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Indigenous Soil and Water Conservation in Africa

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INDIGENOUS SOIL AND WATER CONSERVATION IN AFRICA

Chris Reij

Introduction

Many parts of Africa are experiencing annual population growth rates between 2 and 4%, degradation of the natural resource base, recurrent droughts and a growing dependence on food aid as well as the import of cereals to cover food deficits. During the last two decades increasing financial outlays for agricultural research in Africa have neither produced significant breakthroughs nor led to agricultural growth (Lipton, 1988).

Since the 1920's, numerous reports have warned against the disastrous effects of increasing erosion, land degradation, desertification, mismanagement of natural resources due to increasing demographic pressure, and as a result soil conservation emerged at the end of the 1930's as a central concern in East Africa (Anderson, 1984). In many African countries considerable efforts have been made during and since colonial times to conserve soil and water resources. Yet most soil and water conservation projects in sub-Saharan Africa have failed. A major argument is that what has been constructed – often at great expense – has seldom been maintained by the 'beneficiaries'. Where adequate maintenance is lacking, conservation works quickly dilapidate and accelerate erosion instead of reducing it.

The most important reasons for these failures in African soil and water conservation (SWC) include a dominant top-down approach, the use of techniques which are complicated to design and expensive, both in terms of labour and capital, to maintain and therefore are not replicable by farmers, a neglect of farmer training, a heavy reliance on machinery for the construction of conservation works and an indiscriminate use of food-for-work. Rather than importing soil and water conservation strategies, we must rely more on indigenous SWC techniques:

> *" although many indigenous farming systems in the region are now under severe pressure or are disintegrating into environmental abuse, they are usually grounded in the necessary detailed knowledge of the local environment. Thus they form the most viable basis for the development of a workable soil and water conservation strategy for the future"* (Reij et al, 1986a).

Partly as a reaction to the disappointing results of integrated rural development programmes (IRDP's) with their strong emphasis on 'transfer of technology', the 1980's have seen a growing awareness of the importance of indigenous environmental knowledge (Richards, 1985), farmer first models (Chambers, 1983; Chambers et al, 1989), fanner participatory research (Farrington and Martin, 1988) and Rapid Rural Appraisal (McCracken et al, 1988). These all draw attention to the environmental knowledge, capacities, skills and priorities of rural people. As part of this trend, the awareness of the importance of indigenous SWC techniques has also increased. But an increase in the awareness of its importance does not necessarily imply a corresponding increase in our knowledge of indigenous SWC.

The objective of this paper is to assess our current knowledge of indigenous SWC in Africa and to identify research needs and policy requirements in the field of African indigenous SWC. Three major issues are explored in the main text.

The first demonstrates that despite a growing awareness of its importance, African indigenous SWC continues to be neglected. The second analyses present trends in indigenous SWC. Are indigenous techniques increasingly abandoned and if so, why? Can we identify cases where indigenous SWC techniques continue to be maintained and even expanded? The third briefly examines the effect of project interventions. Some examples will be given of project interventions damaging indigenous SWC and of others improving the efficiency of indigenous SWC techniques. The annex contains details and diagrams of indigenous SWC from Cameroon, Morocco, Somalia, Sudan and Tunisia.

The Neglect of Indigenous SWC

The 57 references listed at the end of this paper would seem to indicate a wealth of knowledge of and a lively interest in indigenous SWC systems. However, our current knowledge of African indigenous SWC is limited and often outdated. Indigenous SWC techniques continue to be neglected by African and expatriate researchers, and by SWC specialists as well as by government staff. The following examples clearly illustrate this point.

1. Some detailed descriptions and analyses of indigenous SWC systems can be found in various documents. Ludwig (1968) studied indigenous SWC techniques on Ukara island (Tanzania), but no other study seems to have been made since then. French researchers studied indigenous SWC in the Mandara mountains of North Cameroon (Hallaire, 1971; Boulet, 1975; Boutrais, 1973), but this research has essentially been carried out in 1965 or 1966 and detailed follow-up studies are lacking. Netting's study of the Kofyar on the Jos Plateau (Nigeria) done in the first half of the 1960’s is the only study I know which has been followed up with a detailed study in the first half of the 1980’s (Netting, 1968; Netting et al, 1989).
2. Several indigenous SWC techniques have not been studied at all. For example, no research has been done on traditional stone lines in the Ader Doutchi Maggia in the Tahoua Department of Niger. No publications can be found about pitting systems in the Djenne - Sofara region in Mali. Indigenous water harvesting systems in the Central rangelands of Somalia have only recently been ‘discovered’ (Critchley et al, in press). Traditional terracing in the Rif mountains in North Morocco has not been the object of serious research. There are dozens of similar examples.
3. Traditional stone lines in the Ader Doutchi Maggia, Niger, can be observed by anyone driving on the main road from Konni to Tahoua. Important SWC projects have been implemented in this region since the beginning of the 1960’s. Scores of SWC experts have visited the area, but their reports contain no remarks about traditional stone lines.

A French researcher, who did a most interesting six year study in the Maggia valley on the impact of different SWC techniques on runoff, soil loss and yields remarked that one of the reasons for selecting the village of Allokoto for the implantation of a research station was the fact that the villagers already had some notion of land rehabilitation as they had constructed contour stone bunds themselves .."de facon assez sommaire bien sur" (Delwaulle, 1973). Although Delwaulle characterised the traditional stone bunds as rudimentary, he recognised that they could be a starting point for future land rehabilitation. Yet they were not studied.

4. Geographers and anthropologists have made numerous studies of the Dogon in Mali and these indicate that the Dogon have developed intricate systems to conserve rainfall. They even transport soils to bare rock in order to create new fields to cultivate rice or onions (Gallais and Sidikou, 1978; Krings, 1988). Despite a recent reconnaissance survey and brief analysis of various techniques (Kassogue and Ponsioen, 1990), a detailed analysis of the range of techniques employed by the Dogon is still lacking.

5. Staff of the Planning Department of the Ministry of Agriculture of the Cape Verde recently produced a challenging document for a major CILSS/Club du Sahel conference on decentralised management of natural resources in the Sahel (at Segou, Mali, in May 1989). According to this document, "the topography, the rainfall characteristics and population pressure, combined with the fact that the population shows a lack of awareness of the problem, has created an erosion process on the islands" (MDRP/GEP, 1989). No mention whatsoever is made in this document of extensive bench terracing on the island of Santo Antao.

6. Heusch (1985) estimates that in Tunisia, Algeria and Morocco traditional irrigation terraces cover about two million hectares. But at the same time he acknowledges that cost-benefit data for traditional irrigation terraces are not available.

An Analysis of Indigenous SWC

Ethno-engineering

African cultivators apply a wide range of techniques, such as crop rotation, crop mixtures, the application of manure, the protection of nitrogen-fixing trees, terrace building, pitting systems, drainage ditches, small dams in valley floors, and so on to conserve soil and water and to prevent soil degradation. I do not in this paper deal with relevant agronomic and agroforestry practices, although these are often used in combination with mechanical SWC. Today agronomic and agroforestry practices are receiving increasing attention. For example, the International Council for Research in Agroforestry (ICRAF) has worked on an Agroforestry Systems Inventory (Nair, 1989) and Young (1989) has summarised the state of knowledge in the field of agroforestry and soil conservation. Yet inadequate attention has been given in the last 25–30years to African indigenous conservation works, and therefore I will concentrate in this paper in particular on what Jodha (1990) has coined *ethno-engineering*, which comprises "such practices as terracing mountain slopes, harnessing the runoff and developing small drainage systems".

Ethno-engineering practices are applied by African cultivators under widely varying climatic conditions. Generally speaking, water harvesting techniques are used in regions with 100mm to about 700mm rainfall. In the context of this paper, water harvesting can be defined as the collection and concentration of runoff for increased and more reliable plant production (Reij, et al, 1986). The *tabias* and *jessours* in Tunisia (see annex) are a good example of floodwater harvesting within a streambed in a region with 100–200mm rainfall. The *meskat* and *mankaa* also in Tunisia and the teras system in East Sudan (see annex) are examples of water harvesting systems using a long slope in regions with 200–400mm rainfall.

In regions with 500mm rainfall or more, the emphasis shifts from water harvesting techniques to in-situ moisture conservation. For example, the Dogon in Mali build small earth ridges around a number of sorghum or millet plants. These 20–30cm ridges have a rectangular or a beehive shape and in principle they conserve every drop of rain falling within them. The use of in-situ moisture conservation techniques in areas with about 500mm rainfall causes problems in years with below average or irregular rainfall when total rainfall may not be enough to guarantee a crop or when long dry spells during the rainy season cause crop damage. In particular in regions with about 500–700mm in the West African Sahel, one can observe a largely project inspired shift from in-situ moisture conservation techniques to water harvesting techniques.

As soon as the annual rainfall approaches a 1000mm or more, combinations of SWC (terracing of steep slopes, stone bunds on low slopes) and drainage systems in farm fields, where waterlogging is a risk, are more common. Examples of this can be found in the Mandara mountains in North Cameroon (see annex).

An interesting but slightly different description of the diversity of traditional and modern strategies for SWC in the Sudano-Sahelian region of West Africa has identified four subareas where traditional strategies differ (Roose, 1990). The South Sudanian area with more than 1000mm rainfall is characterised by what is called drainage farming, such as Senoufo farmers in North Ivory Coast and Southwest Burkina Faso cultivating on broad ridges. The North Sudanian zone with 700mm–1000mm rainfall is characterised by rainfed farming, such as the Minianka farmers of South Mali who build protection earth bunds at the bottom of the hills, but try to capture all the rainfall, in the field by using tied ridges. In the South Sahelian area with 400–700mm rainfall farmers practise runoff farming, such as the Mossi in the Yatenga region of Burkina Faso, who use stone bunds, planting pits, mulching, etc. Lastly, there are farmers in the North Sahelian area (rainfall less than 400 mm) who practise valley farming, which involves intensive cultivation of valley floors, where runoff from the slopes is concentrated.

More than 50 examples of permanent farming systems with soil conserving practices in the African tropics drawn from the literature are presented in Table 1. It is the only systematic inventory of farming systems with soil conserving practices. In 29 out of 52 examples terracing and irrigation farming are practised. For the compilation of this table, Ludwig has used books and reports published between 1935 and 1961. The major value of this table is that it clearly shows that African indigenous SWC techniques are not an exception; they are applied over large parts of the continent. A further 18 examples of indigenous SWC systems using ethno-engineering practices are shown in Table 2. Again Tables 1 and 2 together are not exhaustive. For example, in Mali terracing systems can be found in the Monts Mandingues around Bamako and in the falaise de Tambaoura (no information available) and in Ethiopia bench terracing for chat (*Catha edulis*) is common (Thomas, 1988). In Zimbabwe, so-called *Inyanga* terraces are widespread in regions inhabited by the maShona (Nyamapfene, 1987).

Abandonment of SWC Practices

The overall impression obtained from available reports is that African indigenous SWC techniques are increasingly being abandoned. Traditional terraces in the Djebel Marra mountains in West Sudan are gradually abandoned (Miehe, 1986); traditional terraces in the Mandara mountains are in some places not adequately maintained or completely abandoned, which leads to their collapse (Riddell and Campbell, 1986); traditional earth dams (tabias) in South Tunisia are in some cases no longer adequately maintained or are abandoned, which disrupts the terraced wadi system (Bonvallot, 1986). The reasons for abandonment encompass political stability, population density, efficiency and market forces.

Many mountainous regions in Africa, such as the Djebel Marra in Sudan, the Mandara mountains in Cameroon, the Plateau Dogon in Mali, the Jos Plateau in Nigeria and the Kabye region in Togo, have had a refuge function in the pre-colonial era. Population groups seeking refuge in mountainous regions often had to survive on limited land resources and therefore had to introduce intensive land management practices. In these cases steep slopes have been terraced. Increased political stability and pacification during and after the colonial period made it no longer dangerous for people to move downhill into the plains.

In some cases governments, during the colonial period as well as after independence, made deliberate efforts to draw people out of mountain regions with a high population density in order to settle them in areas with a low population density and a higher potential for agricultural production. Additional arguments were that they could be better controlled by the administration and provided with essential services. The German colonial government in Togo, for example, forced the Kabye to work in South Togo. The French colonial government continued this policy and forced the Kabye to settle in Central Togo (Sauvaget, 1981). The efforts of the German and French colonial governments in Cameroon to move the people out of the mountains were not very successful (Campbell and Riddell, 1984). However, spontaneous migration to cities and to more productive areas both within and beyond the Mandara mountains is now an important demographic variable.

Table 1: Permanent Farming Systems with Tropics Soil Conserving Practices in Africa

Ethnic Group	Country	Average rainfall (mm)	Population density per sq. km	SWC measures a	b	c	d	Main crops
Malinke	Senegal Guinea	1000	10			X		millet, rice, maize
Baule	Ivory Coast	1270	10–20			X		yams, banana, taro
Kita	Mali	1000	10			X		millet
Dogon	Dahomey	800	10–50	X	X	X		millet, yams, banana
Bobo	Dahomey	800	10–50		X			millet, yams, banana
Gurensi	Dahomey	800	10–50			X		millet, yams, banana
Nunuma	Dahomey	800	30–50			X		millet, yams, banana
Mamprusi	Ghana	800	50–100			X		millet, yams, banana
Losso	Togoland	800–2000	230	X		X		millet, groundnut, yams
Kabre	Togoland	1500	50–70	X	X	X	X	millet, yams, rice
Mandara	Nigeria	800		X		X		millet, beans
Kamuku, Kanuri, Chamba	Nigeria	800	50–230			X		millet, yams, banana
Bauchi, Berron	Nigeria	800	50–700	X		X		millet
Sokoto, Kano	Nigeria	800–1000	125–200	X	X	X		millet, groundnut, cassava
Batta, Mundang Mandji, Bamum Dama, Musgu	Cameroons	800–1000	50–230			X		millet, yams, banana
Sana, Adamawa	Cameroons	800–1500	100–150	X	X	X	X	millet, yams, earth pea
Kuru, Bari	Sudan	1000–1400	30–50			X		millet
Konso	Ethiopia	1000–1200	200	X	X	X	X	millet, cotton, maize
Tigre	Ethiopia	600–1000	100–150	X	X			millet
Kipsigi, Kikuyu Nandi, Suk, Keyu	Kenya	1400–1800	50–150	X	X	X		millet, maize, cassava
Rundi	Burundi	1000–1400	100–150	X	X			millet, banana, yams
Ruanda	Ruanda	1000–1400	150–200	X	X	X		banana, millet, yams
Kiga	Uganda	800–1500	50–100	X	X			millet, banana, beans
Matengo, Makonde	Tanzania	1000–1200	30–100	X		X		Maize, millet, casava
Kinga	Tanzania	1000–1400	20–100	X				Maize,millet
Sandawe, Iraque, Fipa, Turu, Gogo	Tanzania	800–1500	10–100			X		millet, maize, beans
Mbugu, Shambala, Pare, Meru, Teita	Tanzania	1500–2000	50–100	X	X			millet, maize, beans
Wakara	Tanzania	1600	200	X	X	X	X	millet, cassava, rice

a = Terracing b = Irrigation farming c = Manuring d = Stabling

Table 2: Additional examples of indigenous SWC techniques in Africa with prominent 'ethno-engineering' practices

Country	Ethnic group	Rainfall (mm)	Population density persons/km2	Indigenous SWC techniques	Major crops	Publications
Burkina Faso (Central)	Mossi	400–700		stone lines, stone terraces, planting pits (zay)	sorghum millet	Savonnet (1958) Reij (1983)
Burkina Faso (South)	Kassena	700–800	80–100	stone lines	sorghum, millet	?
Burkina Faso (Southwest)	Birifor	1000–1100	35	stone bunds on slopes; network of earth bands and drainage channnels in lowlands	sorghum millet, maize	Savonnet (1976)
Burkina Faso (Southwest)	Dagari	1000	35–80	contour stone bunds on slopes, drainage channels	sorghum millet	Pradeau (1975)
Cameroon (North)	20 ethnic groups	800–1100	80–250	bench terraces (0.5–3m high) stone bunds	sorghum, peanuts	Boulet (1975) Boutrais (1987) Campbell and Riddell (1986) Hallaire (1972)
Cape Verde (S. Antao Island)		400–1200 (in uplands)	>100	bench terraces (rainfed, irrigated), contour stone walls (murets), floodwater control dams, river bank protection walls (bardos)	sugar cane, maize sweet potatoes, pigeon peas	Haagsma (1990) Kloosterboer and Eppink (1989)
Mali (Djenné-Sofara)	Bambara Sourhai	400	20–30	pitting systems	sorghum, millet	Ayers (1989)
Morocco (Anti-Atlas mountains)	?	100–250	?	teraaces, stone banks and small stone walls	barley	Kutsch (1982)
Niger (Ader Doutchi Maggia)	Haussa	300–500		stones lines, planting pits (tassa)	sorhum, millet	Reij, Martin (1986,1990)
Sierra Leone				sticks and stone bunding on fields and in gullies, drainage techniques		Millington (1984)
Somalia (Hiraan region)	Somali	150–300	?	earth bunds with upslope wing-walls (caug) and earth bunds dividing plots of land into a grid (gawan)	sorghum, cowpeas	Critchley et al. (1990)
Sudan (East)	Hedwena Shukriya etc.	225–400	?	earth bunds (straight) with upslope wing-walls (teras) and water spreading techniques	sorghum	Critchley et al. (1990) Ibrahim (1988) Randell (1963)
Sudan (Djebel Marra)	Fur	600–1000	20–37 (1976)	bench terraces	millet, sorghum	Miehe (1986)
Tanzania (Uluguru Mountains)	Luguru	1500	100	ladder terraces		Temple (1972)
Tchad (Ouddai)		250–650	5–6	various earth bunding systems with upslope wingwalls, in drier regions with catchment area (water harvesting)		Sommerhalter (1986)
Tunisia (Medénine)		100–200	15–25	earth dams (tabias/jessours) within streambeds	fruit trees, lentils beans	Bonvallot (1986)
Tunisia (Sousse)		200–300	?	earth bunds (meskat system)	olive trees	Cel Amami (1983)

Planned and spontaneous migration from the mountain regions to the lowlands may have a negative environmental impact on both the mountain regions and on the area of settlement. As the population density descends below a minimum threshold, maintenance requirements of terraces cannot be assured and fertility management practices cannot be carried out adequately (Boulet, 1975). As a result, terraces risk collapse and yields are diminishing.

An exodus from the mountains may also have a negative impact on the areas of settlement. The Kabye instantly abandon their intensive land use management practices when they settle in areas of low population density and they destroy the natural vegetation (Sauvaget, 1981). The same process occurs in North Cameroon (Boulet, 1975; Campbell and Riddell, 1984), although the Ouldeme continue to construct terraces on the lower slopes of the mountains as long as stones are abundant (Hallaire, 1971). The descent into the plains may also cause social conflicts between cultivators and herders (Riddell and Campbell, 1986). A low density population of the plains does not mean that these areas are empty and available to cultivators (Boutrais, 1987).

A low efficiency of indigenous SWC techniques can be another reason for abandonment. In the Ader Doutchi Maggia, Niger, as well as on the Plateau Dogon, Mali, fields treated with stone lines have been abandoned. The most likely reason for abandonment in these cases is that the techniques were not efficient enough to be able to cope with a combination of recurrent droughts and loss of soil fertility.

Market forces also play a role in the abandonment of indigenous techniques. The opportunities for earning a cash income often are much higher in adjacent towns than in isolated mountain areas with a high population density. In South Tunisia, credit is available for mechanisation, which makes it attractive to move from the mountains to the lowlands (Bonvallot, 1986). In the Matmata area of Tunisia, because of rising costs of manpower and employment opportunities in Libya, most jessours are no longer maintained (Heusch, 1985).

Although many indigenous SWC techniques are able to support reasonable yield levels and high population densities, (up to 250-300 persons/km2), labour investment in maintenance of terraces as well as in fertility management is high and returns to labour are low. In regions of high population density with growth rates in the order of 2%, it is impossible to accommodate significant population growth when the average farm size is at or less than 2 ha. In some regions the situation looks rather grim. Heusch (1985) indicates for the Mahgreb countries that within a generation entire villages will be deserted. Adult male workers have already left. In many cases terrace walls are no longer maintained and women do not have the resources to put back the heavy stones.

Maintenance and Expansion

The preceding section may have created the impression that African indigenous SWC is at peril and has no future. However, there are many locations where indigenous SWC techniques continue to be maintained and even expanded. In some instances, indigenous techniques, abandoned some decades ago, have been revived suddenly.

1. Stone lines in the Ader Doutchi Maggia (Niger)

This region is characterised by the presence of major fertile valleys and large barren plateaus. Rainfall in the area varies from 250–450 mm. Stone lines (Haussa term: *gandari*) have been laid out mainly by the people living on the plateaus to conserve water and trap windblown sand. They are often laid out in straight lines (grid pattern), but in some cases efforts are made to follow a contour line. It is not possible to estimate how many hectares have been treated with *gandari* as they are dispersed over a large area. The size of the fields treated varies from a few hectares to several hundreds of hectares – for example on the Plateau Wandali not far from Koura Abdou in the Badeguicheri valley.

The *gandari* seem to be used mainly for the rehabilitation of barren degraded lands with a hard impenetrable crust (Haussa term: *fako*). These *fakos* have sandy-clayey soils. Once laid out, farmers wait till the harmattan has deposited sufficient sand to permit cultivation. They usually have to wait five or six years before the land treated with *gandari* can be cultivated.

Although numerous fields have been abandoned, elsewhere stone lines continue to be maintained and fields can be found where stone lines have recently been laid out. All construction is done by individual farmers on a voluntary basis without any project support. Farmers cover part of the soil with millet stalks or some manure, which, according to them, helps trap sand.

In 1988 farmers in this region suddenly started making planting pits (*tassa*) to rehabilitate degraded land. It is not yet clear where they got the idea from. Some say it is a revival of indigenous techniques, but according to others, Haussa migrants from Niger who travelled on the Jos Plateau in Nigeria picked up the idea there. An International Fund for Agricultural Development (IFAD)-funded SWC project is now assisting these farmers with technical advice (on increasing dimensions of the pits and using organic matter) and although applied now on a small-scale, I expect a rapid adoption of this technique by the farmers in this region.

2. Planting pits in the Djenne – Sofara region (Mali)[2]

According to Ayers (1989), 12% of the farmers she interviewed practised pitting to retain more water. Forty-four per cent of the farmers practising pitting had introduced them since 1985. Some farmers mentioned that they had observed the technique in other villages in the region, but others claimed that pitting was an ancient technique which had been superseded by the plough. Increasing problems of crusting and compaction apparently are a reason for farmers to revive pitting. There are some indications that pitting of crusted barren land is increasing rapidly (observations of CARE project manager).

2. I interviewed some young people in the village of Yala in September 1989. They mentioned without a trace of hesitation that the pitting system had been introduced by their ancestors and not by extension agents.

3. Terracing in the Rif mountains (Morocco)

No systematic study has been made of traditional terraces in the Rif mountains of Morocco, but field observations indicate that farmers continue to maintain and expand their traditional terraces[3]. In some areas expansion of the terraces is related to the cultivation of kif (hasj).

4. Traditional small scale water harvesting in the Hiraan region (Somalia)

Traditional small scale water harvesting systems for crop production are common over an extensive part of Hiraan Region in the Central Rangelands of Somalia. It has been estimated that up to half of the families within the region practice some water harvesting (Caag and gawan systems: see annex). Farmers continue to maintain the structures and examples have been found where farmers experiment with the techniques (Critchley et al, 1991).

5. Traditional teras cultivation in the Eastern plains (Sudan)

Teras cultivation is a traditional form of water harvesting used extensively in the clay plains of Eastern Sudan (see annex). The word *teras* itself refers to the earthern bund which surrounds three sides of each cultivated plot, and impounds runoff from the plains. While some traditional areas of *teras* cultivation have been replaced by irrigation schemes, others are becoming mechanised and apparently may even have expanded in area (Critchley et al, 1991).

An Emerging Interest

African indigenous SWC has long been ignored by researchers and developers. It is striking that interest in indigenous resource management systems is increasing simultaneously in Latin America[4], Asia[5] and in Africa. It is therefore not a coincidence that the first resolution of the 6th International Soil Conservation Conference (Addis Abeba, Ethiopia and Nairobi, Kenya; November 6–18, 1989), is about learning from traditional techniques from small-scale farmers. It states that:

- In recognising the immense wealth of traditional know-how, especially in agricultural systems, we should learn from the principles behind their success or failure in the handling of soil and water management.
- In particular, it is necessary to integrate the successful and promising principles into modern research and development efforts in meeting challenges of the present and future land use.

3. Observation during short field trip in June 1990.
4. Growing interest in traditional agricultural resource management in Latin America is illustrated by Wilken (1987) and Browder (1989).
5. In June 1991 a workshop was held at ICRISAT, Hyderabad, about traditional SWC techniques in India. Earlier, the Asian Soil Conservation Network organised a workshop on "Indigenous Conservation Farming Practices" in Papua New Guinea (December 1990).

- Such integration will require that present day sectorial institutions work together in order to exploit this traditional potential since it is almost invariably of a multidisciplinary nature.

Slowly but surely, a certain consensus is emerging that indigenous SWC techniques could be used have a role to play. This trend reflects a feeling of disappointment with or even despair about the failure to narrow the gap between food needs and food production in Africa and the inability to create conditions for sustainable rural development. Although I fully support the view that indigenous SWC has a role to play, some caution is required. First of all we should avoid deifying indigenous SWC techniques as they are in many instances no longer sufficiently efficient. A marriage between indigenous and modern techniques may be required to increase the technical efficiency (coping with degradation) as well as the returns to labour (higher incomes). Secondly, indigenous techniques have been developed in a particular socio-economic context, but labour migration and market forces have profoundly changed that context[6]. Thirdly, as indigenous SWC techniques are location specific, a question to be researched is under what conditions can they be transferred to other regions? Finally, at present we know too little about the current state of most indigenous SWC in Africa, and as a result it is difficult to design project interventions taking indigenous SWC techniques as a starting point.

The Role of Project Interventions

As indigenous SWC techniques have been neglected by researchers, a major risk is that interventions are proposed which are insufficiently rooted in the priorities and perceptions of local populations. What do we know about the present state of terracing and other techniques in North Africa? Despite studies by Kutsch (1982), Bonvallot (1986), El Amami (1983), Despois (1956) and others, the answer is very little. Another risk is that techniques, which are successful in specific regions will be transferred to other regions without adequate testing or adaptive research. Although only few cases can be found of deliberate interventions in African indigenous SWC, some examples will now be given of project interventions with damaging and positive effects.

Project Interventions Damaging Indigenous SWC

In South Tunisia cultivators made lateral spillways in the earth dams constructed across valley floors. About 50 years ago, government services started replacing lateral spillways by a central spillway. One of the major inconveniences perceived by the *djebalia* mountain people is that the central spillway is usually built long and low and therefore reduces the capacity to retain water. The major weakness they perceive is that the central spillway is

6. A participant in the workshop on ‘Conservation in Africa: indigenous knowledge and government strategies’ remarked: "If you adapt or combine techniques without an understanding of the social systems in which they emerge you run the risk of undermining social structures which help to sustain the operation of indigenous technology. We are not just talking about technique; we are looking at part of a social, cultural and intellectual system, which interacts with other parts."

static. The height of the spillway can only be raised progressively in proportion to the rate of sedimentation of the *jessour* (see annex). As soon as a central spillway has been imposed, the farmer feels less concerned about the *jessour* (Bonvallot, 1986).

In the Uluguru mountains of Tanzania, ladder or step terraces are the most widely employed and generally accepted soil conservation method on the western side of the mountains (Temple, 1972). But in 1950 the Uluguru Land Usage Scheme introduced compulsory bench terracing in *shambas* (farms) of medium gradients, with afforestation of steeper slopes, involving their closure to cultivation of annual crops (Temple, 1972, quoting Duff, 1960). Basically, large bench terraces were superimposed on indigenous ladder terraces. The Uluguru Land Usage scheme was abandoned in 1955 after serious riots.

Project Interventions Improving Indigenous SWC

On the Central Plateau in Burkina Faso, the Mossi used to employ various techniques to conserve soil and water (Reij, 1983). One of those techniques was the construction of stone lines. The efficiency of these stone lines in retaining soil and water was quite limited as contour lines were not respected, and gaps were left between stones. The Projet Agro-Forestier (PAF) in the Yatenga region introduced contour stone bunding in the beginning of the 1980s. Contour stone bunding is essentially an improvement of existing stone lines. Thousands of farmers have been trained in using simple survey equipment based on water tube levels to determine contour lines and in basic rules of construction. The annual rate of implementation increased from 150 ha in 1982–83 to some 5000 ha in 1987–88 (Reij, 1988). Contour stone bunds are constructed on cultivated fields, but they are also used on a considerable scale to rehabilitate degraded soils with a hard impenetrable crust. Farmers spontaneously introduced (or revived?) planting pits, zay, in the beginning of the 1980s. They systematically combine contour stone bunds and zay to rehabilitate degraded soils. Yield increases are substantial. Farmers estimate that yields on already cultivated fields increase with about 40%. In years with fairly regular rainfall, yields of 1000-1200 kg/ha on rehabilitated fields are not exceptional.

The ASAL Programme in West Pokot and Northern Marakwet (Kenya) made some effort to improve indigenous irrigation systems. The programme provided technical assistance and material support to villagers to solve two problems they faced: (a) when furrows cross permeable soils or a rocky surface and (b) where recently developed gullies cross furrows or where furrow sections have been swept away by landslides (Dietz, 1990, quoting van Klinken, 1987).

The Need for Research on Indigenous SWC in Africa

Our current knowledge of indigenous SWC techniques in Africa is extremely limited and many of these studies are more than 25–30 years old. For this reason we do not know whether techniques are gradually abandoned or whether they continue to be maintained and expanded. Many reports only mention the existence of indigenous techniques, but due to lack of research cannot provide any detailed information. Many indigenous SWC techniques have not been studied at all, leaving an important gap to be filled[7].

More research on indigenous SWC techniques is essential for two major reasons. First, many SWC projects have failed and although we have at present very little factual evidence to support the assumption, we believe that indigenous SWC could be used as a starting point for new programs. Second, we are faced with a growing exodus from African fragile regions and mountains to lowlands and urban areas. The consequences are serious for the zones of departure where intricate terracing systems are no longer adequately maintained, collapse, increase erosion and aggravate flood hazards in the lowlands. At the same time, the areas of settlement cannot always cope with the arrival of considerable numbers of settlers from the mountains and in particular not when they instantly abandon their intensive land use management practices.

To fill gaps in our current knowledge of indigenous SWC techniques and to get a better idea of constraints and opportunities with regard to the development of indigenous SWC, the first step could be to make a fairly large number of relatively quick studies. At the same time it would be useful to initiate, wherever possible, small trials in close consultation with the local resource users. The objective of such trials could be to improve the technical efficiency of indigenous SWC techniques. Another objective could be to test techniques which are successful in similar conditions. A good, but rare, example of this type of adaptive research can be found in Kitui District, Kenya. Traditional pitting practices of the Kofyar, on the Jos Plateau, Nigeria, and the Matengo of southwest Tanzania are used as a source of inspiration for the development of modern variants of pitting to assist in the rehabilitation and revegetation of eroded grasslands (Jones et al, 1989).

Some research on indigenous SWC systems has recently been or will soon be initiated in Sudan on *teras* in the Kassala region, in Niger on traditional stone lines and planting pits (*tassa*), in Mali on planting pits in the Djenne – Sofara region and in Morocco on traditional terracing in the Rif mountains. It is hoped that these first research efforts signal the beginning of what will evolve into a new paradigm in African development research.

Policy Requirements

Even if, due to increased research efforts, our knowledge of indigenous SWC will have increased substantially within a few years, the practical use of this knowledge may still be hampered by a number of institutional constraints. Two important institutional constraints are the inappropriateness of present project design and the tendency of governments and donor agencies to go for quick and tangible results.

7. The Centre for Development Cooperation Services and the Drylands Programme of IIED have recently formulated a joint research effort on indigenous SWC in Africa. This project plans to involve African researchers in case studies of indigenous SWC techniques. Information can be obtained from Chris Reij at CDCS, or Camilla Toulmin at IIED.

If we want to give indigenous SWC and other forms of local environmental knowledge a real chance, then conventional project design should be thoroughly changed.

Many donor agencies field a number of missions for project identification, preparation and appraisal. These missions often take three to four weeks in the field followed by a similar period for report writing at headquarters, they involve several consultants and gaps of several months between each mission are common. This design chain is highly inadequate. Project identification missions tend to spend half their time in the field talking to public administrators, staff of various ministries (agriculture, environment) and to some representatives of the target group – often village elite. The rest of the time is spent in the capital on data collection (census data, price data, etc.) and on discussing with ministries and donor agencies. This type of identification mission is usually not in the position to identify and analyse local perceptions, priorities and environmental knowledge. Assuming some continuity between what has been identified and what has been appraised, it is important that identification missions get it right. Therefore the emphasis during design should shift from appraisal to identification. A solution is to field small identification missions (two or three consultants instead of six or seven), who know the region well and are prepared to stay three months in the field.

The second constraint is that governments, donor agencies and the press want quick and tangible results.

The easiest way to achieve this is to use ample food-for-work supplies and/or to rely on the use of heavy machinery for earth moving or transport of stone. No consideration is given to whether activities can be sustained in the post-project phase or whether they can be applied by the land users without or with a minimum of external support. Indigenous SWC techniques are not well known and require some research. Experiments should be designed to improve their technical efficiency, and several techniques should be tested at village level and evaluated by technicians and villagers. It may take three to five years before the best and most acceptable technical package is identified, hence tangible results can rarely be obtained before five to ten years have elapsed. It is essential that donor agencies and governments accept these time frames for projects.

Notes

This paper is a revised version of a paper written for a workshop on "Conservation in Africa: indigenous knowledge and government strategies" held in Harare (December 2–7, 1990). The paper was commissioned by the American Social Science Research Council (Project on African Agriculture). Without the support from different collegues, this paper could not have been written in the short period available to the author. Fred Zaal did background research on various examples of indigenous SWC techniques. Stephen Turner stimulated me at a time when I risked to "drown" in other work, Alie van de Wai collected documentation and produced with Fred Zaal a bibliography. Will Critchley's shared interest in indigenous SWC has been a considerable incentive. However, only the author is responsible for omissions or errors of interpretation.

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ANNEX 1
EXAMPLES OF INDIGENOUS SWC IN AFRICA

1. MOROCCO: ANTI-ATLAS (SOUTH MOROCCO)

In the Moroccan Anti-Atlas, where rainfall is of the order of 100–250 mm annually, there are three indigenous techniques for water harvesting and concentration (Figure 1):

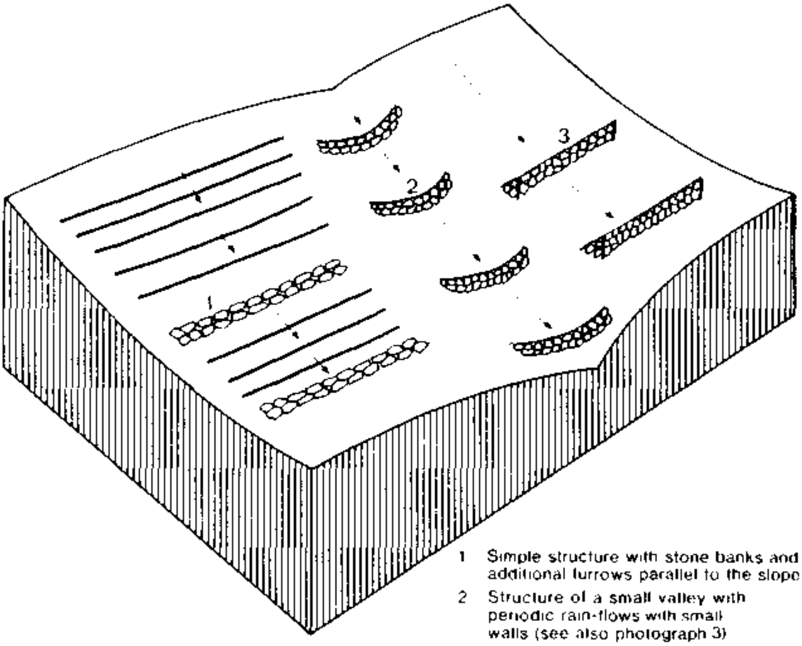
- Stone banks and small walls to hold back water running off slopes;
- Narrow troughs parallel to the slope (on particularly steep slopes); and
- Terraces - 25% of which reach to the crest of a hill or mountain; the other 75% are restricted to the lower slopes.

Barley is the principal crop, and water harvesting techniques allow yields of 500 to 1000 kg/ha. Recent trends include the deterioration of the drinking water supply in the larger basin landscape may have detrimental effects upon agriculture (emigration, reduction of agricultural activities).

Three technical and agronomic measures have been suggested by Kutsch (1982) to improve this water concentrating culture:

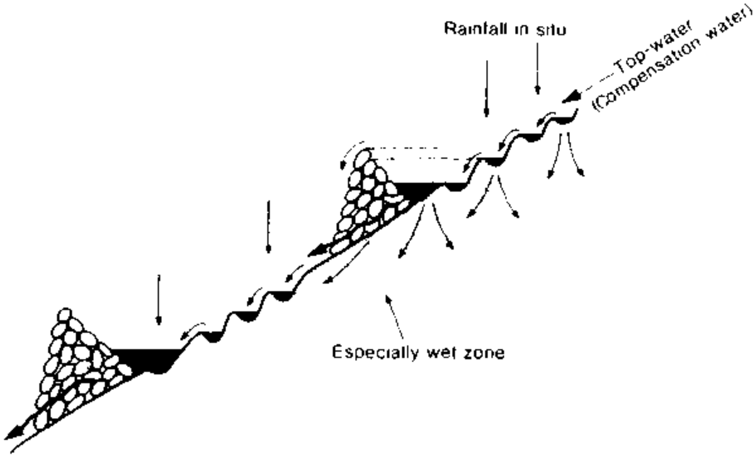
- More insistence on the importance of wedge shaped reinforcement of the terrace walls on the slope side to make them more durable;
- Systematic measures for improving the soil on terrace structures, especially on the upper terraces; and
- Green manuring, fodder cultivation, improvement of almonds' resistance to frost, cultivation of other cash crops (safflower, etc.).

Lay-out and functioning of the run-off structures



1 Simple structure with stone banks and additional furrows parallel to the slope
2 Structure of a small valley with periodic rain-flows with small walls (see also photograph 3)
3 Structure with stone banks with a triangular profile (see also photograph 2)

Functioning of the run-off structures in the case of stone banks



2. TUNISIA: REGION OF MEDENINE (SOUTH TUNISIA)

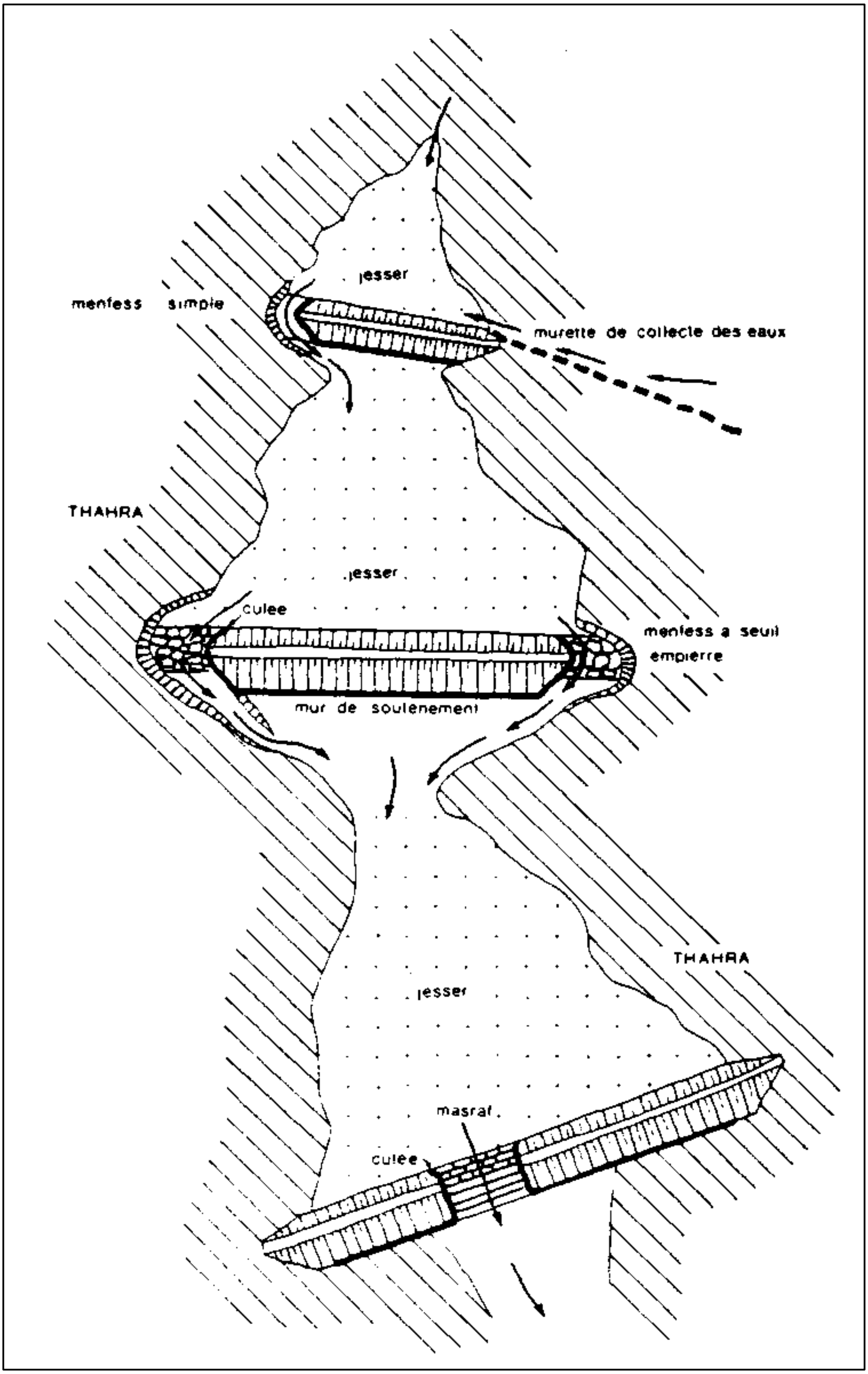
In the Tunisian region of Medinine, where rainfall is 100–200mm annually, population density is 15-25 people per square km, and the soils are calcareous covered with several metres of loess, there is an important traditional technique for floodwater harvesting within the streambeds. These earthdams or *tabias*, which are 2–5m high and up to 100m long, are constructed across valley floors. In 60% of the cases they are equipped with one or more lateral spillways (*menfess*), and soils gradually accumulate upslope the *tabias* (Figure 2). The principal crops are fruit trees (olives, almonds, etc.), but barley, lentils and beans are also grown.

These *tabias*, if adequately maintained, allow a certain control of floodwater. But the present trend is lack of maintenance and slow abandonment of these indigenous techniques because of strong migration, which is a direct threat to numerous small earth dams recently constructed (with tractors) on relatively flat areas downstream.

State intervention has not been successful, as technical services introduced and imposed central spillways, instead of lateral spillways in the *tabias*, which are costly to construct, prone to damage and retain too little water (according to the farmers). Some 30% of the *tabias* are now equipped with a central spillway (*masraf*).

In order to avoid or reduce damage to structures in the lowlands, Bonvallot (1986) proposes more support from the State for the farmers in the highlands; he suggests the suppression of the central spillways, because they are not appropriate, imposed from outside, and rejected by the farmers. The State should also provide some labour and tools for maintenance.

Figure 2: Tabias and jessour from southern Tunisia (Bonvallot, 1986)



3. SOMALIA: TRADITIONAL SMALL SCALE WATER HARVESTING IN HIRAAN REGION (CENTRAL RANGELANDS)

Traditional small scale water harvesting (WH) systems for crop production are common over an extensive part of Hiraan Region in the Central Rangelands of Somalia, with up to half of all families practicing some WH (Critchley et al, 1991). The majority of those involved are agropastoralists who supplement their income from livestock by cultivation and simultaneously benefit their animals with the fodder by-products. The systems used are simple and cost little to construct.

The average annual rainfall for the region is 150-300 mm. Although most of the Central Rangelands is sandy, those areas where WH is common are the clay zones, where adequate runoff occurs, not far from the Shabelle river. Fertility is higher than in the sandy zone, but land is traditionally rested after a number of years to restore the nutrient status.

Small scale WH techniques are implemented voluntarily by the local agropastoralists because, they say, harvested runoff improves crop performance and, without it, crop failure may occur. These techniques have evolved over several generations. In certain areas of Hiraan Region, such as Bula Burti and Halgan, few farms can be observed without *caag* or *gawan* systems. These are low cost systems. The *caag* system is found where considerable overland flow, or flow from a small *toog* (gully) can be captured behind bunds, whereas the *gawan* system acts mainly as an in situ moisture conservation system on the plateaus, though it is modified sometimes to accommodate runoff from outside.

The *caag* system is used where slopes are above 0.5% and there is significant runoff to be harvested. These are long slope, external catchment systems. Water may be diverted into the plot, commonly from small *toogs* or even road drains (Figure 3). "Contour" bunds are formed within the fields, typically to a height of 50cm and base width of 150cm. These bunds commonly extend across the entire plot (often one hectare or more in size), excess runoff typically being spilled around one upturned arm of the bund. The other arm extends higher upslope. Overflow then may be collected in front of a second, lower bund. There are rarely more than two such bunds in a field. An alternative overflow system occasionally used is the incorporation of a plastic pipe (of approx. 10cm diameter) within the bund. The layout of the bund is achieved by a combination of eye and experience, but a contour alignment is clearly the objective. A precise maximum depth of flooding is not specifically designed for; rather it is said that if excess flooding occurs and water stands for more than five days the bund may be deliberately breached. In practice flooding depths can reach 30cm.

The techniques used on *gawan* sites are on the borderline between WH and in situ moisture conservation. These are typically almost flat sites which sometimes receive runoff from outside. The system itself comprises bunds of about 30cm height, which divide plots of land into a grid, with individual basins in the order of 500m2 and upwards in size (Figure 3). Sometimes the basins are "blind", that is they have no inlet or outlet. However, in the situation where runoff is expected from outside the plot, water is spread and controlled by the provision of gaps or breaches in the bunds, which act as spillways. Sometimes runoff is allowed to back-up and spill around a sidewall of the basin, in a similar fashion to the *caag* system. The configuration of two fields is never identical.

Sorghum is the usual crop of choice, providing grain and also stover which is a valued by-product for livestock feed. Cowpeas are also common. Sesame is sometimes grown, and if sorghum becomes waterlogged, then sesame is sometimes planted later into the residual moisture. Dry planting is practised by some people, though others wait until after the rains have begun. Two crops are taken during each year, if both the rains succeed. Yields for WH fields are not specifically available, though general average yields for this area are given as 415 kg/ha for sorghum and between 330 and 530 kg/ha for cowpeas.

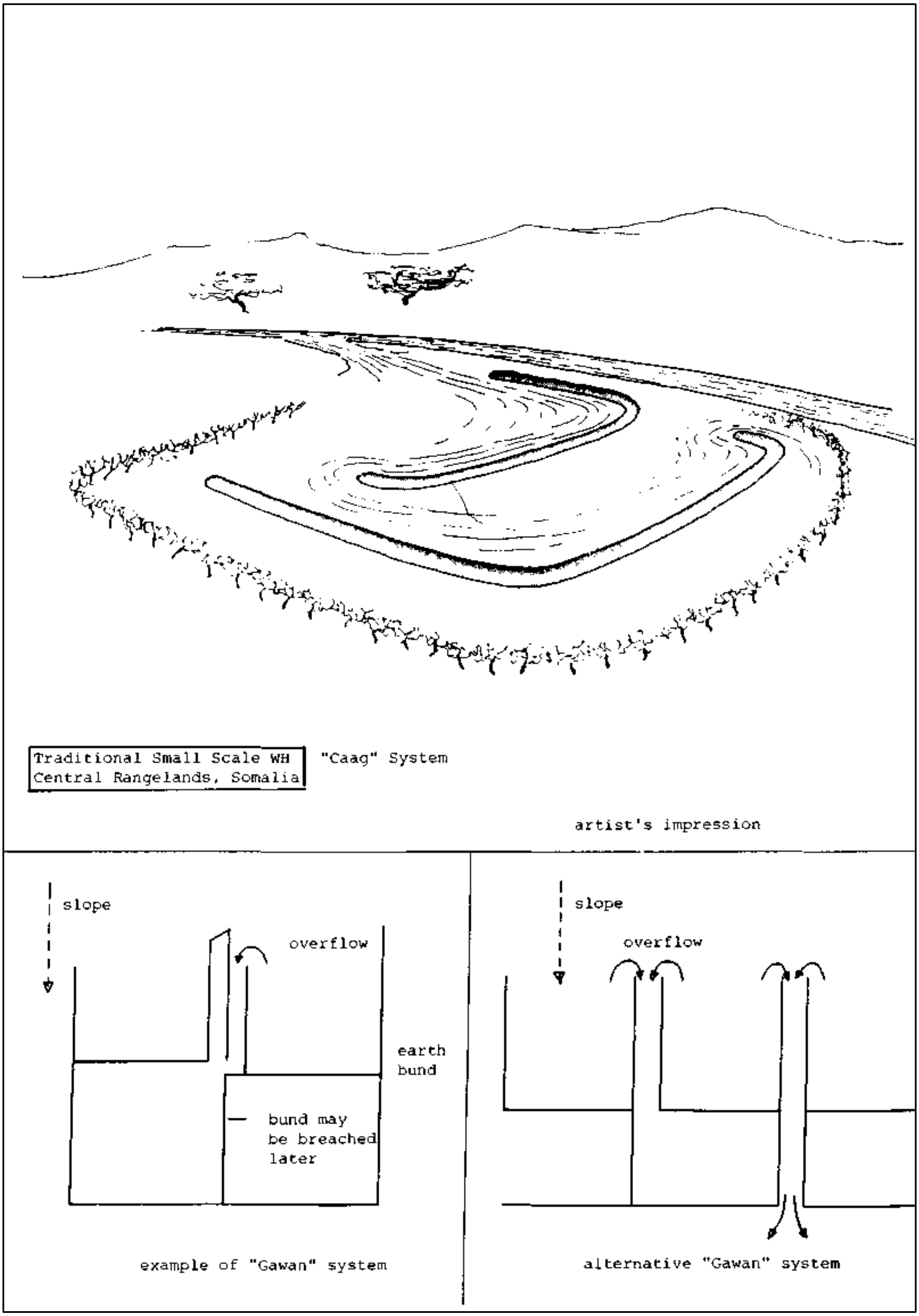
These WH systems are entirely traditional. They are implemented by the farmers themselves at their own expense. No details are available about costs or labour input, but these are estimated to be modest, judging by the costs incurred by the Central Rangelands Development Project (CRDP) on trial plots using similar techniques. The *gawan* system holds rainfall effectively in situ and where runoff is harvested it works best where an overflow is provided for, around side bunds. The less sophisticated models with gaps in bunds are less efficient at impounding runoff. Smaller basins could be an improvement and this indeed is one of the modifications being tested under CRDP.

The *caag* system is a simple and effective method of impounding and spreading flows of runoff from small channels. Indeed it is basically the type of system which is being introduced under a number of projects in sub-Saharan Africa, usually at much greater expense and with little extra efficiency. Nevertheless it is evident that there are some problems – with waterlogging in some situations and also with bund breakages. The *caag* system could thus be improved in a number of ways, principally by the introduction of simple surveying instruments to establish the contour and to determine vertical intervals for spacing of bunds and positioning of spillways.

CRDP are working toward recommendations for extension in the field of water harvesting. Without revolutionising the techniques or cropping pattern, there are several useful modifications which could improve the systems and make them more productive and sustainable. These will form the basis of an extension programme. There may be potential for the introduction of alternative crops. Other promising crops being tested under CRDP include bulrush (pearl) millet and green grams (mung bean). CRDP are developing an agropastoral system for cropping in the Central Rangelands and extension packages are available for sandy zones. It is anticipated that similar cropping practices would be viable under water harvesting. The basis of the system is the incorporation of woody shrubs and trees to help maintain fertility as well as to provide economic products such as timber, fuelwood and browse. A further benefit would be the stabilisation of the bunds by the establishment of vegetation.

Within the same district, large scale water spreading schemes are also found, whereby *toogs* of 50 metres width or more are diverted into flood plains and cultivation carried out. A number of such schemes were started as local initiatives. While these can be very productive, they are only appropriate for specific sites and commonly suffer from breaches of the diversion bund itself.

Figure 3: Traditional small scale water harvesting, Somalia



4. SUDAN:TRADITIONAL TERAS CULTIVATION IN THE EASTERN PLAINS

Teras cultivation is a traditional form of WH used extensively in the clay plains of Eastern Sudan (Critchley et al, in press). The word *teras* itself refers to the earthern bund which surrounds three sides of each cultivated plot, and impounds runoff from the plains. The *teras* system is of particular interest because it is one of the few examples of traditional WH spread over a very extensive area. This profile concentrates on one focal point of *teras* cultivation: the area around Kassala.

Several ethnic groups practice *teras* cultivation. Around Kassala the Hedendwa (basically cattle herders, many of whom have now settled) are the principal practitioners, though some Rashaida (tent-living semi-nomads) also grow crops under *teras* systems. In the Butana plains, major groups using these techniques are the Shukriya and the Lahawin, both mainly herders. Although there is a considerable number of pure pastoralists within Kassala Province, only 12% of the 1.5 million population are considered true nomads. Population density over Eastern Region is about seven people/square km, though there is considerable local variation.

Kassala is on the threshold of the semi-desert zone to the north, but it is just within the arid zone, which has 225 – 400mm of annual rainfall. The area used for *teras* cultivation are clay plains. Often these plains are alluvial in origin, such as the old Gash Delta near Kassala. Many of the clays show some degree of cracking and indeed there are some vertisols cultivated under this system. Typically the plains are open with few trees. The trees which do include *Balanites aegyptiaca* and *Acacia spp*. In some places, especially close to settlements and roads, *Prosopis juliflora* has become quite densely naturalised.

While there is a considerable range in the design of the structures under teras cultivation, plots around Kalahout, west of Kassala town, serve as an example. The visual impression of the landscape is of a checkerboard, with individual plots interspersed within an uncultivated plain. The plain acts as the catchment, and the catchment/cultivated area ratio is rarely below 2:1 and is sometimes considerably greater. The system is essentially an external catchment, long slope technique of water harvesting (Figure 4).

A typical plot may be up to 3 hectares in size: in this case the bottom bund (straight, but approximating to the contour) is 300 metres or more in length and the upslope arms or wingwalls, aligned at right angles to the bottom bund, are between 50 and 100 metres long. In addition to the side arms which define the extent of the plot, there are usually other parallel bunds every 50 metres or less within the plot. The earthen bunds are 35-40cm in height, after settling, with a base width of 1.5 – 2 metres. Most bunds in the Kalahout area have been created with a disc plough, but the few bottom bunds which have been built up with a front loader are as high as 75cm. There is no deliberate provision of a spillway for the evacuation of excess water. On these slopes of approximately 0.5% the bottom bund will normally breach (or be breached) before runoff can back up around the tips of the side bunds. In a description of *teras* cultivation in Butana from the 1960s, the catchment area is referred to as the *sadra* and the cultivated area as the *hugna* (Randall J.R., 1963). Within the main *hugna* there was sometimes a smaller bunded plot termed a *gataa*, which would collect a lesser depth of runoff and could be planted earlier.

The *teras* system is essentially for sorghum production. One of the most common varieties grown is *feterita*, a white sorghum with a pigmented testa. Another common variety in the Kalahout area is *aklamoi*, a brown seeded, goose-necked variety. Planting is in holes at one metre by one metre spacing. Yields of sorghum are said to reach 750 kg/hectare in an average-to-good season, though they are usually lower. It is quite common to see watermelons planted on the bottom bunds, where they can benefit from the relatively good supply of runoff.

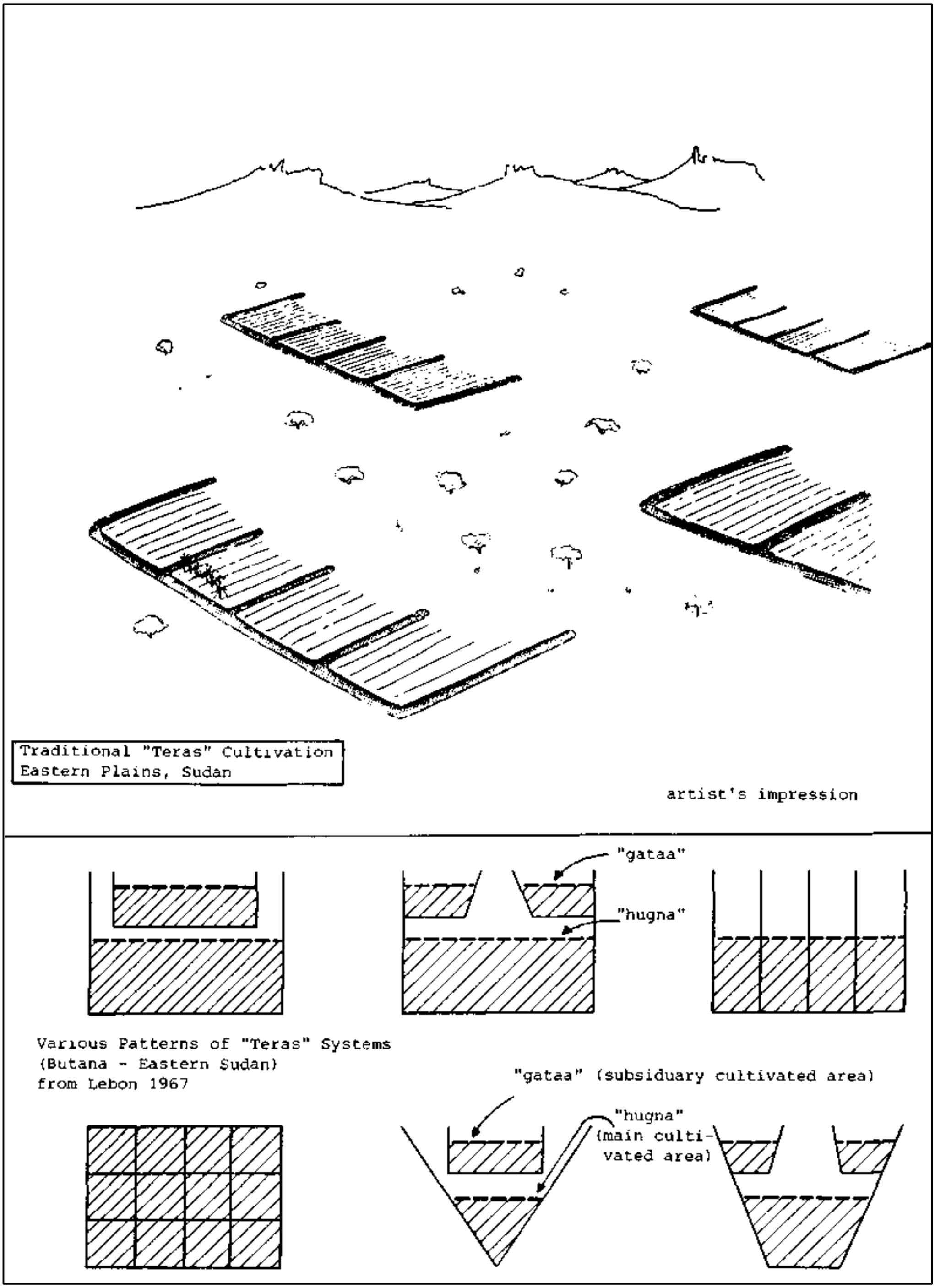
The *teras* system is entirely traditional and all operations are either carried out by the cultivator manually, or by hired tractors which are becoming more common. The only example of direct assistance from an outside source in the Kassala area was the provision of a front loader for bunding by the Soil Conservation Department in 1987. Maintenance of the bunds is required seasonally, but this is a modest task unless breaches have occurred.

The system is very widespread in specific areas. Between Kassala junction and the Atbara River, there are said to be thousands of such plots. The most significant area for *teras*, in the country are the Butana plains, to the west of the Atbara River. There are no training or extension programmes specific to the *teras* system.

Teras systems are not exclusive to the Eastern Region of Sudan and variations can be found as far away as South Darfur, where such bunding is apparently sometimes associated with cultivation of the flood plains of wadis. However, as the term *teras* refers to the bund itself, not all *teras* systems are WH systems; some *teras* on hillsides are for soil conservation.

Within Eastern Region, water spreading from *khors* is commonly used for cultivation. Often spreading occurs naturally when the *khor* bed fans out into a *wadi* or onto a plain. Sometimes local cultivators have built traditional diversions, and even used brushwood barrier to collect wind-driven sand which thus develop into bunds which help spread runoff.

Figure 4: Traditional teras cultivation in Sudan



5. CAMEROON: MANDARA MOUNTAINS (NORTH CAMEROON)

Twenty different ethnic groups practice WH in the Mandara Mountains of Northern Cameroon, though the Mafa are the most skilled practitioners (Boulet, J. 1975; Riddell and Campbell, 1986. Rainfall varies from about 700mm in the plains to 1100mm on the plateaus. Population density is some 250 per square km.

Farmers have an intricate system of indigenously developed terracing of steep slopes. For fertility management, they use household, animal wastes and crop residues. Manure is spread and worked into the soil, and crops are rotated and intercropped. Some cattle are stall fed year round. The two most important trees growing on the terraces are *Acacia albida* and *Khaya senegalensis*.

There have been recent attempts to settle mountain people in the lowlands, which have not been successful. Development efforts so far have not built on, nor have they utilised the existing indigenous knowledge base. Riddell and Campbell (1986) suggest that external intervention might be appropriate in a number of areas:

- water development;
- weed and pest management; and
- increasing crop inventories.

6. SUDAN: DJEBEL MARRA HIGHLANDS (WESTERN DARFUR)

In the Djebel Marra Highlands of western Darfur, the Fur tribe practice terracing systems (Miehe, 1986). Rainfall is 600–1000mm, and the soils are dark humic montane under humid highlands conditions and ash soils. Some 60% of the massif surface is terraced. The population density is currently some 20–37 persons per square km, down considerably compared with 50 years ago. Dung is highly valued, and *Acacia albida* dominates over wide areas where the terrace soils contain large proportions of volcanic ashes. Crop yields were 650–800 kg/ha for millet and sorghum in 1982, a rather bad year.

There is currently considerable migration to the lowlands, inducing a switch from an intensive agroforestry system to simple extensive bushfallow or shifting cultivation practices. There is a decline of tree canopy, and irrigation development on existing terraces based on cash crops.

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Sustainable Agriculture and Rural Livelihoods Programme

The Sustainable Agriculture and Rural Livelihoods Programme

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