Critical Review of Dryland Restoration in Tanzania: Elements of Success and Failure & Technologies Employed

Authors: Harry B. M. Wells & Leigh A. Winowiecki
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World Agroforestry Centre (ICRAF), Nairobi, Kenya

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Photo of a Dryland Landscape in Central Tanzania. Credit: Tor-Gunnar Vågen, ICRAF.

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I. INTRODUCTION – Degradation in the Drylands of Tanzania

Arid, semi-arid and dry sub-humid areas cover 61 % of Tanzania (United Republic of Tanzania, 1999) and, over the past decades, several restoration projects have worked toward reversing degradation in these areas (Kikula, 1999; Kisanga *et al*., 1999). These projects have addressed from social and ecological perspectives and have spanned for decades, thereby allowing for a genuine opportunity to identify and articulate lessons learned and develop good practice guidelines for restoring productive capacity of drylands. We have conducted a critical review of experience in the drylands in Tanzania using both published literature, project documentation and grey literature to learn from past successes and failures.

Restoration of social-ecosystems is a complex process with many interacting variables that affect outcomes and the degree of success. Thus, it is difficult to tease apart interacting influences that lead to success/failure of particular techniques in particular places and times. There are also issues with extrapolation to other social-ecosystems due to spatial (e.g. biophysical/socio-economic/cultural) and temporal (e.g. rainfall amount/distribution) variability. However we try to assess social, ecological and economic impacts and causes of land degradation.

Land degradation is a result of a complex interaction between biophysical and socio-political factors, so it is important to begin by using these factors to contextualise land degradation in Tanzania. From the biophysical perspective, despite the tendency to regard land degradation in Tanzania as being of relatively recent origin, caused solely by anthropogenic impacts, reports from early travellers indicate the existence of pockets of degradation in the late 19th century (Kikula, 1999). In fact, synthesis of geographical, environmental and anthropological evidence suggests that soil erosion in certain areas has a far deeper history. In the Kondoa Eroded Area (KEA), for example, two main phases of soil erosion can be identified. The first has been dated to between 11,400-14,500 years ago, using optically stimulated luminescence dating of colluvial sediments, and is thought to have been caused by tectonic activity (crustal movements) and climatic fluctuations towards the end of the Pleistocene (Eriksson, Olley, & Payton, 2000; Eriksson, Reuterswärd, & Christiansson, 2003). The second began at least 900 years ago, intensifying around 1,200 AD, and has continued until today. This has been suggested to have resulted from the introduction of arable iron-smelting and animal agriculture (Eriksson et al., 2000). It appears that the cause of soil erosion cannot be attributed to a single anthropogenic (e.g. overstocking or deforestation) or natural force (e.g. climate), but both processes have exerted differential influence through time. Furthermore, ethnographic and archaeological information suggests that local communities have been living with – and adapting their land use practices to – soil erosion for hundreds of years (Lane, 2016). From the socio-political perspective, soil erosion has been a growing concern in Tanzania since the 1920s (Gillman, 1930; Kikula, 1999), and has been greatly influenced by three events: i) colonialism ii) independence (*Ujimaa* and villigisation), and iii) economic liberalisation (Kisanga, 1999; Ylhäisi, 2003).

Colonial era (1891-1961): Tanzania was first colonised by Germany then Britain. Like other colonialists, the Germans were interested in natural resource management (NRM) and production. The German colonial administration often challenged the traditional institutions and the village-level social conventions that previously managed natural resource use. Consequently, social divides formed between farmers cultivating export and traditional crops. During British rule, authors suggest that traditional regulations governing land tenure, sustainable production and distribution deteriorated (Ylhäisi, 2003). A major environmentally activity during this period was the clearing of woodlands to eradicate tsetse flies during the 1920s (Barrow, 2014; Kikula, 1999). However, awareness of land degradation rose and, and following World War II, several large-scale land management-related schemes were developed under the Colonial Development Welfare Act, including: the Uluguru Land Usage Scheme (1944-1955); Usambara Mountains Development Scheme (1946-1958); and Sukumaland Development Scheme (1947-1957). Activities included tree-planting, contour ridging and crop planning, but these schemes were largely unsuccessful due to: inadequate planning; high labour costs; disregard for culture and social organisation of local people; and rejection of activities related to colonialism.

Independence (1961 onwards): After Tanzania gained independence, conservation initiatives, now firmly associated with colonialism, were expected to come to an end. This led citizens to disregard conservation through a form of civil disobedience. In addition, politicians used antagonism towards such initiatives to rally support, for example, promising to reintroduce livestock previously evicted as a rehabilitation measure (Kikula, 1999). The 1967 Arusha declaration expressed Tanzania's socialist guidelines (or *Ujimaa*), and nationalisation of land removed local people's rights to natural resources, and so too their incentives to conserve them. Another important outcome was villagisation, which resulted in over half of the rural population being relocated between 1973-1976. This was based on the premise that centralised provisioning of services would improve development (Barrow, 2014; Enfors & Gordon, 2007). Concentration of people and activities during villagisation facilitated administration, but prevented sustainable, locally adapted traditional land use practices, and increased the pressure on natural resources via deforestation, overgrazing and soil erosion (Barrow & Mlenge, 2003). In 1972, Tanzania began a decentralisation programme, with the aim of devolving power to the local and regional levels. This eroded traditional local government institutions and community-based organisations, and lack of control over public lands by the restructured government led to deforestation and land degradation (Ylhäisi, 2003). Land degradation possibly also resulted, in part, from the lack in NRM capacity among resource-starved local authorities, who prioritised natural resource exploitation (to raise revenue) over conservation (Kikula, 1999). Another important factor was population growth, which gained momentum towards the end of the colonial period and continued post-independence, putting pressure on natural resources (Enfors & Gordon, 2007).

Economic liberalisation (1985 onwards): As a result of Tanzania's severe economic decline due to internal and external factors, a structural adjustment programme was initiated after negotiations with the International Monetary Fund (IMF). This marked the start of Tanzania's economic liberalisation but, it was not until the early-1990s that State control was weakened and foreign influences became more common. Then, involvement of non-governmental organisations (NGOs) in rural development increased, contributing to the narrowing knowledge gap between farmers, authorities and researchers (Enfors & Gordon, 2007). The possible erosion of traditional knowledge – due to factors such as socio-cultural shifts, population growth, demand for economic growth and market-oriented crops – and low applicability of local knowledge to new environments were cited to contribute to unsustainable land-use practices (Ylhäisi, 2003). To summarise the socio-political and biophysical perspectives is much more complex as presented, as land degradation has a deep history influenced by both human and non-human forces. However, it appears to have been exacerbated by population growth, poverty and socio-cultural shifts influenced by political decisions.

II. TECHNOLOGIES

A wide range of local 'indigenous' and 'non-indigenous' agricultural technologies have been practiced in Tanzania for soil and water conservation (SWC) and soil fertility improvements. Many of these technologies have the potential to continue to be employed to rehabilitate degraded lands. Mati (2005) compiled a comprehensive list of the water and soil nutrient management techniques under smallholder rain-fed agriculture in East Africa. In addition, rainwater harvesting (RWH) techniques and their use in semi-arid Tanzania have also been reviewed (Gowing et al., 1999; Hatibu & Mahoo, 1999). Table 1 lists some these technologies, which can be categorised into structural (here including 'terraces and contour barriers', 'tillage-related', 'rainwater and floodwater harvesting', 'soil fertility improvements') and agronomic (including 'livestock management', 'arable crop management', 'silvicultural practices'). We will explore the evidence for the effectiveness of a few of the technologies in Tanzania in the subsequent sections.

Table 1: Agricultural technologies employed in Tanzania for dryland restoration.

Type	Name	Brief description	References
Terraces and contour barriers	Contour bunds/ridges or *Fanya chini*	Trench/terrace where excavated soil is dumped down-slope to form earth bunds along contours; widely advocated for slopes up to 5 %	Mwango, 2016; Shrestha & Lingonja, 2015; Gowing et al., 1999
	Fanya juu (Swahili for 'throw up')	Trench/terrace where excavated soil it dumped up-slope to form earth bunds along contours	Tenge et al., 2005; Celander et al., 2003
	Stone bunding	Linear stone barriers to slow runoff and accumulate soil	Celander et al., 2003
	Kainam terrace	Technique indigenous to the hills southwest of Lake Manyara, Tanzania, involving terraces protected by storm drains; ridges along contour are then planted with careful mulching	Mati, 2005
	Cut-off drains or trenches	Ditches dug to intercept fast-flowing water to avoid excess runoff in fields on sloping land and prevent gullying	Kangalawe & Lyimo, 2010; Ligonja & Shrestha, 2015
	Grass strip	Vegetative structural barrier composed of grass densely sown in 0.5-1 m wide strips along contours (spaced as terraces) to reduce runoff, soil erosion and provide forage or mulch	Tenge et al., 2005; Winnegge, 2005
	Mgeta system	Laying down grass and weeds along contours to counter sheet wash.	Temple, 1972
	Trash lines	Buffer strips of crop residues along contours	Celander et al., 2003
	Ladder/step terraces	Strips of organic waste (for soil fertility) covered with soil from above to form ladder-shaped terraces	Materu, 2016; Kayombo et al., 1999
	Bench terrace	Terraces with vertical intervals ranging from 1.2-1.8 m; usually for high-value crops for which the slope is too steep	Tenge et al., 2005; Mati, 2005

	Tied ridges	Smaller sub-ridges/cross-ties built within main contour ridges to create micro-basins for in-situ rainwater harvesting	Kangalawe & Lyimo, 2010
	Miraba (Swahili word for 'squares')	Rectangular grass-bound strips that may or may not follow contours.	Msita 2013; Mwango et al., 2016
Tillage-related measures	Minimum tillage	Soil not turned and aims to minimize soil manipulation.	Ligonja & Shrestha, 2015
	Zero tillage	Extreme form of minimum tillage without pits/furrows	Ligonja & Shrestha, 2015
	Conservation tillage	Breaking up compacted soil and facilitating *in-situ* rainwater harvesting.	Gowing et al., 1999
	Strip catchment tillage	Strips of crops alternating with strips of grass/cover crops; usually used on gentle slopes in semi-arid areas	Gowing et al., 1999
Rainwater and floodwater harvesting	*Ngoro/Ngolo* (or *Matengo*/*Ingolu*) pitting	Technique unique to the Wamatengo people of Matengo highlands (Mbinga District, Tanzania), which combines pits and ridges with yield-dependent fallow and crop-rotation; practiced on slopes of 35-60 % steepness	Gowing et al., 1999: Mati, 2005
	Chololo pits (named after the village in Dodoma Region where it was developed)	A modification of zai pits from the Sahel involving holes ~22 cm diameter, ~30 cm deep and ~60 cm apart. Excavated soil is used to make small bunds around the holes, into which manure, crop residues and ash (to expel termites) and soil are added. 1-2 seeds of maize/millet are sowed per hole.	Mati, 2005
	Semi-circular bunds	Crescent-shaped bunds to harvest runoff, particularly when planting tree seedlings in semi-arid areas	Mati, 2005
	Meskat system or '*Negarim*' technique	Basin system in which each micro-catchment feeds runoff to a single cropping basin (typically 10-100 m^2) surrounded by an earth bund (~30-40 cm high)	Gowing et al., 1999;
	Majaluba/ Majaruba	Cross-slope earthen barriers and basins to intercept and store hillslope runoff, typically for lowland rice. Similar to other basin micro-catchments but with larger external catchment	Mati, 2005; Gowing et al., 1999
	Ephemeral stream diversion	Divert water from ephemeral streams into cascades of open bunds (*Caag* system) or closed basins with small spillways	Gowing et al., 1999; Hatibu & Mahoo, 1999
	'*Charco* dams'	Excavated pits/ponds on relatively flat ground to store runoff; often used to water livestock	Mati, 2005; Gowing et al., 1999
	Ndiva or *Ndiwa*	'Indigenous' irrigation dams often fed by springs	Enfors & Gordon, 2007
	Stream bed flood water harvesting	Diverting floodwater from the stream bed onto adjacent plains to cultivate crops	Hatibu & Mahoo, 1999
	Vinyungu	Camber-bed type cultivation typically practiced clay-heavy soils in wet valley bottoms or other low-lying areas	Kayombo et al., 1999
	T-basins	Series of basins connected to external catchments (e.g. roads/footpaths); crops are planted on the T-shaped earth between basins, in which trees can be planted	Mati, 2005
Soil fertility improvements	Compost (*Mboji* in Kiswahili)	Crop residues, household waste, manure, grass, branches piled or in pits.	Danida, 2007a; Shrestha & Ligonja, 2015
	Manure	Organic matter from animals (typically faeces) or plants (green manure) to improve soil fertility	Kajembe et al., 2005
	Mulching (e.g. *Tughutu*)	Living or dead plant biomass (or stones) to reduce evaporation and improve soil fertility (if organic matter)	Msita 2013; Mwango et al., 2016
	Trash heaping	Organic waste accumulated on flat land (e.g. between trash lines) mainly for soil fertility improvement but also for SWC	Kayombo et al., 1999
	Burying trash and weeds	Organic matter from waste/weeds buried mainly to improve soil fertility but also to control weeds	Kayombo et al., 1999
	Plowing in crop residues	Crop residues are plowed into the soil prior to planting to improve soil fertility	Kajembe et al., 2005
	Trench farming	Planting in trenches into which large amounts of organic matter are added to improve soil fertility (also improves infiltration and moisture storage)	Mati, 2005
Livestock management	*Ngitili*	Wet season grazing restriction of rangelands to provide forage during dry periods ('indigenous' practice in Tanzania)	Barrows et al., 2003,2014
	'Zero-grazing' or 'stall-feeding' or 'cut-and-carry' system	Livestock kept in stalls to raise energy conversion efficiency and animal product yields (e.g. milk). Forage (e.g. cut grass) is collected from nearby to feed the animal and manure can be used to improve soil fertility	Ogle, 2001; Celander et al., 2003; Danida, 2007a
Arable crop management	Inter-cropping or mixed cropping	Two or more crops planted together to control pests/disease and improve efficiency of resource utilisation	Kayombo et al., 1999; Ligonja & Shrestha, 2015
	Crop rotation	Rotating crops to reduce pests/diseases and soil nutrient loss	Shrestha & Ligonja, 2015

	Cover-cropping	Crops planted primarily to manage soil (fertility, erosion), water (quality, infiltration), pests/diseases etc.	Mati, 2005
Silvicultural practices	Rotational woodlots	Cultivating trees in rotation with crops	Kisanga, 1999
	Agroforestry	Incorporating trees/shrubs into arable/animal agriculture	Calender et al., 2003; Klingebiel et al., 2000

SWC = soil and water conservation

Contour barriers and terraces: Experiments in semi-arid Mwanga district showed that contour earth bunds increase maize yields by 7 % (mean = 2177 kg/ha, SEM = 112) and 33.8 % (mean = 2473, SEM = 326) during long and short rains respectively compared to flat cultivation controls. Although, during long and short rains respectively, contour ridges led to slight decreases in maize yield of 2 % (mean = 3031 kg/ha, SEM = 509) and 8 % (mean = 624, SEM = 267) relative to controls. It is important to note that the sample sizes were small ($n = 6$ and $n = 9$ for long and short rains respectively) and yield variation was high, particularly during short rains (Hatibu, Young, Gowing, Mahoo, & Mzirai, 2003). In the Soil Conservation and Agroforestry Project in Arusha (SCAPA), bean yields under contour bunds were 49 % and 116 % higher than controls (land without SWC measures) in high and low potential areas respectively. Furthermore, aboveground biomass was 67 % and 71 % higher than controls at high and low altitudes respectively. In the same project, bean yields under *Fanya juu* were respectively 37 % and 142 % higher than land without SWC measures (control) in high and low potential areas. Furthermore, aboveground biomass was 96 % and 99 % higher than controls at high and low altitudes respectively (Celander, Sibuga, & Lunogelo, 2003).

In the humid-warm Kwalei catchment of the West Usambara highlands (annual precipitation between 1000-1200 mm), data from Gerlach trough experiments suggest that, at slopes between 13-25 % steepness, *Fanya juu* reduces soil loss by 99 % and surface runoff by 89 % compared to controls without SWC measures (Tenge, 2005). However, the methodology used may have been too crude to detect differences between SWC measures, only between land with and without SWC. Soil loss maybe affected by various contextual variables. For example, soil loss on the 15 % slopes Makonde plateau were 65 % and 57 % lower (averaged across 3 years) under maize with lemongrass strips than bare land and maize alone respectively. On 2 % slopes of the inland planes of Mkumba, soil loss under lemongrass strips was 88 % and 50 % lower than bare land and maize alone respectively (Kabanza et al., 2013).

Tenge (2005) compared the effectiveness of bench terraces, *Fanya juu* and grass strips. Bench terraces and *Fanya juu* significantly reduced soil loss compared to controls, during long and short rains, at all four slopes (32, 35, 41 and 59 %). Grass strips significantly reduce soil loss at all four slopes during long rains, but only at slopes of 32 % and 41 % during short rains (Tenge, 2005). *Fanya juu* experienced 37 % and 74 % less soil loss than bench terraces during short and long rains respectively. But, bench terraces had 9 % (short rains) and 27 % (long rains) greater soil moisture than *Fanya juu*. Interestingly, the soil moisture holding capacity of bench terraces is not only greater than *Fanya juu*, but it also only drops by 4 % (compared to 18 % for *Fanya juu*) between short and long rains. Regarding soil loss between short and long rains, *Fanya juu* lost 58 % less soil, while bench terraces experienced negligible change. Although there is no significant difference in soil moisture between grass strips and the control, the former experienced 36 % (short rains) and 45 % (long rains) less soil loss (Tenge, De Graaff, & Hella, 2005). In Tengeru, near Arusha, maize under grass bunds reduced soil loss by 40 % and 58 % for strips separated by 2.1 m and 3 m vertical intervals (VIs) respectively, compared to maize alone (control). Similarly, runoff (measured as a percentage of the annual total) was decreased by grass bunds with 2.1 m (2.2 % of annual) and 3 m (2.3 %) VIs compared to controls (3.4 %). However, grass bunds had 7 % and 37 % lower organic carbon and total organic matter respectively than controls, when averaged across 2.1 m and 3 m VI strips. Furthermore, total P (phosphorous), organic P and available P were respectively 6 %, 41 % and 19 % lower under grass bunds than controls, after averaging across 2.1 m and 3 m VI strips (Temple, 1972).

Soils under *Fanya juu* also held significantly (at the 5 % probability level) more moisture than controls at slopes of 41 % and 59 % during short rains, by 25 % and 35 % respectively. But, no significant difference in moisture retention was observed at 32 % and 35 % slopes during short rains, nor at any slope steepness during long rains. Bench terraces held significantly more moisture than controls, during both short and long rains, at all slopes except 41 %. No significant differences in moisture retention were observed between grass strips and controls. Generally, *Fanya juu* performs better than bench terraces and grass strips in controlling soil loss and surface runoff. However, bench terraces tend to hold more top soil moisture than *Fanya juu* and grass strips (Tenge, 2005). Concerning crop yields, the percentage increase in maize yields compared to controls due to bench terraces was 51 % and 25 % greater than for *Fanya juu* in farmers' fields and experimental fields respectively. But the percentage increase in bean yields compared to controls due to *Fanya juu* was 47 % and 21 % greater than for bench terraces in farmers' fields and experimental fields respectively. Yield increased due to grass strips were 21 % (farmers' fields) and 35 % (experimental fields) smaller than under *Fanya juu* for maize, and 7 % (farmers') and 39 % (experimental) smaller than under bench terraces for beans (Tenge et al., 2005).

Hatibu et al. (2003) showed that live vegetative barriers (similar to grass strips) increased maize yields by 11.1 % (mean = 3446 kg/ha, SEM = 334) compared to flat cultivation (mean = 3101, SEM = 418) controls during the long rains; but, decreased yields by 7.9 % (mean = 644, SEM = 299) compared to controls (mean = 699, SEM = 338) during the short rains. In the same study, stone bunds increased maize yields by 12.8 % (mean = 789, SEM = 351) compared to control during the short rains; but, decreased yields by 13.4 % (mean = 2686, SEM = 451) compared to the control during the long rains.

Tenge et al., (2005) also showed that the cultivatable area lost in unstable soils, for slopes from 5-12 % to over 50 %, was similar for bench terraces and *Fanya juu*, ranging from 7-42 % and 8-40 % respectively. For stable soils, bench terraces lost slightly less cultivatable land (ranging from 5-31 %) than *Fanya juu* (8-40 %). Labour costs, which were higher for bench terraces (stable soil: 66-427 Labour Days per Ha (LD/Ha) for slopes from 5 to over 55 %; unstable soil: 92-592 LD/Ha) than *Fanya juu* (stable soil: 43-281 LD/Ha; unstable soil: 60-388 LD/Ha). Grass strips required the least labour (stable soil: 7-43 LD/Ha; unstable soil: 10-388 LD/Ha). Tenge et al., (2005) also conducted a financial cost benefit analysis (FCBA) that incorporated opportunity costs of labour, discount factors (with interest rates to account for future benefits), and a 15-year timeline. The analysis showed that initial investment was greatest for bench terraces, followed by *Fanya juu*, then grass strips. However, between years 3 and 15, bench terraces provided the highest cash-flow, followed by *Fanya juu*, then grass strips. Both indicators of financial efficiency used (net present value and internal rate of return) also followed the same trend. High initial labour requirements may be overcome by labour-sharing groups, micro-credit schemes, or gradual construction (e.g. grass strips as a first step towards *Fanya juu* and bench terraces.

Miraba are rectangular grass-bound strips that often follow contours. Soil loss averaged over two years under *Miraba* in Migambo and Majulai villages was, respectively, 89 % and 82 % lower than controls with maize or beans alone (Mwango et al., 2016). In another study in Migambo village, annual soil loss under *Miraba* is 99 % and 100 % lower than controls and bare ground respectively. Annual loss of N (nitrogen), P and K^+ (potassium ions) under *Miraba* were respectively 97 %, 74 % and 100 % lower than controls. All of these differences regarding soil and nutrient losses were significant according to the Duncan Multiple Range Test (Msita 2013). In Majulai village, *Miraba* increased %OC (organic carbon) by 17 %, P by 22 % compared to controls, while K^+ and percentage total N did not differ (Mwango, Msanya, Mtakwa, Kimaro, Deckers, Poesen, Meliyo, et al., 2015a). In another study, averaged across Migambo and Majulai villages over two years, *Miraba* reduced losses in OC by 86 %, N by 88 %, P by 83 % and K^+ by 85 % compared to controls (Mwango, Msanya, Mtakwa, Kimaro, Deckers, Poesen, Nzunda, et al., 2015b). *Miraba* also increased soil %OC by 9 %, %N by 12 %, P by 35 % and K^+ by 29 % compared to controls, when averaged across both villages (Mwango, Msanya, Mtakwa, Kimaro, Deckers, Poesen, Massawe, et al., 2015c). Regarding crop yields, *Miraba* increased yields of maize (by 70 % and 77 %) and beans (by 27 % and 37 %) in Migambo and Majulai villages respectively, compared to controls with no SWC (Mwango et al., 2015b). In another study in Migambo village, *Miraba* raised maize yields by 57 % (significant under the Duncan Multiple Range Test), but did not affect bean yields (Msita 2013). However, in another study in the same village, *Miraba* gave 19 %, 27 % and 4 % lower mean yields than controls on upper, mid and lower slopes respectively. This also suggests that the position on the topographic sequence may influence a technology's effect on crop yields. In the same study, maize yields were 27 % higher for micro ridges than bench terraces on both upper and middle slopes; but, this trend was reversed on lower slopes, where bench terraces gave 23 % higher yields than micro ridges (Mwango et al., 2015a).

Rainwater and floodwater harvesting: Malley et al. (2004) compared *Ngoro* pits of various sizes: 1 m x 1 m (small), 1.5 m x 1.5 m (medium), and 2 m x 2 m (large). Maize height 35 days after planting increased significantly as pit size increased (LSD = 40, $p < 0.05$) on both 15 % (small = 230 mm; medium = 250 mm; large = 300 mm) and 55 % (small = 150; medium = 180; large = 230) slopes. Similarly, maize yield increased with pit size on both 15 % (small = 1.66 mm; medium = 1.69 mm; large = 1.75 mm) and 55 % (small = 1.44; medium = 1.66; large = 1.85) slopes, although non-significant. Moreover, labour requirements on 55 % slopes were 30 LD/ha for small and medium *Ngoro*, and 20 LD/ha for large pits. This is conservative compared to Ellis-Jones & Tengberg (2000), who estimate labour for construction and annual maintenance at 45-55 days/ha and 15-20 days/ha respectively. Regardless, after incorporating benefits of maize yield increases and labour costs, Malley et al. (2004) estimated that net benefits were greater for larger pits (small = Tsh 4,800; medium = Tsh 14,700; large = Tsh 43,250). Incidentally, larger pits also had lower soil penetration resistance, but soil moisture was unaffected by pit size (Malley, Kayombo, Willcocks, & Mtakwa, 2004).

Hatibu et al. (2003) investigated the effectiveness of microcatchment RWH with ratios of rain producing areas (RPAs) to rain receiving areas (RRAs) at 0:1, 2:1 and 4:1. During both long and short rains, maize yields in the cropping area increased as the proportion of RPA rose, but the opposite trend was observed when taking into account cropped and non-cropped areas. A macrocatchment system, which involved diverting water from an ephemeral stream into a brick-lined channel (similar to the *Caag* system of Somalia) was also tested. This increased maize yields by 22.1 % (mean = 2483 kg/ha, SEM = 94) and 48.1 % (mean = 2736, SEM = 313) during long and short rains respectively compared to controls.

Soil fertility improvements: In sub-humid/semi-arid Misufini in Morogoro, tied ridges with farmyard manure (FYM) had 20 % higher N (LSD = 0.001, $p < 0.01$), 351 % more available P (LSD = 4.35, $p < 0.001$), and 208 % greater K^+ (LSD = 0.31, $p < 0.001$) than the tied ridges alone. But, there was little or no difference between these treatments in SOC, soil moisture content at saturation or after 1.5 MPa suction (Kaihura et al., 1999). This study also covered two sites in the sub-humid Mlingano area in Tanga. At one site, tied ridges with FYM had 336 % more available P (LSD = 1.17, $p < 0.001$), 43 % greater K^+ (LSD = 0.31, $p < 0.001$), and 12 % higher SOC (LSD = 0.03, $p < 0.001$) than the tied ridges alone; but no significant difference in N between these treatments. At the second site, incorporating FYM increased N by 16 % (LSD = 0.03, $p < 0.05$), available P by 450 % (LSD = 4.05, $p < 0.001$), K^+ by 77 % (LSD = 0.24, $p < 0.001$), and SOC by 9 % (LSD = 0.24, $p < 0.05$) of tied ridges. This demonstrates the issues of extrapolating the effects of treatments on certain variables to other areas, and even sites within the same area. Incorporating FYM also raised maize yields of the tied ridges treatment by 36 % and 39 %, averaged across the 3 Misufini sites and 2 Mlingano sites, respectively. Incidentally, the corresponding figures for tied ridges alone were 2 % and 10 % higher maize yields than controls with no SWC (Kaihura et al., 1999).

Regarding mulch, averaged across Migambo and Majulai villages, *Tithonia diversifolia* mulch increased %OC (by 10 %), %N (by 10 %), P (by 52 %) and K^+ (by 103 %); while *Vernonia myriantha* mulch increased %OC (by 20 %), %N (by 21 %), P (by 81 %) and K^+ (by 153 %) compared to *Miraba* alone (Mwango et al., 2015b). In the same two villages, *Tithonia diversifolia* mulch increased %OC (by 20 %), %N (by 18 %), P (by 55 %) and K^+ (by 120 %); while *Vernonia myriantha* mulch increased %OC (by 26 %), %N (by 31 %), P (by 70 %) and K^+ (by 175 %) compared to *Miraba* alone (Mwango et al., 2016). These two studies suggest that soil OC, N, P and K^+ contents are higher under *Vernonia myriantha* than *Tithonia diversifolia* mulch. Further investigations in Migambo and Majulai villages revealed that *Tithonia diversifolia* mulch reduced losses of OC by 46 %, N by 44 %, P by 33 % and K^+ by 13 %; while *Vernonia myriantha* mulch reduced losses of OC by 38 %, N by 40 %, P by 17 % and K^+ by 17 % compared to *Miraba* alone when averaged across two years. The same study showed that annual soil loss on maize or bean fields under *Tithonia diversifolia* and *Vernonia myriantha* mulch were similar. Averaging both much types across both years showed that, compared to maize or beans under *Miraba* alone, these mulches reduced soil loss by 73 % and 43 % in Migambo and Majulai villages respectively (Mwango et al., 2015c). On 15 % slopes of the Makonde plateau, soil loss under maize with crop residues was 57 % and 66 % lower than bare land and maize alone respectively. Comparatively, on 2 % slopes of the inland planes of Mkumba, soil loss under maize with crop residues was 76 % lower than bare land, but only 3 % lower than under maize alone (Kabanza et al., 2013). Maize yields under *Tithonia diversifolia* and *Vernonia myriantha* mulches were 25 % and 50 % higher than *Miraba* alone when averaged over Migambo and Majulai villages. Bean yields under *Tithonia diversifolia* and *Vernonia myriantha* mulches were 10 % and 16 % higher than *Miraba* alone when averaged over both villages (Mwango et al., 2015b). In sub-humid Mbinga district, maize yields under *Matuta* (ridge cultivation) were 35 % (averaged over 3 seasons) and 29 % (averaged across 2 seasons) higher after organic matter addition, when rotated after beans and maize respectively. Similarly, incorporating organic matter into *Matuta* increased bean yields by 46 % (averaged over 3 seasons) when following a fallow (Ellis-Jones & Tengberg, 2000).

Livestock management: During the HADO (*Hifadhi Ardhi Dodoma*, which translates to Soil Conservation in Dodoma Region) project, net profits from the sale of milk, manure and breeding stock was 10x higher for zero-grazed than free-grazed cattle (Ogle, 2001). In another study, daily milk yields were reported to be 19 % higher in zero-grazed than pasture grazed cows. However, there was no difference in daily milk yield between zero-grazed (mean = 6.6 L, SE = 0.5, $n = 438$) and pasture grazed (6.7 L, SE = 0.5, $n = 302$) *Bos taurus* crossbreeds (with either Friesian or Ayrshire) on Tanzania's eastern coast (Bee, Msanga & Kavana 2006).

It is evident from these examples that a range of indicators are used, including: soil physical and chemical characteristics (particularly nutrients and moisture content), crop yields (occasionally plant height or biomass), labour requirements and reduction in cultivatable area. The variation in effectiveness within technologies may be due to differences in a variety of factors, such as edaphic characteristics, slope steepness, local climate. Lastly, as exemplified by Tenge et al. (2005), the extent of the various benefits differs between technologies, so suitability will depend on local environmental priorities and social values.

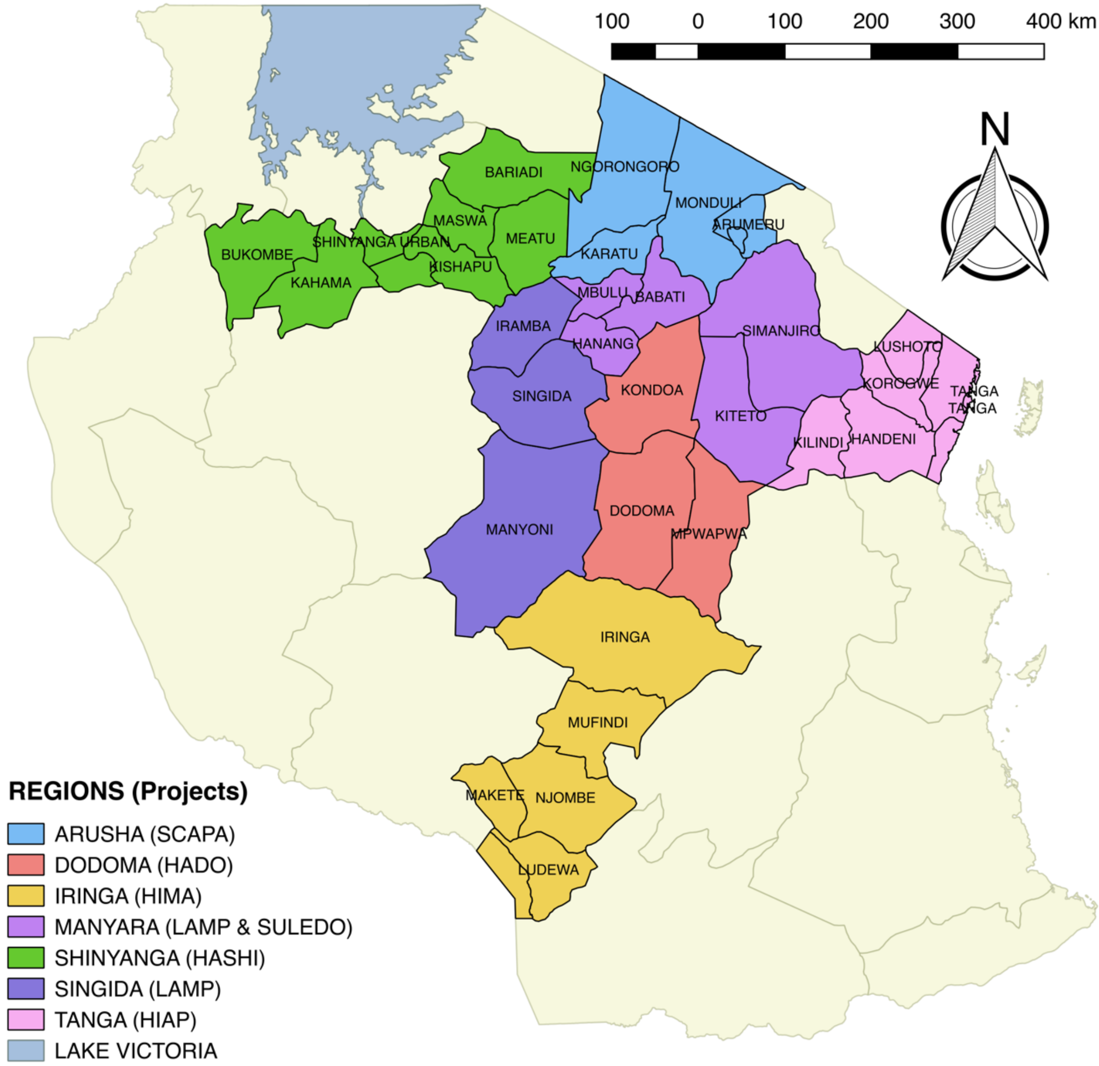

Figure 1: Map of Tanzania illustrating the regions within which the projects reviewed here operated (including non case study projects). Districts are labelled within the map, while the legend displays colour-coded regional labels and the projects that operated within them in parentheses.

III. CASE STUDIES

The large-scale restoration projects (n=2) and case studies (n=5), cover 20 districts across seven regions of Tanzania (Figure 1). The land area covered by the projects' operational regions is 253,259 km^2 (29 % of Tanzania's total land area), much of which is arid and semi-arid. These projects spanned approximately 40 years (Figure 2), promoting a variety of technologies (Table 1).

1. HADO (*Hifadhi Ardhi Dodoma*, which translates to Soil Conservation in Dodoma Region):

Background: HADO (1973-1997) was a large-scale project initiated by the Government of Tanzania post-independence, with financial support from SIDA (Swedish International Development Agency). The project aimed to address land degradation in the Dodoma Region, particularly the severely affected Irangi Hills, which became known as the Kondoa eroded area (KEA). Degradation was also a political concern as the Kondoa District was a potential food source for the future capital, Dodoma Town (Kikula, 1999). Annual precipitation ranges between 400-1000 mm with high spatial variability, averaging 650 mm. The natural vegetation is dry montane forest and Miombo woodland, although grassland with low trees and shrubs dominate the drier areas (Eriksson et al., 2003; Ligonja & Shrestha, 2015). Phase 1 objectives (1973-1986) focused on promoting tree-planting, bee-keeping, SWC and reclaiming degraded land. The initial approach proved unsuccessful and, after the project management was exposed to information through workshops, seminars, study tours and visits to other areas, the approach was modified. In 1979, in a desperate attempt to halt degradation, over 85,000 head of livestock were evicted from the 1256 km^2 KEA, and in 1985, over 64,000 head were evicted from a 713 km^2 area in Mvumi Division (Shayo, 1992). Local participation and soil conservation were emphasised in Phase 2 (1987-1997), and integrated land-use practices introduced (Kikula, 1999). This was highly beneficial for the project in terms of revegetation, returning wildlife and support from local people. However, rehabilitated areas are currently in danger of degradation due to the return of illegal free-grazing livestock (Shrestha & Ligonja, 2015).

Major outcomes: Eviction of livestock from two areas, which together totalled 1,969 km^2 (Shayo, 1992), was the most dramatic intervention. HADO also implementation of zero-grazing (ZG), which was adopted by over 120 farmers at its peak in 1996 (Ogle, 2001). Several hundred hectares of woodlots were also established (Nuhu Hatibu & Mahoo, 2000). A survey of 240 households (10% of total) revealed that 70 % and 89 % of respondents perceived an increase in vegetation and soil fertility respectively, due to SWC activities. A high proportion of households reported increased firewood (98 % of respondents), decreased soil erosion (68 %), food sufficiency (68 %), greater crop yields (56 %) and more fodder (50 %) (Shrestha & Ligonja, 2015). Between 1960-1987, although badlands in Ausia catchment expanded by 7 %, those in the Kondoa catchment shrunk by 15 %. The area occupied by unvegetated sandy riverbeds decreased by 69 % and 64 % in Ausia and Kondoa catchments respectively. Comparisons of site appearance during field surveys with aerial photographs from 1960, 1977 and 1987 reveal that the narrowing of rivers and sediment stabilisation mainly occurred post-1977. However, changes in vegetation cover between 1960-1987 are difficult to compare due to higher total precipitation in 1987 (980 mm) than 1960 (630 mm) (Eriksson et al., 2003).

Reasons for successes:

i) *Augmented natural resource base*. Re-vegetation has resulted in fewer conflicts over firewood and other forest products, however, there have also been land-use conflicts over rehabilitated areas. Stabilised sandy rivers enabled cultivation of sugarcane (up to TSh 140,000/acre annually) and vegetables (TSh 160,000-200,000/acre annually for tomatoes) (Kikula, 1999). However, a systematic assessment of the impact of rehabilitation on household incomes was not performed.

ii) *Tangible benefits of tree products, crop yields and cropping area.* In a recent survey of 240 households in the project area, 50 % reported collecting firewood from domestic sources (e.g. farmland, village woodland, HADO plantation forests), and 48 % from wilderness in the vicinity (Shrestha & Ligonja, 2015). Unfortunately, baselines were not reported for comparison. An evaluation of HADO by Sida and Tanzania's Ministry of Tourism and Natural Resources in 1995, criticised the project for the minimal improvement of productivity in croplands resulting from the on-farm SWC methods promoted over the previous 25 years (Nuhu Hatibu & Mahoo, 2000). However, in 2010, 56 % of 240 households reported higher crop yields due to improved soil fertility (Shrestha & Ligonja, 2015). Furthermore, the vegetation that now covers much of the earlier open sandy streambeds is in many cases cropland (Eriksson et al., 2003).

iii) *Socio-economic support to farmers*. Phase 2 saw the incorporation of extension services on land-use, animal husbandry, forestry and beekeeping among others. Data from a survey of 240 households shows that access to extensions significantly influenced participation (Multiple Linear Regression, *beta* = 0.219, t = 3.256, p = 0.01), but the overall model only explained 12.2% of the variation in participation (Shrestha & Ligonja, 2015).

iv) *Modification of top-down approach (technological/physical focus) and greater local participation in Phase 2*. Household survey data showed that participation was a significant factor in reducing erosion between 1986-2008 (Multiple Linear Regression, *beta* = 0.177, t = 3.032, p = 0.003) (Ligonja & Shrestha, 2015).

v) *Decentralisation*. Decentralisation of tree-planting resulted in long-term maintenance of tree-planting through active participation (Shrestha & Ligonja, 2015).

vi) *Raised awareness*. Phase 2 also focused on raising awareness regarding land degradation and capacity building. The former was achieved by screening educational movies in villages and farmer field visits; the latter, through training farmers, village leaders, teachers, ward and divisional officers, councillors, district and regional leaders and HADO staff (Kikula, 1999). Awareness of HADO significantly influenced participation (Multiple Linear Regression, *beta* = 0.082, t = 1.249, p = 0.05), but variation in participation was not very well explained (R^2 = 0.122) by the overall model (Shrestha & Ligonja, 2015). A survey of 2 villages (Mulua and Halubi) in Kondoa District, show that many farmers (75 % and 92 % respectively) perceived soil degradation is an issue (Kangalawe, Christiansson, & Östberg, 2008).

vii) *Capacity building*. HADO generated capacity in all institutions involved (Kikula, 1999). For example, project staff were trained in providing extension services and educating farmers in SWC techniques (Ligonja & Shrestha, 2015).

viii) *Broadening focus to take a more integrated approach*. In Phase 2, the focus was broadened, shifting away from pure SWC, and towards a more integrated land management approach. Kikula (1999) cites this as the most significant change in HADO's approach.

ix) *Enabling policy and favourable markets*. Policy reform led to greater support from extension services, subsidies for ZG, favourable crop market and prices and land tenure security. Secure tenure allows long-term land occupation, and participation in SWC was significantly influenced by the duration of land occupation (Multiple Linear Regression, *beta* = -0.072, t = -1.063, p = 0.05) (Shrestha & Ligonja, 2015). Favourable markets for arable crops incentivised SWC, but also led to deforestation in parts of KEA (Ligonja & Shrestha, 2015).

Reasons for failures:

i) *Initial top-down approach and lack of local participation in decision-making and ownership*. Low levels of participatory decision-making and thus local ownership was detrimental to HADO (Ogle, 2001). The lack of sustainability of HADO can be partly attributed to the concentration of decision-making power within central government, leaving little authority at regional, district and village levels. Particularly after the forced destocking of 1979, the lack of involvement of local people fuelled hostility towards the project, leading to the sabotage of HADO activities and even the murder of a project staff member and death threats to many others (Kikula, 1999). Lack of ownership was also implicated in the sustainability of tree-planting, which was implemented by HADO in communal rather than private land (Ligonja & Shrestha, 2015).

ii) *Domination by one sector/discipline*. All HADO staff had backgrounds in forestry and were not sufficiently trained in soil conservation (Kikula, 1999), and the project lacked a multi-sectoral, multi-disciplinary approach (Nuhu Hatibu & Mahoo, 2000). This led to a narrow focus during Phase 1, which emphasised mechanical approaches such as tree-planting, constructing contour bunds and plugging gullies, using heavy machinery and hired labour (Kikula, 1999).

iii) *Lack of planning before implementation or evaluation of possible impacts*. Destocking merely increased grazing pressure to other areas, which consequently suffered degradation. Some even argued that destocking led to malnutrition among the local population, but scientific evidence is lacking (Ogle, 2001).

iv) *Regulations poorly enforced*. Illegal free-grazing livestock have been returning to the area since early 1990s (Kangalawe et al., 2008), and poor enforcement of regulations is an issue across Tanzania (Kikula, 1999). Advised by Central Government, the Kondoa District Council enacted a by-law prohibiting grazing, cultivating, felling trees and digging water channels without permission, but it was not effectively enforced (Kikula, 1999). The ability of offenders to bribe District Courts, or avoid capture by exerting social pressure on villagers guarding rangelands, rendered policing ineffective (Lovett et al., 2001).

v) *Inaccessibility of technologies and exacerbating socio-economic and gender disparities*. Shrestha & Ligonja (2015) reported that the significant influence of annual crop income on participation (Multiple Linear Regression, *beta* = 0.089, t = 3.256, p = 0.05) suggest that socio-economic status restricted adoption of project activities. Furthermore, household size also had a significant influence on participation (Multiple Linear Regression, *beta* = 0.182, t = 2.774, p = 0.01), indicating that participation was constrained by low labour availability in smaller households. Six years into the ZG project, there were only 100 participating families in KEA, which fell to 82 by 1999 (Kangalawe et al., 2008). The major constraint to adoption was considered to be ZG's labour costs, which was higher than free-grazing, as reported by around 2/3 of the 60 farmers interviewed. Moreover, the poorest families gained no direct benefits from ZG, due to insufficient resources to meet HADO's preconditions. Regarding gender, although free-grazing cattle were the responsibility of adult men and children, the already high workloads of women were further increased in ZG through milking, marketing and collection of fodder and water (Ogle, 2001).

vi) *Lack of baseline socio-economic data, predefined indicators nor systematic monitoring to assess impact of intervention*. HADO's monitoring of the survival rate of distributed seedlings was minimal. Moreover, Ogle (2001) heavily criticised the absence of formal indicators or baseline socio-economic data prior to ZG implementation. Data collection was performed by the Man-Land Interrelations in Semi-Arid Tanzania (MALISATA) research programme; a multi-disciplinary, involving biologists, geomorphologists, soil scientists, hydrologists, demographers, sociologists, agriculturalists and policy analysists. However, research and monitoring started almost 18 years after HADO initiated, by which time, there was little room for MALISATA to contribute (Kikula, 1999). Initial data collection and analysis may have exposed the importance of soil moisture, which was a greater limiting factor to crop yields than erosion (Nuhu Hatibu & Mahoo, 2000).

vii) *Weak communication between actors*. Communication between farmers, village elders, extension staff, donors and local- and ministerial-level politicians was weak. MALISATA's scientific data, although detailed, was not regularly communicated to the ministry (Ogle, 2001). Moreover, objectives of HADO and MALISATA were not aligned and some research activities may not have been fully understood by HADO and perceived as irrelevant (Kikula, 1999). Soil and water management was not clearly communicated via extension (Nuhu Hatibu & Mahoo, 2000), and local communities were not consulted on activities, which were therefore unpopular (e.g. tree-planting and inappropriate species selection) (Kikula, 1999).

viii) *Lack of long-term plan and/or poor phase-out*. The decline in adoption of ZG after HADO's termination was in part due to a reduction in accessibility of veterinary medicines, which HADO provided during the project. Furthermore, in absence of a long-term sustainability plan, withdrawal of donor funding led to rise in illegal activities such as free-grazing and deforestation in protected areas. Excessive donor dependency appears to have hampered HADO's sustainability (Ogle, 2001).

2. HASHI (*Hifadhi Ardhi Shinyanga*, which translates to Soil Conservation in Shinyanga Region):

Background: HASHI was established in 1986 by MLNRT (Ministry of Lands, Natural Resources and Tourism) to control desertification in the Shinyanga Region (Kangalawe & Lyimo, 2010; Ostyina, 1993). The project promoted the restoration of the *Ngitili*, a traditional practice of restricting grazing in areas of rangeland during wet seasons for use during dry periods (Barrow & Mlenge, 2003). The Shinyanga Region has an average annual rainfall of 600-800 mm, which is erratic and unevenly distributed. Historically, natural vegetation consists of extensive Miombo and Acacia woodlands (Ghazi et al., 2005), but these woodlands were cleared to eradicate tsetse flies, create space for agriculture and the growing population. The high and continually rising population density, combined with dominant agro-pastoral lifestyles, exacerbated existing land clearing issues. Moreover, rural collectivisation (*Ujimaa*) and nationalisation of land reduced incentives to conserve forests and their products as people lost rights to these natural resources (Barrow, 2014).

Major outcomes: Around 78,000 Ha of *Ngitili* were restored by the 1990s, over 300,000 Ha by 2004 (Maro, 1995), and this figure may currently be over 500,000 Ha (Pye-Smith, 2010), although empirical evidence is lacking. A survey, published 9 years after HASHI began, showed that 90 % of farmers reported that restored *Ngitili* were an important source of pasture during critical times of year (Barrow & Mlenge, 2003). A 2004 survey of 240 households across 12 villages in conjunction with market analysis estimated the value of the benefits from *Ngitili* to be USD 14/month per person. This is significantly higher than the average monthly spending of rural Tanzanians in that year, which was USD 8.50 (Monela, 2004). This survey also revealed reductions in the time spent collecting fuelwood (by 2-6 hours), poles (by 1-5 hours), thatch (by 1-6 hours), fodder (by 3-6 hours) and water (by 1-2 hours). Furthermore, biodiversity increased, including the return of 145 bird species that were previously locally extinct (United Nations Development Programme, 2012). In addition, of the 51 mammal species that had disappeared from Meatu District, 21 had returned since re-establishment of *Ngitili* (Pye-Smith, 2010). Lastly, the amount of carbon sequestered was estimated at 23.2 million tons, valued at USD 213 million or USD 3.8 per person annually averaged over 25 years (Barrow & Shah 2011; Otsyina, 2008). These achievements won HASHI a 2002 United Nations Development Programme (UNDP) Equator Initiative Prize (UNDP, 2012).

Reasons for successes:

i) *Local need for restoration*. There was a desire by local people to invest in restoration to supply highly valued natural resources (Barrow & Mlenge, 2003).

ii) *Local knowledge*. Detailed local knowledge of uses of local tree species and the importance of NRM existed prior to HASHI (Barrow & Mlenge, 2003), and the project benefited from considering and respecting this knowledge (Barrow, 2014).

iii) *Building on existing institutional structures*. *Ngitili* were protected by traditional rules, which most Sukuma people adhered to, and the village government was empowered to enact by-laws (Barrow, 2014).

iv) *Generating social capital*. Barrows (2014) stated that the main outcomes were due to augmenting social capital, through building on local institutions that enhanced cooperation.

v) *Enabling policies*. By 1987, policies that incentivised restoration replaced ones that encouraged forest degradation. One of the most important concerned tenure changes, affecting access to and control over resources, which facilitated restoration and sustainable management of natural resources by groups or individuals (Barrow, 2014). HASHI's activities were supported, in particular, by the revised Forest Policy (1998), which placed strong emphasis on participatory management and decentralisation. Moreover, the National Land Policy (1997), Land Act (1999) and Village Act (1999) actively supported *Ngitili* establishment (Barrow & Mlenge, 2003).

vi) *Capacity building and support.* The former was achieved through training and the latter via extension and technical advice (Barrow, 2014).

vii) *Participatory approach and facilitatory role of HASHI*. The project emphasised the participatory approach and HASHI staff played a facilitatory role, which empowered locals to drive the restoration process. Local participation was also increased by decentralisation of tree nurseries, allowing villagers to plant their own trees (Barrow, 2014).

viii) *Tangible benefits, mainly from restored natural capital*. The restored *Ngitili* augmented grazing availability and fodder production (Barrow, 2014), however data on the magnitudes of these increases are not available.

ix) *Benefits experienced by many*. By 1993, only 9 % of villagers did not own or have access to *Ngitili* (Barrow, 2014). An estimated 90 % of farmers with livestock and 50 % of arable farmers owned *Ngitils* by 2010 (Pye-Smith, 2010).

x) *Long-term approach*. The project ran for almost 25 years and this long-term commitment was cited as in important factor contributing to HASHI's successes (Barrow, 2014).

xi) *Personalities or champions*. The crucial shift to a participatory approach was made by HASHI's programme leader. This was a risky decision in a time of predominantly top-down development, but proved highly successful. Having the right personalities at the right time seemed to play in important role in HASHI's successes (Barrow, 2014).

Reasons for failures:

i) *Issues with equality*. Although benefits of restored *Ngitili* were felt by many, they were not shared equally. People with higher socio-economic status had greater access to benefits of restoration via 'elite capture' (Barrow, 2014).

ii) *Costs associated with returning wildlife*. These costs were estimated at USD 5.25/month per family (Pye-Smith, 2010). However, this is minimal in comparison to the economic value of the benefits of *Ngitilis*, which in Bukombe District was estimated to be USD 99.23/month per household (United Nations Development Programme, 2012).

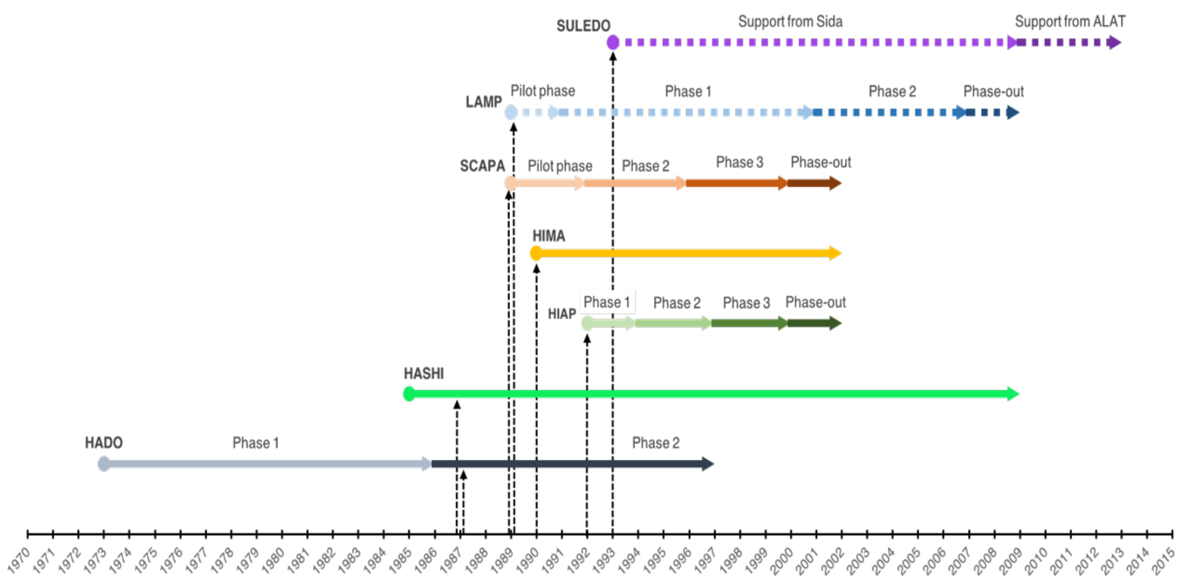

Figure 2: Timeline of restoration projects. The vertical black dotted lines indicate the approximate points when participatory approaches were incorporated into each project.

3. SCAPA (Soil Conservation and Agroforestry Project in Arusha):

Background: SCAPA (1989-2002) was initiated to tackle the serious land degradation issues around Mount Meru, where moderate and severe soil erosion affected 110,200 Ha and 171,100 Ha respectively. It was funded by Sida's semi-autonomous Regional Land Management Unit (Relma) during the pilot phase and later by Sida itself. Most project areas in Arumeru District were in high and medium potential areas with annual rainfall between 1,000-1,200 mm and 900-1,000 respectively. However, Arusha District, which was added in the 2nd phase, is composed mainly of medium to low potential areas, annual rainfall ranging between 350-600 mm. The soils of both districts are fine, unstable and mainly volcanic in origin, and the vegetation is mostly wooded, bushed or open grassland. SCAPA activities included establishing nurseries, woodlots, gully control, water harvesting (tanks, jars and ponds), livestock management (grazing management, fodder multiplication, zero-grazing, heifer distribution, pasture trials and hay-making), dryland farming, and beehive distribution (Celander et al., 2003).

Major outcomes: Over 3 phases, 1,000 km of bunds were created and, during the pilot phase alone, 150 tn of plant material (mainly *Pennisetum purpureum*) were planted to stabilise bunds. Furthermore, between 1-1.5 million seedlings were planted for agroforestry. A survey of revealed that large proportions of households perceived improved soil conservation (61 % of respondents), increased crop yields (56 %), and higher income (58 %) (Kajembe, Julius, Nduwamungu, Mtakwa, & Nyange, 2005).

Reasons for successes:

i) *Raised awareness*. SCAPA educated politicians and other government officials about SWC, and organised study tours, field days and exchange visits (Celander et al., 2003). Interviews of the heads of 84 (5 % of total) randomly selected households, from 4 (10 % of total) randomly selected villages, shows that all households were aware of land husbandry and environmental conservation. Moreover, around 70 % perceived degradation as severe (Kajembe et al., 2005).

ii) *Capacity building*. Capacity was enhanced in district-, division-, ward- and village-level extension staff (Celander et al., 2003; Tumbo, Mutabazi, Kahimba, & Mbungu, 2012). Extension staff developed multidisciplinary skills and capacity for how to integrate these disciplines into meaningful extension messages (Celander et al., 2003). Between 1989-1997, 683 extension staff, 300 ward and village leaders and 10,878 farmers were trained in basic SWC. In a survey of 4 randomly selected villages (10 % of total), where 84 households (5 % of those in the selected villages) were interviewed, 71 % of household heads reported being provided with basic SWC training. Furthermore, paraprofessionals were able to spread knowledge via farmer-farmer transmission to many more famers than would have been possible through extension staff alone (Kajembe et al., 2005).

iii) *Significant local institutional development*. This was a particular strength of SCAPA. Several institutions were responsible for guiding and supporting project implementation including the Regional Soil Conservation Committee (RSCU), District Soil Conservation Committee (DSCU). More direct implementation was undertaken by Village Soil Conservation Committees (VSCCs), together with local extension workers and farmers. VSCCs were elected by villagers and created by-laws enforcing protection of natural resources (Celander et al., 2003).

iv) *Active participation of village government in organisational and administrative matters*. VSCCs in each village ensured farmer participation in planning and implementation, while SCAPA extension staff played a facilitatory role. Consequently, farmers experienced ownership and pride when communicating techniques that they had implemented on their own farms to fellow farmers. Formation of VSCCs also ensured continuation in absence of SCAPA (Celander et al., 2003).

v) *Interventions were technically sound and appropriate to local farming practices*. This was the case for the soil erosion control measures during the 1st phase and, during later phases, to improved crop management and reduced susceptibility to degradation (Celander et al., 2003). SCAPA's employment of 'indigenous-based' interventions and the use of locally available materials for conservation activities, reported by 84 % of villagers surveyed (Kajembe et al., 2005), likely contributed to continuation of these activities. Furthermore, interventions requiring less labour and/or capital investment were reported to have been more readily adopted (Kajembe et al., 2005).

vi) *Tangible benefits*. Farmers reported yield increases of 70-500 % due to a combination of SWC measures, agroforestry and improved crop varieties. The large variation reflects the extremes of an exceptionally good year and a particularly poor year with pests and drought (Celander et al., 2003).

vii) *Holistic approach*. SCAPA's approach integrated crops, livestock, SWC and agroforestry with fuel-efficient stoves and beekeeping.

viii) *Good relationships*. Frequent farm visits enabled trust to develop between farmers and SCAPA extension team. Strong collaboration between project officials and villagers was reported by 78 % of households surveyed (Kajembe et al., 2005). Almost all people from village to central level praised SCAPA during discussions and, in 2000, the East African Soil Science Society awarded the project a certificate in recognition of its work, which exemplifies SCAPA's positive reputation (Celander et al., 2003).

ix) *Gender aspects systematically addressed and ensured women were involved in various activities*. This was likely due to the high proportion of female members of SCAPA's extension teams (67 % in Arusha and 54 % in Arumeru) (Celander et al., 2003).

Reasons for failures:

i) *Some expensive technologies inaccessible to poor farmers*. This occurred particularly during the 2nd and 3rd phases (e.g. heifers for dairy and water tanks). Furthermore, 89 % of households surveyed found inputs (e.g. inorganic fertiliser, pesticide, or improved seed) expensive or unavailable, while 82 % had issues with access to credit (Kajembe et al., 2005).

ii) *Lack of baseline data and informative monitoring*. Changes that occurred, particularly ecological or socio-economical, were not well documented during the project (Celander et al., 2003).

iii) *Insufficient integration of activities into existing institutional structures*. Costs of SWC activities were not integrated into the district budget and were therefore curtailed after SCAPA support was terminated. There was also a heavy reliance on donor funds for certain activities (e.g. the 60 % subsidy on expensive rainwater harvesting structures) (Celander et al., 2003).

iv) *Ineffective regulations*. Although 83 % of households surveyed were aware of the village by-laws, 52 % reported that they were ineffective. Moreover, "inconsistencies" in offenders' fines were revealed in informal discussions (Celander et al., 2003).

v) *Lack of ownership and strong relationships.* SCAPA lacked ownership at the central level and had a weak relationship with the Ministry of Agriculture (Celander et al., 2003).

4. HIMA (*Hifadhi Mazingira Iringa*, which translates to Environmental Conservation in Iringa Region):

Background: HIMA (1990-2002) was established to promote conservation, sustainable agriculture and NRM in Iringa Region, with funding from the Danish International Development Agency (Danida). Climate in this region ranges from semi-arid to cool tropical, with average annual rainfall of around 700 mm. The project expanded from Iringa District to include Njombe and Makete Districts in 1992, and to Mufindi and Ludewa Districts in 1998. As HIMA's operational area expanded, it shifted its focus from conservation to crop, livestock and forestry productivity.

Major outcomes: Between 2006-2007, a consortium of consultancies from Denmark (Orbicon A/S) and Canada (Goss Gilroy Inc.) conducted an impact evaluation for HIMA. This included a survey of 330 households from the same 12 villages in Njombe surveyed in 1996, as well as a participatory rural appraisal (PRA) of 13 HIMA villages and 6 non-HIMA villages. In this former survey, 75 % of male-headed and 60 % of female-headed households reported higher incomes over the last 5-10 years (when HIMA was active). Moreover, perceived food security rose from 80 % to 85 % and reports of hunger dropped from 15 % to 12 % between 1996-2006. However, caution must be taken with these results as baselines for income were incomplete and not representative of the 12 villages, and PRA baselines were non-existent.
The PRA survey also showed that households dependent on natural forests for fuel wood fell from 23 -13 % between 1996-2006. Furthermore, reports of water sources drying up decreased from 33-23 % during the same period, with 57 % of households reporting water source closer to home. Again, 1996 baselines for water availability were absent so these results are recollections.
Finally, although soil erosion was still an issue in 9/11 PRA villages in which HIMA introduced soil erosion control measures, 83 % of households in the 2006 Njombe survey reported using some type of erosion control measure. This apparent contradiction is partly because the latter statistic does not reflect the degree of implementation. Only 17 % of households reported practicing one or more erosion control measure on all, 41 % on some and 42 % on only a small portion of affected land (Danida, 2007a).

Reasons for successes:

i) High awareness. The awareness of SWC, forest protection and NRM was high in villages in which HIMA was active (Danida, 2007a). However, it is difficult to determine the extent to which this was the case during the project, nor the degree to which it was a result of project activities.

ii) Village-level participatory approach and use of relevant 'indigenous knowledge'. HIMA emphasised the participatory approach, including village-level participatory planning. Involving local people allowed the project to tap into relevant 'indigenous knowledge', which likely fostered a sense of ownership (Danida, 2007a).

iii) *Integrated into and built on existing local government structures.* HIMA originally operated under the the Prime Minister's office, but after 1998, it was placed under the jurisdiction of the Ministry of Agriculture. The Government of Tanzania provided project staff and various district councils acted as implementing agents for HIMA (Danida, 2007a).

iv) *Simple, low-cost (both labour and financial) and easy to maintain technologies*. Many of HIMA's less complex and inexpensive interventions were successful, both during the project and 4 years after termination. For example, the simpler, less costly, easy to maintain measures for ensuring a constant water supply were more viable. This was also true of composting techniques, and these three traits also increased an intervention's replicability (Danida, 2007a).

v) *Identified and built on areas with potential for growth*. Building on already thriving timber markets was highly advantageous for HIMA. Although forest-related activities were present prior to project establishment in 11/13 villages included in the PRA survey, around 2/3 villagers reported a positive impact of HIMA on tree-planting activities (Danida, 2007a).

vi) *Capacity building*. District-level government improved planning, multi-disciplinary teamwork and use of technology. Moreover, village planning capacity was greater in HIMA than non-HIMA villages and, several years after HIMA's termination, village governments are still active and engaged (Danida, 2007a).

vii) *Enabling policies*. The Community Development Policy (1996) emphasised the need for multi-disciplinary, participatory approaches in planning and development, particularly at the local-level. Local government reform (1996) stressed decentralisation, which facilitated the gradual shift of finances and responsibilities from HIMA to the district administration. HIMA focused on working through district-, ward- and village-level environmental committees, the formation of which was called for by the National Environment Policy (1997). The New Land Act (1999), in particular the Village Land Act, was highly important for HIMA, as it facilitated village and forest management and administration. The latter Act also allowed citizens to acquire land title deeds and placed women in a stronger legal position regarding land ownership and representation in decision-making bodies. Unfortunately, the bureaucratic procedures associated with taking advantage of these policies are impenetrable for small-scale farmers. HIMA's activities were greatly influenced by the 1997 Forest Policy (supported by acts passed in 2002 and 2004), which clearly defined the responsibilities of communities regarding natural forests and woodlot establishment promoted by HIMA (Danida, 2007a).

viii) *Tangible benefits of income, crop yields, food security and natural resources.* In the Njombe household survey, 70 % reported higher income over the time that HIMA was active. An ANOVA showed that this reported rise in household income correlated significantly with changes in maize (p = 0.003) and potato (p = 0.028) production, which respectively explain around 5 % and 3 % of variation in income rise. Crop yields increased for maize (by 58 %), potatoes (by 46 %), beans (by 103 %) and wheat (by 93 %). However, this was mostly due to improved varieties, greater use of chemical fertilisers, mono-cropping and reduced fallows (rather than sustainable agricultural techniques). The Njombe household survey found that, between 1996-2006, food security increased slightly from 80-85 % and experiences of hunger dropped from 15-12 %. Regarding natural resources, the PRA survey revealed that the proportion of sampled households reporting fuel wood issues fell from 50-14 % between 1996-2006. Households that collected fuel wood from their own land rose from 45-71 % over the same period.

ix) *Business or private sector approach*. This was evident when the forestry initiative shifted from centralised to individual nurseries. Danida (2007a) suggest that earlier adoption of a private sector approach with a clear market-driven strategy may have brought further successes.

Reasons for failures:

i) *Reversion to top-down approach and lack of communication*. Interviews with 140 key stakeholders (including extension workers, government officials, and district- and division-level staff) revealed that there was a tendency to revert to top-down approaches between districts and villages. This created a "planning gap" between village and district levels, where lack of dialogue led to participatory village-level plans being distorted at district level, where final decisions were made. This diminished ownership among villagers (Danida, 2007a).

ii) *Interventions that were too costly and/or lacked relevance*. Interventions that were too costly, in terms of labour, finance or complexity, were unsuccessful. For example, a composting technique that was too complex and labour intensive experienced limited adoption. Failures also arose where

HIMA attempted to implement novel livelihood interventions that were not obviously compatible with existing practices, and require much more external support. Moreover, the project failed to consider socio-economic status and ability to invest, particularly in activities with high risk of failure (e.g. fish farming) (Danida, 2007a).

iii) *Drop in support for village by-laws*. The PRA survey revealed that support for village by-laws dropped from 64-51 % between 1996-2006, lowering the effectiveness of by-laws to protect natural resources (Danida, 2007a).

iv) *Insufficient technical assistance and capacity building*. This was mainly the case for novel interventions and technologies, for which much capacity and technical support were needed. Resulting negative effects were particularly felt after HIMA's termination (Danida, 2007a).

v) *Failure to link with central government and build on existing institutional structures*. For a time, rather than building on existing government structures, HIMA acted parallel to them. This improved performance but did not promote long-term capacity building (Danida, 2007a).

vi) *Unfavourable policies*. The Civil Service Reform (1995) led to public sector cutbacks, impacting the availability of district-level government staff to implement HIMA's activities (Danida, 2007a).

vii) *Poor data collection and monitoring*. Evaluation of HIMA activities in Iringa Region was hampered by the absence of baseline data for incomes, the PRA survey and satellite imagery. Village-level data on the duration, intensity, cost and outcomes of project activities were also missing. Aerial photographs of divisions in Makete and Njombe Districts were taken in 2000, but were lacking 'flight run maps' and even basic initial ground interpretation and field verification. Moreover, photographs were not taken over a series of years to monitor HIMA's impact (Danida, 2007b). From 1998 (8 years after the project began), HIMA kept relatively detailed monitoring records for all target villages. However, these records were stored on floppy discs that are no longer readable and computers with long-forgotten passwords. Attempts to retrieve the data from the hard drives of these computers were also unsuccessful due to formatting issues. Ultimately, only two reports were compiled (for 1999 and 2000), which contain inconsistencies in the data from year to year, along with apparent data entry and calculation errors (Danida, 2007c). Poor data collection for monitoring and evaluation resulted in missed learning opportunities.

viii) *Absence of well-planned and executed phase-out strategy*. Many successful interventions, including SWC and paraprofessionals, were not maintained after HIMA withdrew. Moreover, support from extension staff and paraprofessionals dwindled post-termination (Danida, 2007a).

5. HIAP (Handeni Integrated Agroforestry Project):

Background: HIAP (1992-2001) was initiated by the Handeni District Council and Tanga regional authorities, supported by the German Agency for Technical Cooperation (GTZ). HIAP's objective was to lessen the degradation of natural resources and increase agricultural production, with a long-term aim to facilitate village-level natural resource management and planning. The project covered the Nguru mountains and surrounding areas, where annual precipitation ranged between 1,000 mm to less than 600 mm. During Phase 1 (January 1992–June 1994) an integrated agroforestry concept was developed, along with a participatory approach of consultation and implementation within villages in two ecological zones. Phase 2 (July 1994–August 1997) saw the improvement of project activities, expansion to other villages, and development and implementation of participatory land use planning (PLUP) in 13 villages. PLUP was further improved in Phase 3 (September 1997–December 2000) and introduced to 52 villages. No permanent German staff were present during the final 2 years, while development operations were withdrawn (Klingebiel et al., 2000).

Major outcomes: GTZ's report for HIAP in 2000 shows that participatory situation analyses were conducted and ratified by village assembly in 33 villages. Land Use Planning Committees (LUPCs) were set up in 31 villages, and committee members trained in land use planning, SWC measures and their specific roles as members. Furthermore, 23 land use plans were developed via participatory means (including conflict resolution), according to the principals of watershed management, and ratified by village assemblies. Finally, over 500 paraprofessionals were trained in land use issues (Klingebiel et al., 2000).

Reasons for successes:

i) *Awareness raised*. HIAP raised awareness of the importance on the conservation of natural resources and land use planning as a tool for sustainable NRM. This was achieved through participatory situation analysis (Winnegge, 2005).

ii) *Participatory approach, empowerment and representation of socio-politically marginalised groups*. HIAP emphasised village-level participation in NRM via situation analysis, during which HIAP staff played a facilitatory role, assisting villagers to define needs, identify and discuss issues and conflicts of interest (Klingebiel et al., 2000). Participation was also a focus of PLUP, which involved the majority of villagers, including men and women of all ages and social classes, which led to the empowerment of local people (Winnegge, 2005).

iii) *Relevant and appropriate NRM plans*. Village-level participation and representative decision-making led to technically feasible, locally manageable, socially acceptable, gender-sensitive, solutions that were also economically and ecologically sound (Winnegge, 2005).

iv) *Capacity building*. HIAP supported and strengthened government departments, NGOs and CBOs operating in NRM (Winnegge, 2005).

v) *Decentralisation*. Efficiency was enhanced by decentralisation into zones, each consisting of several wards, delegating major responsibilities to zonal staff (Klingebiel et al., 2000).

vi) *Recognising and building on existing formal and informal institutions*. Also created new ones to improve communication and conflict resolution, such as Village Land Use Planning Committees (VLUPCs), which enabled cooperative NRM, augmenting social capital. Another example is Catchment User Groups (CUGs), which economised scarce resources of labour and transport facilities, while implementing land management practices. CUGs were composed of 15-40 villagers unified by a common interest, each CUG selecting a committee of 3 paraprofessionals to assist them (Winnegge, 2005).

vii) *Tangible benefits from improved natural resource productivity*. This helped ease competition over natural resources. Tangible benefits reduced conflicts between groups of villagers and between villagers and local government officials (Petersen & Sandhövel, 2001).

viii) *Broad geographical and sectoral focus*. Regarding geographical focus, HIAP performed watershed-level planning through integrated watershed management (IWM). In terms of sectoral focus, inter-sectoral coordination extended HIAP's focus beyond solely NRM (e.g. tree-planting, cultivation and livestock management) to include, for example, training in construction of fuel-efficient stoves (Klingebiel et al., 2000).

ix) *Continuous monitoring and periodic evaluation*. This allowed assessment of whether objectives were being achieved. Any adjustment was discussed, agreed and endorsed by village general assembly before implementation (Winnegge, 2005).

Reasons for failures:

i) *Insufficient analysis*. The installation of a reservoir without prior situation analysis aggravated an inter-village boundary dispute. Although situation analysis and land-use planning caused short-term social tensions, these were outweighed by the long-term resolution of conflicts (Klingebiel et al., 2000).

ii) *Inequality*. HIAP's village-based approach may confer advantages to project villages in boundary disputes with non-HIAP villages (Klingebiel et al., 2000).

iii) *Resource intensive.* Implementation of community-based NRM is knowledge and time intensive and, considering the resources required during HIAP's implementation, replication in other regions may be unlikely without comparable support (Petersen & Sandhövel, 2001).

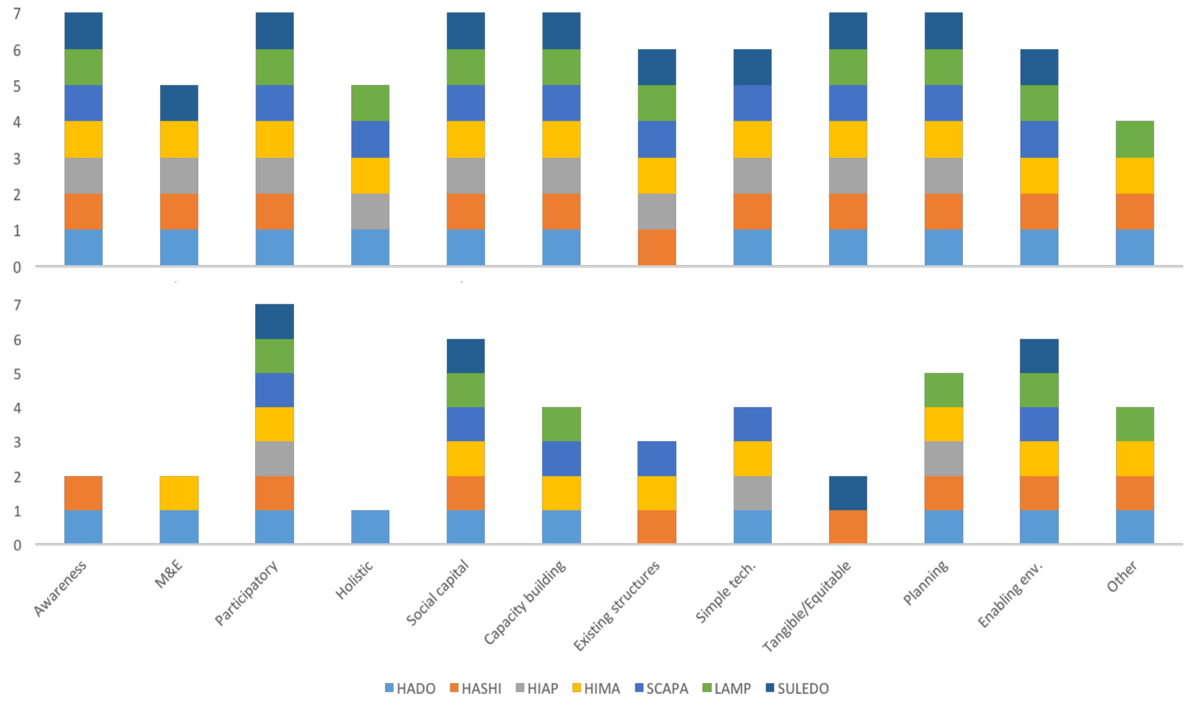

Figure 3: Frequency at which the identified 'lessons learnt' were a) mentioned and b) cited as important in success/failure of activities of the five case studies as well as two additional restoration projects. 'Awareness' = Need/desire for and awareness of restoration within community; 'M&E' = Gathering information from the outset, including baselines and systematic monitoring with clearly defined indicators and controls; 'Participatory' = Participatory approach, decentralisation and local ownership; 'Holistic' = Holistic/integrated, multi-disciplinary, multi-sectoral approaches; 'Social capital' = Developing social capital via strong communication, collaboration and relationships built on trust; Capacity building among all actors; 'Existing structures' = Supporting and building on markets, institutional structures and local knowledge; 'Simple tech.' = Simple, accessible and locally effective technologies; 'Tangible/Equitable' = Tangible benefits that are equitably shared; 'Planning' = Effective planning, phase-out strategy and/or long term commitments; 'Enabling env.' = Enabling policy, legal and institutional environment; 'Other' = Other.

IV. LESSONS LEARNT

Through this review of the elements of success and failure in dryland restoration projects in Tanzania, several factors that lead to successes (many of which interlink), were drawn from the five case studies together with two other projects. Figure 3 demonstrates how often projects cite or mention the various factors affecting success or failure. The following factors were cited as important and/or recurred across the case studies reviewed here:

1) *Need/desire for and awareness of restoration within community*. The need for restoration was arguably present in all case studies, but Barrow (2014) explicitly attributes HASHI's successes in part to the desire for restoration among local people. Generating awareness was cited in all five case studies, whether of causes and consequences of degradation (e.g. in SCAPA and HIMA) or importance of NRM (e.g. in HADO and HIAP).

2) *Gathering information from outset, including baselines and systematic monitoring with clearly defined indicators and controls*. Information is currency of the NRM process. The importance of formal indicators and baselines was stressed by Ogle (2001) regarding HADO, and lack of consistent data collection from the outset inhibited proper impact evaluation for HIMA. It seems that successes can be achieved if i) stakeholder consultation and situation analysis that precedes restoration activities (e.g. HIAP), ii) clearly defined indicators (e.g. HADO), iii) thoroughly planned baselines (e.g. HIMA), and iv) robust feedback loops via systematic monitoring and evaluation (e.g. HADO). Ideally, all of the information gathered will be in a form that is accessible to all actors, and gathered in a participatory

manner. Future projects will benefit from inclusion of control groups (e.g. similar households/villages not involved in project activities) to allow impacts of interventions to be more accurately assessed.

3) *Participatory approach and local ownership*. The participation paradigm was particularly pervasive throughout the case studies, and was sited as important in all five. It shifts emphasis away from 'top-down' approaches and from linear (researcher-extensionist-farmer) to non-linear (joint activities, co-learning and strengthening feedback loops) processes. Village-level participatory land-use planning was also key for the Suledo Forest Community, Kiteo District (Sjöholm & Luono, 2002) and many other community-managed forests (Hillbur, 2013). The Indigenous Soil and Water Conservation Programme (ISWCP) is another example, where high adoption rates were attributed to strong participatory approach involving famer-farmer transmission of technologies and joint experimentation and learning among farmers, extension officers and researchers (Mati, 2005). Participation was increased by various means including: PLUP (in HIAP), VSCCs (in SCAPA) and decentralisation of activities (e.g. in HASHI and HADO).
The participatory approach was important in many aspects including: i) evaluating degradation, ii) identifying most pertinent needs and issues, iii) identifying relevant/appropriate restoration options and evaluating their costs and benefits iv) developing sense of ownership, v) sustainability of restoration/conservation activities, vi) resolving conflicts, vii) representative decision-making, and viii) sharing benefits of rehabilitation. It may also be used in defining appropriate indicators, which assist in long-term participatory monitoring. The participatory approach also changed power dynamics between different actors, as villagers were empowered in decision-making and project staff played more facilitatory or catalytic roles. Participation may be regarded as fair due to its inclusivity, and it often facilitates acceptance by local people (and thus sustainability), who are also enabled to input important knowledge into decision-making processes (Norberg & Cumming 2008).

4) *Holistic/integrated, multi-disciplinary, multi-sectoral approaches*. These came in various forms, including HADO's shift from pure SWC to promote ZG, HIAP's watershed approach, and the inclusion of activities outside NRM by both SCAPA and HIAP. Moreover, lack of disciplinary and sectoral diversity was particularly implicated in the HADO's failures (Nuhu Hatibu & Mahoo, 2000). Interestingly, the importance of diversity may not be restricted to discipline and sector, but also apply to institutions. Mixtures of institutions, and inclusion of complex, layered and redundant institutions, has been suggested to aid land use management involving communal spaces (Dietz, Ostrom, & Stern, 2003).

5) *Developing social capital via strong communication, collaboration and relationships built on trust*. Many projects benefited from building social capital, although not always explicitly phased as such. Social capital has a wide range of definitions, but can be considered to be augmented by trust, strong communication, collaboration, capacity building (point 6), functional institutions (points 7 and 10), learning networks, and mobilisation of institutional memory (Norberg & Cumming 2008). Trust lubricates collaboration (Pretty & Ward, 2001), and is a prerequisite for functional relationships (e.g. between farmers and extension staff in SCAPA). Moreover, clear communication of information is crucial in building and maintaining relationships, as well as facilitating coordination among actors. This was the case in sharing the results of, and rationale behind, systematic monitoring (as experienced by HADO and MALISATA) and in advising restoration technologies. Transmission of technologies was also key (e.g. farmer-to-farmer via paraprofessionals in SCAPA), and affects adoption rates. For example, knowledge dissemination via farmer research groups had a significant influence in adoption of conservation agriculture across 6 districts of semi-arid Tanzania (Lugandu, Dulla, Ngotio, & Mkomwa, 2012). The importance of communication and strong relationships is exemplified by the failures that stemmed from weak links between projects and the village/district level (e.g. in HADO), central government (e.g. in SCAPA and HIMA), or other projects (e.g. in HADO). For HIMA, poor dialogue between village and district levels, led to lack of ownership among the local population despite village-level participatory planning, as final decisions were made at district level.
Strong communication is also the foundation of functional learning networks, which enable effective collection, analysis and distribution of data, to gain a better understanding of the complex social-ecosystem. However, this learning process was underdeveloped in most projects, due to lack of appropriate data collection to demonstrate the magnitude of successes/failures (particularly in relation to control groups), or evaluate factors that led to successes/failures and their relative importance. As this also hampers subsequent comparisons between, and learning from, past projects, lacking this information may be seen as a significant failure of a project. Deficiencies in institutional memory and

inability to learn from past projects was implicated in the failures of activities (e.g. HADO). To avoid this, future projects could, from the outset, define indicators clearly (e.g. of adoption rates, socio-economic impacts, effects on ecosystem structure and function), collect relevant baseline data and conduct systematic monitoring.

6) *Capacity building among all actors*. Generating capacity – which is an aspect of social capital – at various levels was an important aspect of all 5 case studies. Capacity building and well-resourced extension services in the Sida-funded LAMP (Land Management Programme) was also emphasised in enabling successful land management activities (Hillbur, 2013).

7) *Supporting and building on existing markets, institutional structures, and local knowledge*. Phrased differently, the *relevance* of project activities with regards to markets, institutional structures and local knowledge led to successes. Building on the already thriving timber market was a great advantage for HIMA. The project's forestry interventions also highlighted the importance of a business approach that incorporates a clear market-driven strategy (Danida, 2007a). The firm establishment of HASHI within local and central government administration was highly advantageous (Pye-Smith, 2010), and pre-existing social coherence, strong social structures and functional institutions within the communities was a strength (Barrow & Mlenge, 2003). Existing local knowledge and its recognition were also identified as key to HASHI's successes (Barrow, 2014), and tapping into 'indigenous knowledge' via participatory approaches proved fruitful for HIMA (Danida, 2007a). Interestingly, many 'indigenous' techniques were derived from migrants (Kisanga, 1999), so the successes attributed to these technologies may lie in their adaptation to suit local conditions, rather than their geographical origin. Thus, the process by which the technology is generated (e.g. developed via village-level participation rather than imposed in a top-down manner) and disseminated (e.g. farmer-farmer transmission from on-farm trials rather than advice based on research from elsewhere) may be more important for successful uptake than the technology, or output, *per se*.

8) *Simple, accessible and locally effective technologies*. Again, the *relevance* of activities to local people (including history, culture and beliefs) and local environment is key. Interventions that were too expensive (e.g. water tanks in SCAPA), complex or labour-intensive (e.g. sophisticated composting in HIMA) were generally unsuccessful. Lack of accessibility to capital and returns on investment (e.g. fish farming in HIMA) can hamper sustainability (if subsidised by the project) and/or adoption of technologies. Benefits mainly came in the form of augmented natural resource bases (e.g. in HADO, HIMA and HIAP), crop yields (e.g. in HADO, SCAPA and HIMA) and income (e.g. in SCAPA and HIMA).

9) *Tangible benefits that are equitably shared.* Tangible benefits were important in all 5 case studies, particularly in the short-term. More universally accessible technologies also lead to equality through dissolution of socio-economic constraints. Equitability was also an issue with respect to livelihoods (e.g. conflicts between arable farmers and pastoralists in HIAP) and gender, specifically distribution of costs and benefits of a technology between men and women (e.g. ZG in HADO). The equitable sharing or benefits was undermined by neglected regulations, resulting from corruption, in HADO, SCAPA and the Suledo Forest Community (Sjöholm & Luono, 2002).

10) *Long-term plan*. A long-term approach was beneficial for HASHI, possibly due to continued support and building strong relationships. Poor phase-out strategy, heavy reliance on external support, and curtailment of project activities when funding is withdrawn was implicated in project failures post-termination (e.g. in HIMA and HADO). To account for this, definitions of success could express outcomes as a proportion of external inputs, and/or incorporate the sustainability of project activities into the future after external support is withdrawn.

11) *Enabling policy, legal and institutional environment*. Policies and legislation affect many aspects of restoration projects including: extension services, markets, land tenure and subsidies. However, legislation alone is ineffective unless enforced, as demonstrated by the initial failure of the HADO project to prevent damaging activities. Lack of enforcement of local by-laws was also implicated in low adoption of land conservation measures introduced by LAMP in Kiteto District (Hillbur, 2013). In a LAMP-facilitated project in Babati District, organised village and democratic governments were among the main factors that enabled sound community management of the Duru-Haitemba woodland (Iddi, 2002). This highlights the importance of functional institutions in successes (e.g. those surrounding *Ngitilis* in HASHI). The importance of an enabling legal and institutional environment was

stressed in a review of commons governance, which identified two 'keystone' elements of successful NRM in communal areas: i) clearly defined boundaries of resources and their user rights, and ii) sanctions that are enforced and perceived to be legitimate by participants (Dietz et al., 2003).

12) *Other factors*. This includes personalities/champions, weather conditions and mitigating costs resulting from restoration, none of which are easy to control. Key individuals can be implicated in the success of projects (e.g. HADO, HASHI), but this may represent a weakness regarding resilience if successes rely on few individuals. Across 6 districts of semi-arid Tanzania, weather significantly influenced the adoption of conservation agriculture (Lugandu et al., 2012). The amount and distribution of rainfall is a major limiting factor for agriculture in semi-arid areas (Kisanga, 1999), and is therefore the main climatic variable to affect project outcomes. For HIMA, the magnitude of crop yield increases may have been limited by below-average rainfall (Danida, 2007a). Although weather cannot be controlled, the long-term success of projects is likely to benefit from consideration of impacts of climate change, for example, variability in patterns and amount of rainfall, temperature patterns, incidences and severity of droughts, and wind. Lastly, costs of restoration are not limited to financial, labour and opportunity costs. Restoration can lead to issues including land-use conflicts over rehabilitated areas (e.g. in HADO) and losses due to returning wildlife (e.g. in HASHI). These potential costs are worth considering and may be mitigated via PLUP (as used in HIAP), strong communication between resource users and continuous adaptive management.

V. OPPORTUNITIES

Firstly, restoration of social-ecosystems is a complex process with many interacting variables that affect outcomes and the degree of success. Thus, it is difficult to tease apart interacting influences that lead to success/failure of particular techniques in particular places and times. There are also issues with extrapolation to other social-ecosystems due to spatial (e.g. biophysical/socio-economic/cultural) and temporal (e.g. rainfall amount/distribution) variability.

Secondly, the paucity of accessible reports for past projects limited the number of case studies available for evaluation. It also restricted the scope, balance and depth of the reviews for the case studies, which is a weakness of this work. Furthermore, a large proportion of the information on these projects resides in the 'grey literature', which posed some challenges for this review. However, the greatest challenge was the dearth of baseline data, controls, clearly defined indicators and systematic monitoring to make quantitative descriptions of changes in the indicators over time. Moreover, reports often state outcomes that resulted from restoration efforts, but few of these statements are reinforced by empirical data. These deficiencies greatly hampered attempts to judge external validity, compare the effectiveness of restoration techniques, or identify factors that enable successful restoration.

Despite these limitations, the lessons gleaned from these projects are echoed by a study of conservation policies in nine African countries (including Tanzania) published before 4/5 of the reviewed projects began (Stocking, 1985). It highlighted the successful uptake of technologies that are familiar to locals and provide tangible benefits, and identifies local-level consultation and participatory planning as indispensable to soil conservation. Stocking (1985) also cautioned the failure of complex, labour-intensive, external input-dependent measures or those requiring centrally-imposed regulation. This demonstrates limited learning, which may be overcome through improved research and communication.

VI. CONCLUSIONS

It is important to understand the historical context of land degradation prior to implementation of a rehabilitation project. Identifying relevant technologies is also crucial but, due to lack of systematic data collection, determining the relative effectiveness of technologies in different social, economic and/or environmental contexts has proved challenging. Although it is difficult to judge the relative importance of the factors associated with successes in these case studies, there are several elements that appear to most strongly influence successes/failures. First, participatory approaches were particularly successful and influenced many aspects of the projects reviewed. Another major factor was building social capital, which encompasses communication, coordination, collaboration, capacity building, functional institutions, institutional memory mobilisation, and learning. The latter requires gathering and communication of information, which can be facilitated by well planned data collection. Facilitation from the political, legal and institutional environment was also important, as was effective long-term planning. Finally, *relevance* to local social-ecological contexts was key in influencing a technology's accessibility and adoption.

Defining 'successes' will facilitate future comparisons between projects. Definitions of success in restoration projects may incorporate, not only the efficiency of activities considering external inputs, but also the continuation of activities after the project comes to a close. The discussion of indicators of success is worthy and important one to engage in, both from the farmers' perspective as well as the projects'. Success during the project and post-termination may require resilience, which can be conferred by participatory approaches, diverse functional institutions and continuous adaptive management (Norberg & Cumming 2008). Furthermore, success is also conferred by good data collection, as information on factors that lead to both successes and failures are valuable in the learning process, to benefit current and future projects.

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