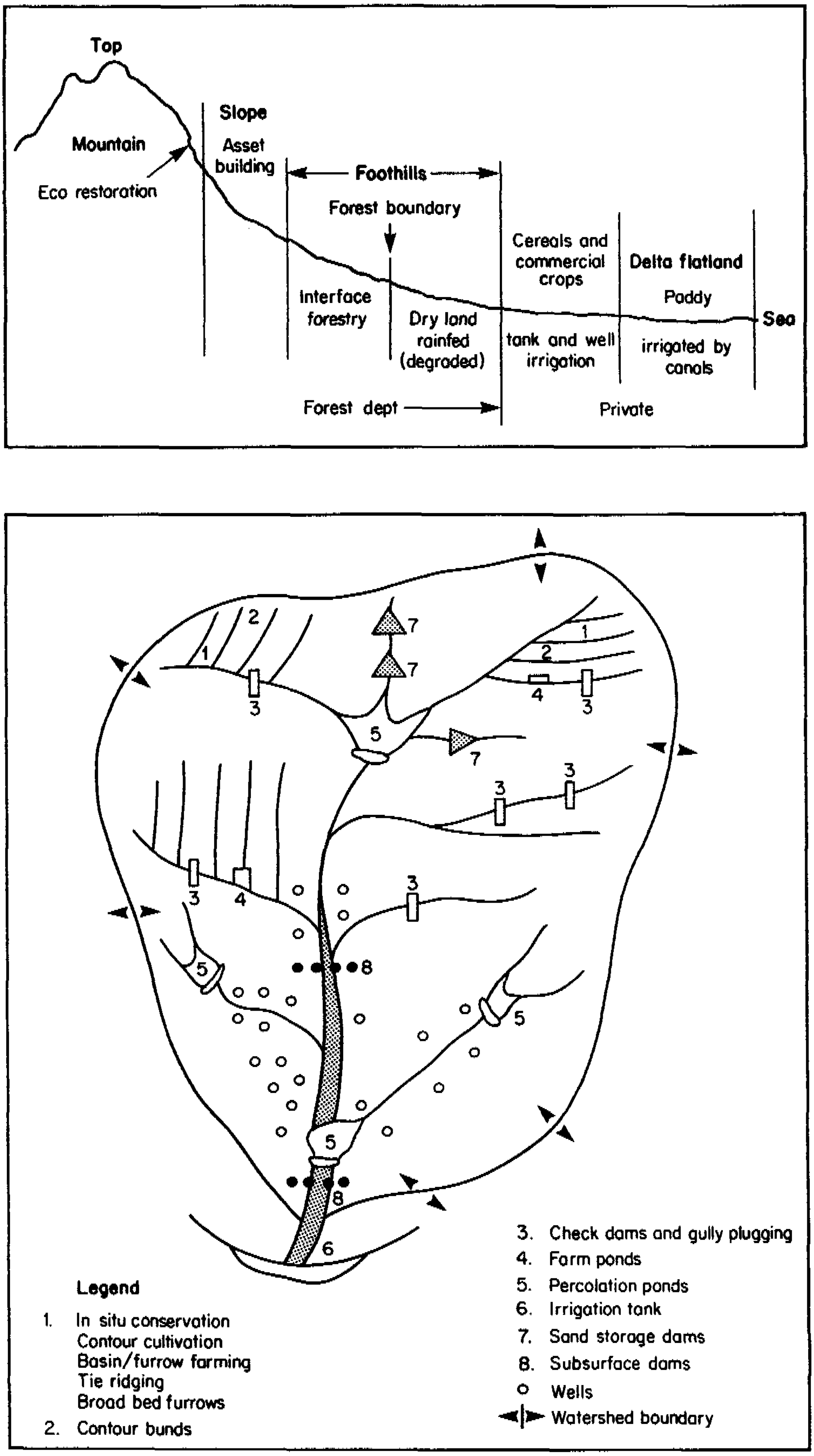

Figure 2. Landscape zonation of soil and water conservation measures.

The upper figure shows vertical, the lower figure horizontal arrangements.
Source: After Sivanappan (1989).

Adaptability a key component

Historically people in Africa and in Asia have proved to be able to adapt well to an adverse environment with large variations in climate. A diversified cropping pattern and an ability to adjust the commencement of the growing season to rainfall pattern have been important principles in making use of the potential of semi-arid areas. This adaptability reflects considerable dynamics and resilience in traditional societies which are often missed in current interpretations of the context in which rural development occurs. According to popular belief, perceptions and knowledge prevailing in traditional local communities are static and 'fossilized'; but there are noteworthy refutations of this myth. Niamir (1989) gives ample evidence of the great spectrum of 'indigenous technical knowledge of natural resource management'. He stresses its functional and utilitarian values and notes that 'although lacking a regional/national outlook, it makes up by being rich on local details and historical trends'. However, its functional relevance and attachment to local conditions means that it is easily eroded if not used. The extension service and perhaps also formal education are obviously faced with a big challenge to maintain and upgrade traditional technical knowledge.

The professional knowledge informing many development efforts is accumulated and tested according to criteria quite different from the knowledge of local communities. In contrast to 'laboratory-tested' attempts to boost development, local communities have acquired a truly holistic insight into the behaviour and potential of the integrated human-environmental system through a 'time-and-field-tested approach' (Madduma Bandara, 1985). It is through combining knowledge and preferences from the local communities with formal scientific knowledge that efficient and sustainable development may prove possible (Niamir, 1989).

Project design in development assistance certainly requires changes in communication with people residing in local communities. At the seminar Jöran Fries expressed the change of approach as follows. Some time ago development assistance was typically prescribed; it was the approach of a veterinarian who did not ask the 'patient' nor did he expect the 'patient' to have any ideas about how to treat the problem. Then came the approach of the house doctor who examines and talks to his 'patient', but hardly discusses his proposals with him. What is aimed at now is the approach of a waiter in a restaurant. After a presentation of the menu, the waiter and the client would discuss the options, and the good waiter would leave the decisions to his client.

The idea that people in local communities should themselves be the basis for development has achieved wide acceptance. However, in spite of all the talk about community participation it seems that development efforts are rather based *in* communities than *upon* community preferences and capabilities, that is they are not *of* the community but placed in it by some external agency. Such a situation leads to local lack of interest, non-cooperation and dependency on government or outside agencies for the simplest projects. This is probably the best way to create a society of 'aid junkies'.

The question of replicability

An efficient strategy is lacking. In the literature it is easy to find examples of successful resource management practices which have increased production, boosted income and contributed to a halt in outmigration. To what extent they are successful, for whom and how lasting the successes will be, can no doubt be debated. But perhaps the most important question is to what extent the promising examples can be replicated on a larger scale. In view of the rapidly degrading environment, a growing population and escalating pressure on the resource base, there is a very great need to spread successful management practices from isolated examples so that we will not end up saying that 'Individual battles have been won, but we are losing the war' (Shaik *et al*, 1988, pp 42–43).

In a detailed search and analysis of successful natural resources management projects in the Sahel, Shaik *et al* collated observations from 70 successful initiatives in four countries (pp 42–43). They concluded that 'initiatives are not successful on their own terms, but show considerable promise of being replicable in other contexts' (p 22). An efficient strategy for spreading successful practices is obviously lacking, however. The spreading of techniques is often a futile exercise, particularly when they are costly or complicated. Nevertheless, sound principles of resource management with respect to socioeconomic and environmental conditions that can be replicated are urgently needed.

Strengthen intercommunity contacts. Conventional development assistance typically disregards intervillage networks of communication. A vital and functional way to stimulate the spread of information about successful methods to meet droughts, to economize on human effort and to identify acceptable ways of increasing food production and other outputs is sadly missing. In principle and in practice, information and good examples in bilateral aid projects and in national development programmes are primarily spread in a hierarchical manner. Target groups or target areas are delineated in order to facilitate and to speed up the channelling of resources to the most needy segments of the population or the most urgent cases. Such a principle also serves accounting purposes.

But quite often the target groups are missed and various 'spillover effects' are noticeable. A certain technology which has been designed for a specific objective and given to a community may be used for some quite different reason than originally intended. A stove programme launched with the intention of saving forests in Mali was adopted by the women because it helped them to save time (Shaikh *et al*, 1988, pp 43–44). A household water supply scheme in Malawi had a noticeble positive effect on households that did not belong to the target group; meanwhile not all of the intended beneficiaries were reached (Lindskog and Lundqvist, 1989).

Without denying the need to support site-specific projects, it is nevertheless of vital importance to strengthen intercommunity contacts, to increase contacts between the actual and potential 'doers' of development. The dynamics within communities and especially intercommunity contacts are often neglected in research. By focusing on individual interviews the dynamics of groups are hard to grasp and evaluate. A research methodology which incorporates interactions within groups looks very promising, however (Chambers and Jiggens, 1986). Organized contacts or meetings between farmers from various villages to discuss common problems and alternative approaches would similarly hold considerable promise as a means of estimating the potentials and limitations of various resource management strategies, including their replicability.

Adopting the principles of NGOs. About three decades of development efforts have left a legacy of distrust and misconceptions among farmers and other groups in Third World countries, whereas their supposed lack of responsiveness has nourished reciprocal cynical attitudes on the part of development agents and national governments. Given the psychological and institutional drawbacks of formal organizations in this connection, it is obvious that non-governmental organizations (NGOs) may play a significant role: 'agencies and governments, to avoid past errors, are either going to have to work more *through* NGOs and small local organizations, or work more *like* them – or maybe do both' (Timberlake, 1985, p 217).

The role of NGOs in mobilizing, supporting and spreading viable resource management practices is increasingly being recognized. At the seminar Camilla Toulmin provided information about the range of organizations engaged in efforts to improve the situation in the drylands of the world. She emphasized the importance of having a clearing house for stimulating contacts between the various organizations and individual researchers engaged in dryland issues. Similarly, stimulating the spread of information to and from development practitioners working at local level is crucial. Among the objectives of the International Institute for Environment and Development in this regard is to bridge the communication barrier between English- and French-speaking Africa (see IIED, 1988).

National policy for sound development

Short-term v *long-term challenges*

It has to be realized that the problems of poverty-prone, semi-arid regions suffering from land degradation and the threat of famine look quite different when seen in a short-term as opposed to a long-term perspective.

In the short term the main challenge is rural development and finding a way out of the present vicious circle and the threatening ecological collapse of entire regions. This includes finding ways to adapt to the effects of hydroclimatic (endemic) water scarcity (modes A and B), and to mitigate and remedy the effects related to water scarcity C. It has been shown earlier in this overview that there are ways out of the present dilemma. The main actors are local farmers. What is demanded from national government is mainly interest in supporting such rural development, even of the poverty-prone and most backward regions of the country. What is needed at the policy-making level is the incentives necessary to make the efforts worthwhile as seen from the perspective of the individual farmer.

In the long term the problem looks entirely different (Falkenmark, 1988). The challenge is then to accelerate biomass production even further so as to meet the demands of a rapidly growing population. If 3 tons/ha are achievable in the short-term development of low-input crop production, as indicated by Datye's experiments, it would be necessary to double these yields in a time perspective of only around two decades in order to feed twice as many people. This might involve difficulties due to a reduced per capita amount of water available for protective irrigation. Whether the root zone water security essential for securing such yield levels is achieved by facilitating increased infiltration of local rainfall which would otherwise form runoff in local streams, or by regular irrigation with stream water, the effect will be a decreased amount of water available in streams or aquifers for other purposes (Figure 3). Improved root zone water security will therefore have to compete with other human needs for water (municipal water, rural water supply, local industry, irrigated cash crop production).

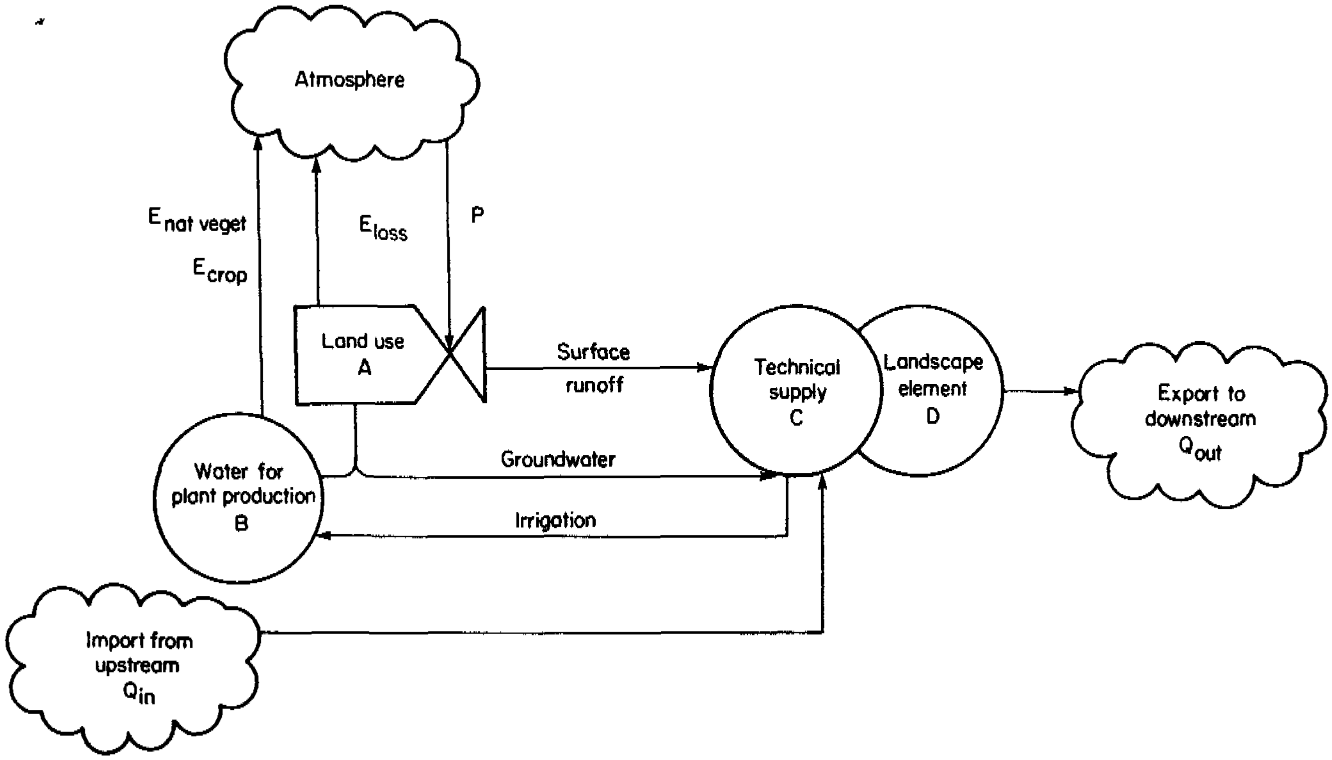

Figure 3. Principal relations between freshwater supply and human water uses at the country or catchment scale.

Source: Falkenmark (1989).

Experience from other regions indicates that this might involve big problems when the number of people per flow unit of water available from the water cycle increases (water scarcity D).

Population policies and water futures

Successful population policies are necessary to avoid water starvation, which will inevitably mean migration out of the area. As has been shown by Falkenmark, Lundqvist and Widstrand (1989), population growth will soon be forcing many African countries into a situation where a water amount of no more than say 5 H (H being the amount needed simply for household needs, assumed to be 100l/person/day) would be available to support *all* water needs. For comparison, this amount is what Sweden is using for municipal water supply only. The amount is also dramatically less than typical water demands in semi-arid irrigated countries. 5 H should be compared to what is used today in irrigated developing countries (20–100 H) and what is used in most irrigated industrialized countries (75–200 H). However, the most water-conserving of these countries need no more than 12 H.

It is easy to understand from this discussion that a water scarcity of type D constitutes an extremely severe constraint, which must be avoided by all means. The earlier the population can be stabilized, the better quality of life will it be possible to achieve in water-scarce rural areas and the more water will there be to support crop production and socioeconomic development. Rapid population growth in regions where water availability is finite but also scarce is equivalent to futures forgone in terms of life quality. The less water there is per capita, the more famine-prone will conditions be when there is insufficient extra water to mitigate droughts and crop failures.

Long-term planning within environmental constraints

It is evident that water scarcity will call for dramatic changes in the approach to water. The relevant question is not the traditional one, inherited from consultants with temperate zone training and experience: how much water do we need and where do we get it? but rather: how much water is there and how should we best benefit from it? (Falkenmark, Lundqvist and Widstrand, 1989). In other words, the challenge is to promote a strategy which aims at proper management of water demand rather than supply-oriented water resources management.

There is consequently an urgent need for a new awareness among politicians and high-level decision makers that problems that seem to be related to land may in fact be caused by water penury. What has to be aimed for is *best use criteria*, basically in line with the ideas brought forward by the Brundtland Commission (WCED, 1987), ie to delineate broad land categories and identify land according to best use criteria, based on inventories of land capabilities and descriptions of a country's fundamental natural resources.

At the same time it is vital that the new approaches needed to develop sound methods for land husbandry and nature management pay due attention to the role of water scarcity in the various life-supporting systems. This importance of water scarcity in fact escaped most observers even in the recent past, including both the Brundtland Commission and the recent international congress on Nature Management and Sustainable Development (cf Ganning and Kessler, 1989). That congress in fact concentrated on natural parks and protected land areas in their discussion of the semi-arid tropical grasslands!

What is most urgently called for is the development of new methods of assessment of the carrying capacity and land use potential of semi-arid lands as a basis for sound forms of land husbandry.

Water-balance-based planning

At the Vadstena seminar the need to further develop traditional methods of water resources assessment was stressed by Abdulay Diawara from Mali. Only when such an assessment has been made does there exist a basis for long-term planning of land use with due regard to water limitations.

It is, however, necessary to go beyond temperate zone practices, which are mainly applicable to conditions of humid climate, concentrating on water in the horizontal branch of the water cycle (rivers and groundwater). Arid areas pose completely different water resource assessment problems. For one thing it is necessary to include water in the vertical branch of the water cycle, ie in particular soil moisture, the critical resource that defines biomass production potential. What is needed is methods for the assessment of the recharge and water-holding capacity of the root zone, but also the recharge of groundwater aquifers in an arid climate. Furthermore, it has to be recalled that groundwater recharge takes place in different ways under humid and arid conditions (Falkenmark and Chapman, 1989). A humid climate allows regional groundwater recharge, whereas in arid regions groundwater may only be recharged in mountain areas and recharge is otherwise limited to river bottoms during flash floods and inundated banks along flooded stretches of major rivers.

It is also necessary to introduce a distinction between *water-producing* areas in the landscape, where terrestrial water systems are being recharged from local rainfall, and *water-consuming* or evaporating areas where emerging groundwater seepage and river flow evaporate, leaving salt crusts behind and reducing the flow along the river. Margat (1982) suggests we distinguish between river basins when discussing water-producing parts of the landscape, and 'anti-basins' when discussing evaporating areas. Examples of the latter are the Jonglei region along the White Nile, and all the numerous *sebkhas* and *chotts* around the arid regions.

Obviously, because of the marginal conditions and the scarcity of water, both agriculture and forestry in water-producing areas should be carefully based on water-balance planning on a catchment basis. It was reported at the seminar that in India both federal and state governments have now agreed in principle to this concept.

Conclusions

The current situation in semi-arid regions gives a gloomy impression of a series of parallel problems (land degradation, rapid population growth, tremendous debt burdens, official detachment from poverty-prone areas, etc), which is a strong reason for very serious concern (see Figure 4a). The gravity of the situation is reinforced by misconceptions about the proper and effective ways to deal with the situation. A characteristic of conventional approaches to the problem is a focus on lacks and needs rather than the potential that exists to improve the situation. The posibility of tackling the situation is also hampered by a dominant technical bias when dealing with the most scarce resource of semi-arid regions, ie water. The conventional approach has typically been to ask how much water we need and where we can get it, rather than how much water there is and what can best be produced from that available amount of water.

The impression from the Vadstena seminar is that knowledge of how to cope with water scarcity and mitigate fertility degradation is most advanced in South Asia, although efforts are underway in many parts of Africa as well. One main problem seems to be the replicability in other environments of successful resource management practices. It is of paramount importance that development should start from available resources and that land use should make the best possible use of local rain. This would mean maximizing the productive part of the return flow to the atmosphere and minimizing unproductive losses. Such efforts to maximize biomass production per unit of water will also have implications in terms of soil conservation.

Typical additional components of a biomass strategy are diversification, allocation of assured water to food crops to achieve food security, intercropping of trees with seasonal crops, etc. The biomass strategy by necessity leads to diversified production which it is possible to implement at the level of the village

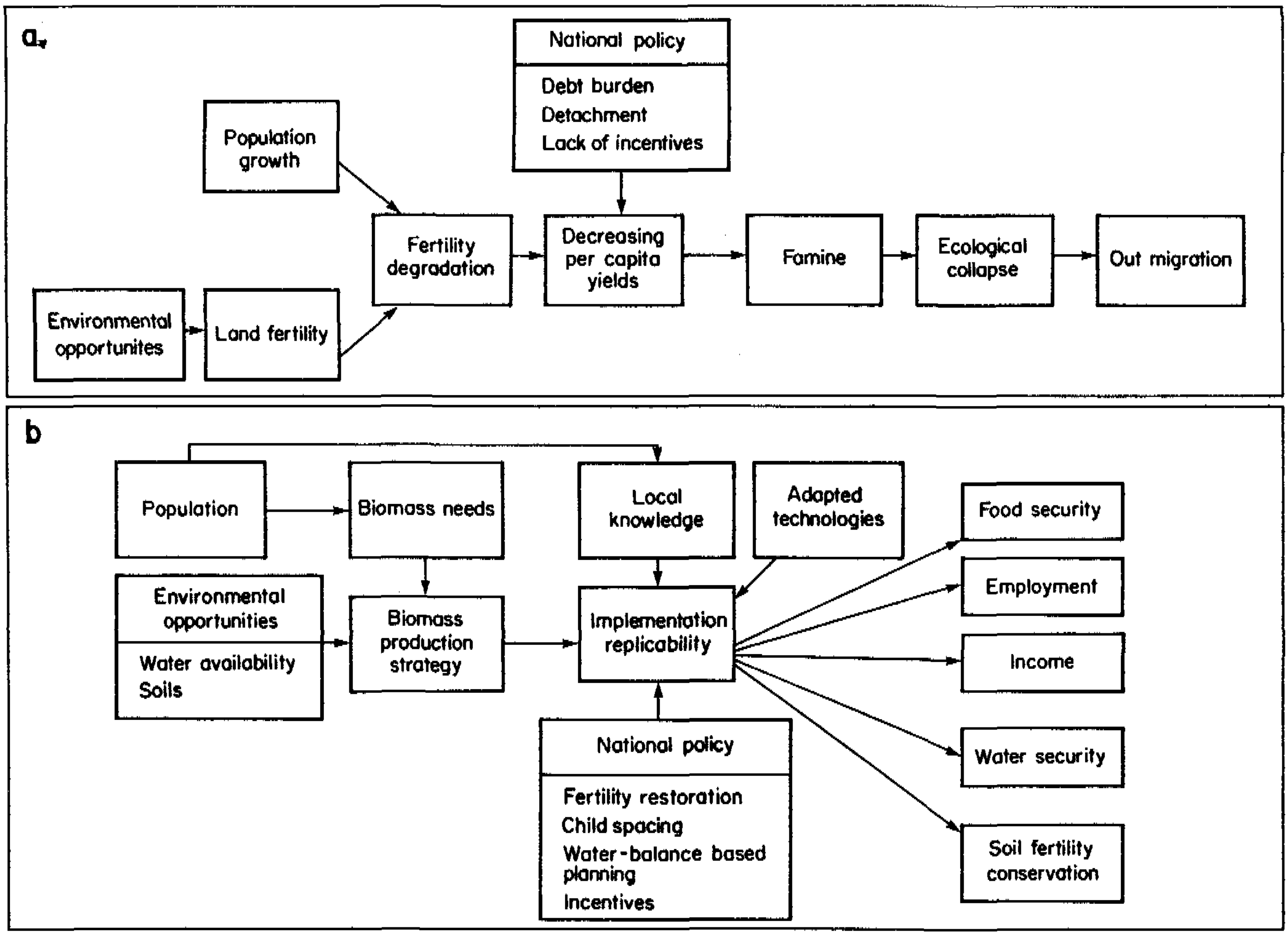

Figure 4. Systems view of factors influencing rural food security.

The upper figure shows the present predicament, the lower figure conclusions from the Vadstena seminar.

community without expensive inputs from the outside and manageable within the community context. This presumes active participation by local communities (see Figure 4b).

There are a multitude of isolated success stories all around the semi-arid tropics. A fundamental issue to be addressed by careful interdisciplinary research is the criteria for replicability. This is a major challenge for donor support and includes supporting networks of community contacts rather than individual projects.

The long-term prognosis for many semi-arid countries with rapid population growth remains gloomy unless governments can respond to the demand for access to methods of child spacing. This demand comes from women and is manifested in a massive number of abortions, estimated to be in the order of 50 million in Africa alone. In short, the option is either access to sizeable amounts of water per capita to support the socioeconomic development which is largely dependent on water, or access to extremely limited amounts per capita, given the projected population growth before stabilization. The result will be continued poverty, environmental stress and probably outmigration from the most severely hit areas.

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