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Sustaining the Soil: Indigenous Soil and Water Conservation in Africa

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INTRODUCTION

Soil erosion is widely perceived to be a major problem in sub-Saharan Africa. Most agency reports and government publications highlight the degradation of soils as a major development challenge, but soil and water conservation (SWC) efforts in Africa have had a chequered history. From the early colonial era to the present, attempts have been made to introduce SWC measures in a wide range of settings, yet many have failed. This paper asks why this is so, and whether there is an alternative approach which builds on local traditions in soil and water management. Drawing on the wide range of case studies presented in Reij, Scoones and Toulmin (1996),[1] this paper considers the following questions:

- What are the key characteristics of locally-managed SWC systems?
- What are the conditions for their successful adoption and expansion?
- How can development approaches be more effective in promoting the process of local-level SWC technology development?

SOIL EROSION IN AFRICA: MYTHS AND REALITIES

One of the overriding assumptions driving current policy and informing development interventions across Africa is that soil erosion constitutes a major problem. There have been a number of influential studies carried out over the last 50 years which measure the degree of soil loss resulting from different agricultural and livestock management practices. However, most of these studies derive from plot-based measurements which are then extrapolated to estimate total soil loss per hectare. There is no problem with such estimates when the measurements and the scale they refer to are fully acknowledged, but too often this is ignored and figures are extrapolated from a small plot to wider and wider scales making the conclusions drawn from such extrapolations largely meaningless.[2]

While it is certainly true that soil erosion is undermining agricultural production in certain places, the crisis may not be as prevalent as some studies suggest. Indeed a concentration on soil loss as 'the' major issue has eclipsed other important production constraints such as plant available water, soil nutrient levels, labour availability, market incentives and so on. What is urgently needed is a more sophisticated debate on the nature of soil erosion, its implications and consequences.[3]

STANDARD SOLUTIONS FOR STANDARD PROBLEMS: THE CONVENTIONAL APPROACH TO SWC

Alarm about the potentially damaging consequences of soil erosion has prompted a long history of external intervention in SWC measures in Africa, as elsewhere.[4, 5, 6, 7] The experience of the Dust Bowl in the United States proved highly influential in policy thinking from the 1930s onwards.[8, 9] This was compounded in southern Africa by the experience of drought. In South Africa the Drought Commission reported in apocalyptic tones:

> Enormous tracts of the country have been entirely or partly denuded of their original vegetation, with the result that rivers. *vleis* and water holes described by old travellers have dried up or disappeared.... the logical outcome of it all is the Great South African desert, uninhabitable by man.[10]

The prospect of such disasters afflicting the newly established colonies worried many administrators and politicians. Major programmes of soil conservation were initiated in some parts of Africa, where the colonial state was strong and there was a need to ensure that demands for land by African farmers did not undermine the expansion of large-scale, European-owned commercial farming enterprises. The result was the emergence of a set of interventions focused on the mechanical conservation of soil: soil bunds, ridging, contour ploughing and so on.[11, 12, 13, 14, 15]

By the late 1940s, a wider set of environmental concerns had come to influence colonial development thinking: soil fertility decline, overgrazing and deforestation had been added to the list of ills inflicted on the land by African farming and livestock husbandry. This more comprehensive view of the environmental problem suggested a wider approach to land management which went beyond individual SWC techniques. By the 1950s an era of land-use planning emerged based on a set of land husbandry principles.

In many areas the land husbandry package was rejected by local people. Farmers felt that the imposition of a particular model of land use practice undermined their existing agricultural management practices. In Southern Rhodesia colonial policies banned traditional wetland and river bank cultivation and so limited people's coping strategies in dry years; they enforced reductions in cattle numbers undermining people's ability to survive during drought; and they forced people to build a standard design of contour ridge to conserve soil and drain away water from the field, often with detrimental effects on productivity.[16, 17] Not surprisingly, in such situations colonial soil conservation and land husbandry measures were resisted, and in many countries they became the focus for nationalist opposition in the rural areas, leading to the widespread destruction of conservation structures, as a form of political protest.

However, in some places the suite of techniques and management practices offered by the land husbandry approach was widely adopted by farmers eager to invest in agricultural transformation. The well-documented case of parts of Machakos district in Kenya is a good example. Here, increasing population densities and resultant land scarcity combined with improved access to the growing market of Nairobi. Access to information through informal networks, as well as formal extension advice, enabled farmers to try out a range of conservation measures. From the mid-1960s a major transformation of the farming landscape took place with huge voluntary investment in conservation works resulting in falling erosion rates, increased environmental rehabilitation and a boost in agricultural productivity.[17] Another example of a successful transformation can be found in Swaziland.[18]

During the 1960s and 1970s, development attention focused on the need to modernise and transform supposedly backward agriculture to raise yields and productivity. SWC technologies, it was argued, could play their part, and some grand schemes were dreamt up. Large project areas across Africa became the experimental laboratory for ambitious engineers with a vision. The results of these adventures are now well known. For instance, in northern Nigeria, attempts to encourage irrigated agriculture around Lake Chad collapsed very quickly with changes in the environment.[19] Equally, in Burkina Faso, the GERES project used earth-moving machinery to construct a dense network of bunds. However, only two-and-a-half years after the project's start in 1962, it was abandoned as farmers failed to maintain the bunds. Engineering solutions did not bring about a sudden modernisation of agriculture; other constraints lay in the way of dramatic transformation.

But developers were not to be put off, for the 1970s provided another spur for action. Much as the 1920s drought in southern Africa had sent shock waves through the British colonial administration in Africa, the 1972–73 drought in the Sahel set alarm bells ringing in the international development community. Some of the most emotive media images in recent times have been of destitute and starving people, struggling to survive in apparently barren, degraded landscapes of dry Africa.

It was during this period that the term 'desertification' entered the international development lexicon. It had first been widely used many years before by Aubreville during the period of environmental furore that had characterised the 1930s and 1940s.[20] However, with growing concern about the links between environmental degradation and famine during the 1970s, the term was revived. At the policy level a growing swell of concern culminated in the United Nations Conference on Desertification of 1977 held in Nairobi.[21] Here delegates from around the world committed themselves to a global plan to combat desertification, and major international investments were made in environmental protection in Africa over the following decade.[22] 'Anti-desertification' projects became commonplace in Africa during the 1970s and 1980s, and SWC measures were central to their design.

Many of these projects were remarkably reminiscent of the earlier large-scale colonial interventions. For instance, in Ethiopia, following the devastating drought of the mid-1980s, the Derg regime, backed by international aid funds and food relief, initiated a programme of SWC in the highlands. The influential Highlands Reclamation Study[23] provided the justification and the familiar range of soil conservation measures provided the technological solutions. The study predicted that by the year 2010, seven per cent of the highlands would be bare rock, eleven per cent would have soil depths of less than 10cm and a further 76,000km^2 would be incapable of sustaining agriculture. These were dramatic conclusions. A standard package of interventions was evolved[24] and implemented on a wide scale throughout the latter half of the 1980s. The Derg regime's political need to exert control over the rural areas coincided with the flood of food aid and development projects that arrived in the aftermath of the 1984 drought. Around US$20 million was disbursed annually as food-for-work between 1980 and 1990.[25]

At one level, the result was impressive. Thousands of kilometres of bunds were built, thousands of hillsides were closed off, steep-slope agriculture abandoned and millions of trees were planted.[26] However, there were high costs. The lack of involvement of people in the planning and implementation of the schemes meant that they were often poorly executed and maintained. In addition, in some places the imposed measures disrupted existing SWC measures, replacing them with alternatives less suited to the local setting. The focus on soil erosion as the core problem also detracted attention from the wider problems faced by rural people; without addressing such issues there was little chance that the soil conservation measures would be widely adopted without significant subsidy and, in some instances, coercion.[27]

At varying scales and to varying degrees a similar story has been repeated in many parts of Africa.[5] By the late 1980s, a growing realisation emerged that soil conservation was not the whole answer. Again the parallels with the colonial period are striking. Indeed the same terms were resurrected. Instead of soil conservation, a wider concept of 'land husbandry' was expounded.[28, 29, 30] Such approaches argued for bringing together a wide range of technologies to deal with the broader environmental problems faced by smallholder farmers.

PUTTING PEOPLE FIRST: PARTICIPATORY APPROACHES TO SOIL AND WATER CONSERVATION

The one important difference between the advocacy of SWC and land husbandry today and colonial precursors is the current emphasis on people's participation. The lessons from the 1960s onwards taught project planners and policy-makers alike that imposed projects just do not work, certainly in the longer term. Advocates of a more participatory approach to development argued forcefully for 'putting people first.'[31] Wider trends of democratisation, decentralisation and the retreat of the state have meant that participation has become both politically appropriate and practically necessary.

This constellation of factors has prompted the emergence of a new style of natural resource management intervention based on holistic, village-based resource management involving a participatory process in planning and implementation. This type of approach is now widely endorsed and representative of a broad consensus about development intervention in the 1990s. Donors and national governments have adopted, at least at a rhetorical level, the language of participation and land husbandry. This is reflected at every level from village project plans, through national environmental strategies and plans to global conventions. The Earth Summit in Rio in 1992 successfully raised environmental concerns at the level of global politics for the first time since the early 1970s. The follow-up strategy for the next century contained in Agenda 21 is replete with hopeful statements about how people's participation is the appropriate route to effective land management.[32] The Convention on Desertification, in contrast to the global and national plans of action to combat desertification developed in the 1980s, is equally strong on the rhetoric of supporting local level, participatory processes, and placing less emphasis on seeking technological solutions to perceived environmental decline.[33]

The shift to local-level planning, appreciation of indigenous techniques and acceptance that there are limits to technological solutions to complex land management problems are undoubtedly a step in the right direction. But, as experience emerges from this new generation of projects, some important questions are emerging.

First, the distance between the rhetoric and reality of participation means that many projects are simply a new vehicle for the imposition of technological solutions. This time they may be more people-friendly (agroforestry, woodland management, small-scale soil conservation and water harvesting systems etc.) than the grand engineering schemes of the 1960s and 1970s, but it is questionable whether they are any more sustainable once the project subsidies have been removed. Second, the well-polished populist rhetoric of community participation may mask hidden conflicts, diverse interests and unnoticed costs. Peter Gubbels observes:

> 'Putting farmers first' is striking, resonant rhetoric, but not easy to put into practice. It requires deciding 'which' category of farmers should come first. 'Not' deciding inevitably means that local elites come first. Indeed, to achieve goals such as promoting self-reliance, peasant organisation and community environmental management, outside intervention is often not able to avoid working with rural power structures and may have to compromise on equity issues.[34]

Characteristics of indigenous SWC techniques

Before describing some of the key characteristics of local SWC practice, it is important to establish what we mean by 'indigenous SWC techniques.' There has been a lot of debate in recent years about the importance of what has come to be known as 'indigenous technical knowledge' in the process of technology development.[35, 36] But what is 'indigenous' and what is 'technology'? Both are contested terms and difficult to define. For our purposes indigenous refers to local practices, as distinct from interventions imposed from outside. However, many practices that may be regarded as indigenous today may have been derived from elsewhere in the past. Indeed, many 'indigenous' techniques have been derived from migrants living in or passing through the area, learned during journeys to other places or adapted from interventions imposed during the colonial era. We are not concerned so much with a static notion of indigenous knowledge and technology, apparently frozen in time, stuck in history. Instead, we are interested in the dynamics of technical change, how innovations are adopted and transformed, how technologies evolve through incremental adaptation and how current practices are the result of cumulative responses to a range of influences over time.

This dynamic interpretation of indigenous SWC leads us to a wide-ranging perspective on technology. SWC technologies are not simply structures defined strictly by engineering parameters; they are the sum of practices involved in managing soil and water in agricultural settings and they also include agroforestry, agronomic and tillage practices. Any analysis of technology must therefore be situated within a social and economic understanding of the role of the technology, the rationale and purpose of its design. Technologies arise out of particular sets of historical and social circumstances, different people have different attitudes and commitments to them and, because of the dynamic influences over their origin and maintenance, they continuously evolve and change.

Thus, most local SWC practices have designs that reflect their multiple functions.[37,38] Soil conservation and water harvesting may have different priorities depending on the average rainfall in the area, the soil types and the position of the site within the landscape. For instance in wetter areas, leaching of soil nutrients and sheet erosion may be a serious problem for agricultural production, and soil conservation measures may be of paramount importance.[39] By contrast, in drier areas, water is the major constraint to agricultural production and so the technologies are designed to capture and spread water to key agricultural sites.[40, 41] This trade-off between soil nutrient management and soil moisture management is central to current understandings of the production dynamics of African savanna environments.[42]

Technologies must also respond to environmental change. This may be through shifts in climatic patterns or local changes in landform.[43, 44, 45]

Types of SWC technique also vary within landscapes. Generally, at the lower point in the slope, sink sites form where soil and water collect. Such areas include a variety of wetland patches within dry areas,[46] with examples including the *wadis* of Sudan, *mbuga* of Tanzania, *dambos* of Zimbabwe and Zambia and lake-shore sites in Nigeria.[1] Within dry areas, such sites are highly valuable, constituting key resources in otherwise fairly low value landscapes. The potential productivity of these low-lying areas is often high, although they tend to demand higher labour inputs than dryland cultivation. Under certain conditions, it may pay to invest in complex SWC measures in these areas in order to maintain high soil moisture and nutrient status, managing seasonal variations of flooding and drought in order to maximise production. For this reason, such sites tend to have the most elaborate forms of SWC technology.[47,48]

Unlike conventional engineering designs of SWC structures which are specified in technical manuals and extension handbooks with precise dimensions and design requirements, local SWC techniques are much more flexible.[49] Flexibility is important as field topography varies greatly from site to site. Soil distribution within the field also changes, demanding new designs for new conditions. Ethno-engineering is a result of 'adaptive performance,' rather than a timeless response to a technical design problem.[43, 50, 51]

Indigenous SWC measures therefore tend to spread labour requirements for construction and maintenance. Again, this contrasts with most introduced techniques which require major investments of labour in construction, often during a single period. Gender differentiation of labour inputs is common, with men often being involved in discrete, time-bound activities such as construction, while women are relied upon for on-going labour inputs such as the maintenance of structures. This division may result in conflicts when men engage in construction (the most likely activity to be subsidised by development projects), while women are not prepared to invest their time in long term maintenance. Gender differences in labour investment may also shift with changes in the value of different landscape components for farming. For instance, in southern Tanzania, men are increasingly taking up gardening in lowland sites, activities that were previously the preserve of women.[48] This may result in changes in the way gardening is practised, with new technologies with different labour requirements being adopted. However, in other areas, where high levels of male outmigration exist, women must take on the full range of tasks. In such areas, labour shortages may be an important reason for the low levels of investment in SWC on small holder farms.[52] In the past, mobilising group-based labour through cooperative work parties has been an important way of alleviating household-level labour shortages, especially for construction activities. However, a number of studies report that such practices are on the decline as the social networks upon which they are based fragment.[53, 54]

Conditions for Success

What are the conditions for the success of SWC systems? Several recent studies illustrate the wide diversity of situations throughout Africa, from areas with extremely low population density in the arid zones, through to high population density areas in some semi-arid and humid zones; and from areas well served by infrastructure with good access to markets, to remote areas far from urban centres, without good road connections and where subsistence production dominates. Equally, the histories of external intervention, access to information on new technologies and broader policy environments all differ between regions.[1]

Table 1 summarises some key characteristics of the regions documented in the collection of case studies presented in *Sustaining the Soil*[1]. The table includes a description of the region and the ethnic or language group, contrasting rainfall, population density and crops grown and relating these to the SWC techniques found at each site.

It is a difficult task to dissect the interaction of influences that condition the success or failure of particular SWC techniques in particular places at particular times. So many factors interact often in conjunction during periods of crisis, that any simple explanation for technological development is always lacking without historical insights.[55,56] However, there are a number of important themes, and these are highlighted below.

Population densities

A wide range of population densities may be found throughout Africa. As Ester Boserup[57] and many others have noted, population density has a major impact on the processes of agricultural intensification.[58,11] With higher population densities, agricultural plot sizes shrink and land, rather than labour, becomes a key constraint to production. This in turn provides incentives for investing in new technologies, conserving the resource base and through this, increasing production.[44, 59]

Access to land and labour, however, may be highly differentiated within a village community, resulting in different dynamics of intensification. Equally, within a household men and women may control different types of agricultural plots, resulting in different types of investment. Often women's plots are small and thus, for them, land enhancing investments are most likely.[60]

Of course, a range of other factors must interact to encourage the process of intensification, but the evidence certainly suggests that rising population density is one of a number of important preconditions for investment in SWC measures. This argument runs counter to the oft-repeated Malthusian view that population growth will inevitably outstrip food supplies, resulting in environmental degradation, collapse in food production and ultimately starvation or forced migration.

What is the evidence to support these different scenarios? It is certainly true that in the areas with the highest population density we find the most elaborate SWC structures.[50] By contrast, the level of labour investment is far lower in low population density areas.[19, 41] But population density provides only part of the explanation, for there are also cases with high population density coupled with low voluntary investment in SWC, as well as areas with relatively low population densities where highly elaborate SWC measures can be seen.[40, 41] The following sections explore a variety of other factors which are influential in providing the conditions for the successful spread of SWC.

Table 1: Characteristics of African regions: from drier to wetter areas[1]

Country	Region	Rainfall (mm)	Pop. density persons/ km^2	Ethnic/ language groups	Major crops	SWC techniques
Sudan	Red Sea Hills	25–150	1–10	Beja	sorghum, millet	earth bunds
Morocco	High Atlas Mountains	45–340	1–10	Mgouna	barley, wheat, maize	bench terraces
Sudan	Central Darfur	100–400	10	Fur, Zaghawa	sorghum	earth bunds
Morocco	Rif Mountains	350–450	10–20	Berber	wheat, barley, fruit trees	bench terraces, stone bunds, step terraces
Morocco	Rif Mountains (east)	400	100	Berber	cereals	stone walls, terraces
Morocco	Rif mountains (west)	400	100	Berber	wheat, barley, pulses, hemp	bench terraces
Niger	Tahoua	350–450	22	Hausa	millet, sorghum	improved planting pits
Nigeria	Borno State	250–500	37	Kanuri	sorghum	earth bunds
Mali	Djenné	275–600	28	Bambara	millet, sorghum	

Country	Region	Rainfall (mm)	Pop. density persons/ km^2	Ethnic/ language groups	Major crops	SWC techniques
Mali	Dogon Plateau	500	25–80	Dogon	millet, sorghum, vegetables	micro-basins, pitting, stone bunds
Zimbabwe	Masvingo Province	400–600	45–60	Shona	maize, millet, sorghum	modification of contour ridges
Burkina Faso	Yatenga	400–700	20–130	Mossi	millet, sorghum	improved planting pits, stone bunds
Burkina Faso	Central Plateau	400–800	40–100	Mossi	millet, sorghum	mulching, contour stone bunds
Zambia	Northern Province	650–850	10+	varied	cassava, maize	raised-bed cultivation
Tanzania	Maswa District	600–900	50–70	Wasukuma	rice, cotton, maize, sweet potatoes	earth bunds
Ghana	Upper East	800–900	204	Frafra	sorghum, millet, groundnuts	stone bunding
Tanzania	Rukwa region	900–1000	30	Wafipa	maize, millet, beans	mounds
Cameroon	Mandara mountains	400–1200	40–100	Mafa, Mandara	sorghum, millet	bench terraces, stone bunds
Malawi	Southern region	500–1300	220–292	Lomwe, Yao, Chewa, Sena	maize, sorghum	contour bunds, strips, vegetation barriers

Country	Region	Rainfall (mm)	Pop. density persons/ km²	Ethnic/ language groups	Major crops	SWC techniques
Swaziland	Swazi Nation Land	400-1500	30-65	Swazi	maize	grass strips
Ethiopia	Hararge	700-1100	230-410	Oromo	sorghum, coffee, chat	earth bunds, bench terraces
Ethiopia	Northern Shewa	1350	70-200	Amhara	barley, wheat, pulses	drainage ditches
South Africa	Transkei	750-1400	84	Xhosa	maize	adaptation of contour banks
Tanzania	Njombe District	900-1600	30	Wabena	finger millet, maize, beans, potatoes	raised-bed cultivation
Tanzania	Mbinga District	900-2000	35-120	Matengo	coffee, maize, beans	pits
Nigeria	Jos Plateau	1000-1500	70-280	Berom, Hausa	vegetables wheat, maize	basin irrigation
Nigeria	Enugu	1600-2000	335	Igbo	yams, maize, cocoyams vegetables	bench terraces
Cameroon	Bamiléke Plateau	≥3600	50-275	Bamileke	maize, cassava, yams	ridge cultivation hedge barriers

Investment and access to capital

The lack of capital markets and, in particular, the lack of formal credit opportunities is often highlighted as a serious constraint to investment in new technology. However, it is not clear that credit is, in fact, a major constraint. The uncertain returns from investment in dryland agriculture, and conservation measures in particular, mean that formal credit arrangements are unlikely to work effectively. In any case, small-scale SWC does not require major capital investment and therefore there is limited need to mobilise cash, except for the payment of labour in some cases. In much of dryland Africa, non-farm income is a key substitute for credit.[61] But whether such income is invested in agricultural technology depends on the profitability and riskiness of investment returns.

Returns to SWC investment
It is notoriously difficult to assess the returns to SWC investment. Studies on the returns to SWC in Africa are few and far between. Too often it is assumed that SWC is automatically beneficial, without looking in detail at the costs and benefits. Those few studies that have been carried out relate to large scale mechanical conservation works and show that in most cases returns are negative.[45, 62, 63]

Some proponents of SWC programmes argue that calculation of immediate returns should not be a concern since such measures are aimed at long-term conservation which must attract external subsidy in order to assure intergenerational equity and to offset wider costs of erosion. But given the constraints on government budgets and the contraction of aid flows to Africa, cost-effectiveness, even in the short term, will remain an important priority for project planners, as it always has for farmers. The limited occasions where subsidies may be justified would include instances where major divergences arise between private and social costs and benefits, such as cases where off-farm or downstream effects are significant.[64] Even in such cases, caution in offering subsidised inducements must be heeded.

Experience shows that subsidies may well alter behaviour and encourage investment, but this may not be sustainable and as soon as the subsidy is withdrawn farmers switch to more cost effective strategies. This pattern is highlighted again and again in the history of SWC in Africa.

Markets and infrastructure
The incentive to invest in intensification will increase as the value of the output rises. But, without good infrastructure and access to markets, the growth in economic incentives may not parallel demographic pressures, and the spontaneous innovation and spread of SWC may not take place. However, if a good road system and competitively priced transport provide access to

urban markets with high demand then crop values increase, resulting in higher incentives to invest for long term gain.

The policy environment that governs both the working of markets and patterns of public investment in rural infrastructure is also critical. In the past, state intervention in agricultural production and marketing has often constrained opportunities.[47] More recently, structural adjustment policies in many African countries have resulted in the liberalisation of markets, the abolition of parastatal marketing agencies and the encouragement of export crops through price reforms.

Two contrary views exist about the likely effects of market liberalisation and improved crop prices on incentives to manage and conserve soils in Africa.[65, 66] Some observers expect that agricultural reforms which bring increased crop prices should encourage more people to remain in rural production and invest in the land. Hence, rising crop prices should bring higher levels of soil conservation, as farmers expect higher returns from their land now and in future.[67] Others argue that higher crop prices may just as well encourage a rapid soil 'mining,' with farmers trying to gain the maximum immediate return from their soils, but no necessary increase in investment in the conservation of soils and their fertility.[68] The reaction of land users to crop price increases is likely to depend on several factors, such as their dependence on the continued cultivation of this land as a source of income. Where land is in plentiful supply, or where the cultivator can easily move into other fields of economic activity, there may be little long term interest in maintaining soil fertility, so that rising crop prices bring accelerated mining of nutrients. The degree to which farmers will change their SWC practice as a result of price changes also depends on their willingness to trade-off income now against income in the future, and whether they confidently expect to benefit from current investments, itself dependent on security of tenure.

Liberalisation of agricultural prices and currency devaluation have also led to changing cropping patterns, with exportable crops generating higher returns. There is no evidence to date, however, for export crops being associated with either more extractive, or more conservative soil management. Soils under groundnut cultivation have been noted as being particularly vulnerable to erosion, given the complete removal of vegetation at the time of harvest. By contrast, tree export crops, such as cocoa, coffee and tea, provide perennial cover and reduce risks of erosion.

Structural adjustment and liberalisation of agricultural markets have also brought substantial increases in fertiliser prices, as a result of devaluation and the abolition of subsidies. In general, inorganic fertiliser can be considered a substitute for labour invested in soil conservation and improvement. When fertiliser becomes more expensive, farmers are likely to economise on its use and ensure minimum losses occur by investing labour in soil management and conservation to prevent runoff of nutrients. Hence, it might be expected that investment in SWC will increase as inorganic fertiliser becomes scarcer.[53, 69] The effects of liberalisation are also influenced by levels of public investment to complement the reform policies. In places where no roads exist, where they are poorly maintained, or where limited transport results in high prices, any benefits of structural reform are barely felt. Indeed, with the withdrawal of subsidies on marketing (e.g. through parastatal pricing), people living in such areas may suffer reduced incomes and lower incentives to invest in SWC.

Security and tenure rights

Investment in SWC will depend on the willingness of farmers to expend labour now for increased benefits which may be obtained in the first year (in particular in semi-arid regions) or some time in the future, for instance, in the case of agroforestry practices. This means that people must feel confident of secure benefits from this investment. But insecurity can arise in a variety of ways.

Conflict and war currently affect large parts of Africa, resulting in major disruption to rural life and production systems. Clearly under such conditions people are unlikely to invest in SWC if it is unsure whether they will be living at the same place in the next few months. On the other hand, war or raiding has sometimes resulted in the origin of major SWC investments, as people retreated into confined refuge areas.[53, 70]

Insecurity may also arise through heavy-handed development interventions. For instance, people expecting, or fearing, displacement may be unwilling to initiate SWC measures of their own. The history of SWC in Africa has unfortunately been characterised by forms of external intervention that have undermined local initiatives.

Tenure insecurity is another important factor which reduces people's willingness to invest in environmental management. Some argue that it is only with privatised land and exclusive tenure that people will be willing to make significant contributions to SWC. There is some evidence to support this claim. For instance, in Malawi much greater investment in SWC is found on private farms and tea estates as compared to smallholder farms.[52] However, the reasons for this do not lie only in the tenure system of the two areas.

Neglect of the small-scale sector over many years has meant that people are required to work as short-term contract labourers on the tea estates and the large private farms, thus withdrawing labour from their own small plots of land.

The introduction of new technology may result in changes in tenure regime as land changes value. For instance, in western Sudan, the introduction of earth bunds, particularly with land moving machinery, has opened up opportunities for cash cropping by merchants and businessmen, resulting in the effective privatisation of high value *wadi* land.[40] The flexible traditional system regulated by community and tribal leaders was thus usurped, and local farmers lost out. By contrast, in the Red Sea Hills, in another part of the Sudan, access to land, and water resources is tightly regulated by Beja tribal groupings, preventing outsiders and elites from taking over these assets.[41]

In some areas, SWC measures have been developed on common land which is managed and controlled by community groups. In such situations, effective enforcement of common property rights is vital for successful resource management. Key conditions for success include the existence of local organisations where a common set of purposes for resource management are agreed. Such organisations must be able to agree on a set of rules, to exclude other users and to employ effective sanctions against 'free riders.' Relatively small, cohesive groups with strong leadership appear the most effective, especially when they are managing resources which are perceived as valuable and easy to protect with relatively low transaction costs involved.[44,45,71,72,73]

In general, there is no clear evidence of investment in land improvement being higher in areas where land title exists compared with where land is held under customary rights of use. It appears that the *de jure* system is less important than the *de facto* tenure regime, so long as secure land rights are guaranteed through customary tenure.[74]

Access to information and technology

Options for SWC evolve with changing access to information and technology. In some cases, the new forms of technology that emerge are combinations of previous practice and introduced innovation. The flexible combination of the old with the new draws on outside sources as well as on generations of local knowledge and practice, and offers an important route to success. However, some traditional practices may not be relevant in today's settings. Just as farmers reject externally imposed interventions that are inappropriate, so too will they abandon indigenous techniques. More important than the technique or technology itself is the process by which it arises; how different information sources and technological choices are derived from a little scientific experimentation and a lot of farmer practices. Building on tradition, rather than either replacing it or re-imposing it, is the key to success.

Building on tradition: supporting indigenous SWC

Farmers across Africa have always understood changes in their local environment and assessed the problems they face. They have needed to design, select and adapt technologies in order to survive and prosper. Their ability to do so successfully is moderated by social networks and local institutions. External intervention adds another dimension to this process. In the final section of this paper the question is asked: how can external intervention build on tradition, and facilitate technological innovation by farmers?

Indigenous and introduced: complementarity or conflict?

As already noted, the distinction between indigenous and introduced technologies is, in many cases, artificial. Indeed it is the fluidity in the processes of technological change that is striking. However, when introduced technologies are imposed, and prospects for local adaptation are constrained, problems arise. For the development planner and project administrator, the appeal of an 'off-the-shelf' technical package is high. Simple diagnosis of a problem over wide areas means that a standard solution can be applied. Administrative procedures for delivery are predictable, equipment needs, labour demands and costs can easily be calculated, and schedules for implementation set, with pre-determined physical targets and monitoring and evaluation procedures. Driven by the logic of internal planning frameworks, such projects have been, and continue to be, implemented on a large scale.

One of the big driving forces behind this style of SWC project in Africa has been food aid. Mechanical SWC appeared the ideal vehicle for the range of food and cash-for-work schemes that are popular components of food aid distribution and employment based safety net programmes in areas suffering chronic food shortages. Experience over the past decades has proved, however, that such programmes are by no means always successful.

The large-scale campaign approach to SWC is largely incompatible with locally generated technology, as demonstrated in Table 2. It is not so much that externally derived technology is necessarily inappropriate; more important is the manner by which the technology is introduced. Large-scale food-for-work programmes aim to mobilise large amounts of labour for simple tasks within a short space of time, an approach which is fundamentally incompatible with supporting indigenous SWC practice.

Table 2: Characteristics of externally and locally derived SWC technologies

Characteristics	External	Local
Designed by	Engineers and development planners	Local farmers
Designed for	Soil conservation	Multiple, depending on setting (including soil/water harvesting, conservation, disposal)
Design features	Standardised in relation to slope features	Flexible, adapted to local micro-variation
Construction	One-time	Incrementally (fitting with household labour supply)
Labour demands	High	Variable, generally low
Returns	Long-term environmental investment	Immediate returns
Project setting	Large scale, campaign approach; food-for-work/cash-for-work/employment based safety net programmes etc.	Longer term support to indigenous innovation; participatory research and farmer-to-farmer sharing

Participatory processes: building on local practices and supporting farmer-to-farmer spread

A participatory approach to rural development is at one level much more modest than the grand scale campaign approach typified by the food-for-work schemes described above. But at another level it is much more ambitious.

Participatory approaches in the development of SWC provide a bridge between indigenous and external expertise, with the resulting interventions often being interesting hybrids, drawing inspiration from a number of sources.

The conditions for success are multiple, combining a conducive policy environment, effective institutional setting, access to a range of participatory methods and approaches, and personal changes among researchers and development workers.[75] The researcher and development worker must acquire new skills, new attitudes and new behaviours.[76, 77] Rather than planning, directing and enforcing, s/he must facilitate, convene, catalyse and negotiate. Rather than technological outputs, the focus is on the process by which technologies arise, become adapted and spread. Rather than dividing responsibilities between researcher, extensionist and farmer, roles combine and joint activities are central. These are big changes to the conventional, linear model of technology development. But they are proving successful. With the shift made from a high level of external intervention in design, planning and intervention, to a more facilitatory role, costs also drop, especially after an initial emphasis on training and local capacity building.[78]

Successful participation therefore involves major reversals, certainly in professional behaviour and attitudes, but more fundamentally in power relations between different actors in the development process.[79] This provides some very basic challenges for development organisations wishing to develop a participatory approach to SWC and natural resource management more generally.

CONCLUSIONS

The challenge of supporting more effective environmental management in Africa is huge. Three issues stand out from our earlier discussion of indigenous SWC and its ability to sustain the soil for the future.

First, we must be wary of simple definitions of a complex 'problem'. Much effort is expended on designing and disseminating 'solutions', but too little time is spent on understanding the problem. We have to ask from where our definition of a problem arises: What data are being used to describe the problem? What evidence is emphasised, and what issues are ignored? What are the political interests involved in describing a situation? With more reflection on assumptions made by the various actors in the development process, more effective solutions will hopefully emerge.

Second, we must recognise that technology exists not simply as an engineering design, but in a social and economic context. For a technology to be attuned to people's needs, local environmental conditions and economic factors, it must be flexible and adaptable. Rigid prescriptions and designs do not work.

Finally, participatory approaches, while clearly desirable, are not uncomplicated. Simplistic adherence to 'community management' may mask important differences, between men and women, between young and old, between rich and poor. Any intervention inevitably affects the balance of interests within and between groups, with some winning and others losing. It is vital to appreciate the political consequences of development activity. This means recognising conflict, rather than ignoring it, and so encouraging a process of negotiation and choice, involving all actors, in development planning and implementation.

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Drylands Programme

The Drylands Programme aims to contribute towards more effective and equitable management of natural resources in semi-arid Africa. It has built up a diverse pattern of collaboration with many organisations. It has a particular focus on: soil conservation and nutrient management; pastoral development; and land tenure and resource access. Key objectives of the programme are to: strengthen communication between English and French speaking parts of Africa; support the development of an effective research and NGO sector; and promote locally-based management of resources, build on local skills, encourage participation and provide firmer rights to local users.

It does this through four main activities: collaborative research, training in participatory methods, information networking and policy advice to donor organisations.

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