REVERSE THINKING AND "AFRICAN POTENTIALS" TO COMBAT DESERTIFICATION IN THE WEST AFRICAN SAHEL: APPLYING LOCAL GREENING TECHNIQUES BORN FROM DROUGHT AND FAMINE IN THE 1970S

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ABSTRACT As their farmland deteriorates, the Hausa people improve its fertility by mixing household waste and urban waste into the soil. These wastes include excreta of cattle, leftover fodder, pruned branches, crop residues, worn-out cloths, plastic bag and metal pans. This local greening technique was developed by villagers in 1973 and 1974, during a time of drought and famine. Since 2003, the author has conducted repeated field experiments on the effectiveness and safety of the use of organic waste from urban and homestead environments. Shrubs grow from waste input after grassland is created, and herders foster forest growth in fenced experimental plots, using their livestock. The author has performed local techniques using external equipment. Although the lifestyle and production patterns of the residents in the Sahel exacerbate the desertification process, urban waste and livestock can restore the degraded land. This path of greening is considered reverse thinking and "African Potentials" based on the indigenous knowledge and day-to-day practice, which combats the desertification of the West African Sahel.

Key Words: African potential; Environmental restoration; Hausa; Indigenous knowledge; Land degradation; Land restoration technique; Republic of Niger.

INTRODUCTION

According to the United Nations Convention to Combat Desertification, which was ratified in 1994, the definition of desertification is land degradation. The 2030 Agenda for Sustainable Development Goal 15 is to protect, restore, and promote the sustainable use of terrestrial ecosystems, combat desertification, and halt and reverse land degradation and biodiversity loss. Desertification occurs through a combination of natural (irregular rainfall, drought, and poor soil fertility) and anthropogenic factors (overcultivation, overgrazing, and firewood collection). Many researchers and international organisations have reported that unsuitable cultivation, grazing, firewood collection, and urbanisation are the major causes of desertification (Anderson & Fishwick, 1984; Dregne, 1986; Turner, 1999; Gonzalez, 2001; World Bank, 2012).

The rapid increase in the human population of the Sahel, the southern fringe of the Sahara Desert, particularly in its urban population, is a fundamental driving force in desertification and land shortage (Reenberg et al., 1998; Wezel & Haigis, 2002). In recent years, famers and herders have both experienced

hunger and poverty caused by desertification in the Sahel, which has led to armed conflict and terrorism (Ayantunde et al., 2000; Mortimore & Turner, 2005; Tschakert, 2007; Oyama, 2014). A downward spiral exists from desertification through hunger and poverty to armed conflict (Blench, 1996; Obioha, 2008), and the spectrum of terrorism is growing throughout the region.

Overcoming the problem of desertification is important not only for reducing poverty and maintaining and improving the quality of life but also for achieving regional political stability. In Republic of Niger, combating desertification is a crucial issue, and routine work is underway on tasks such as tree planting, dune stabilisation, catchment management, and erosion reduction. The national government promotes community participation in these initiatives, providing food for work and cash for work by making the distribution of food aid to villages conditional upon the engagement of their residents in tree-planting and the anti-erosion work. In 2004, the Nigerien government announced that from 2000 to 2002, trees had been planted in an area of 381 km^2, 40 km^2 of sand dunes had been stabilised, and surface runoff management and anti-erosion measures had been instituted across 384 km^2 (Republique du Niger, 2004).

Programs to combat desertification in the Sahel were initiated at the international level in the 1970s, but their progress and outcomes have been unsatisfactory, and drought-induced desertification has continued, together with countless other related problems (Leisinger et al., 1995). The African Union, the European Union, and the Food and Agriculture Organization of the United Nations created the Great Green Wall Project for the Sahara and Sahel Initiative, promising in November 2011, 1.75 million Euro to tackle desertification in the Sahel and North Africa through revegetation projects (Europafrica.net, 2011). The planed greenbelt would be 15 km wide and 7,775 km long. In Senegal, the project planted trees over 50,000 acres. The current approaches to dealing with desertification tend to be directed towards technological development, involving expensive equipment and consuming vast quantities of energy and capital.

In 2012, for example, 5.5 million people in Niger were at immediate risk of starvation following a severe drought the previous year, and the United Nations World Food Programme requested that the international community provide US $800 million in emergency aid to deal with the crisis (World Food Programme, 2012). According to the Global Terrorism Index 2015 (Institute for Economic and Peace, 2015), terrorism and insecurity problems in the region are becoming increasingly serious.

Niger is also experiencing high rates of population growth, with an annual growth rate of 3.7%. This rapid pace has resulted in a doubling of its population in just 20 years. The fertility rate—the number of children each woman is projected to give birth to during the course of her life—has reached 7.4. When this author began research in Niger in 2000, the population was 10.92 million, and in 2015, it was 19.90 million. The United Nations (UN) predicts that it will continue to grow, reaching 83.92 million in 2055 and 137.94 million in 2075 (United Nations, Department of Economic and Social Affairs, Population Division, 2017). This rapid growth may lead to many problems in the near

future including desertification, food shortages, and other forms of environmental degradation, as well as difficulty in allocating resources and energy. These problems are linked to violence, conflict, and terrorism due to resource scarcity.

This paper examines the consciousness of land degradation and day-to-day land restoration practices among the Hausa people residing in southern Niger. Rather than passively remaining at the mercy of their harsh natural environment, they use indigenous knowledge to address the land degradation. This paper sheds light on these practices and the distinctive ways of thinking that underpin them. The author also discusses the trials of action research for developing new land restoration technologies based on the integration of indigenous knowledge and external equipment.

HAUSA SOCIETY AND THE NATURAL ENVIRONMENT OF THE SAHEL

I. Hausa Society

The Hausa are the largest ethnic group in West Africa. Hausa people dwell in an area extending from Filingue, Tahoua, and Zinder in central Niger to the north to as far south as Kano and Zaria in northern Nigeria. They refer to themselves as *Bahaushe* (sg.) or *Hausawa* (pl.), and the area in which they dwell is sometimes referred to in English as Hausaland. Major Hausa communities have formed in northern Ghana and northern Cameroon, and Hausa storeowners and artisans can be found in most of the cities of the Sahel. Most Hausa are Muslims, and it is possible to trace the history of this religion in Hausaland back to the 14th century. Islam spread as the Hausa migrated from one part of West Africa to another. In West Africa, Islam is now sometimes considered synonymous with the Hausa people, and in the spread of Islam, locals may see a kind of "Hausanisation" occurring (Adamu, 1978).

The Sahel once contained numerous kingdoms. Rather than being viable, stable nation-states founded on agricultural surpluses, these kingdoms were largely supported by livestock rearing and commerce. The true Hausa is the patrilineal descendants of the people who dwelled in the region controlled by the Hausa kingdom in the 15th century (Smith, 1971). This kingdom flourished as a centre of intermediary trade in produce from the coastal regions to its south, as well as of rock salt from the Sahara Desert and goods imported from the Mediterranean (Baier, 1980). The Hausa actively pursue commerce in urban areas of West Africa.

The region that is home to the Hausa is part of the Sudan–Sahel zone of West Africa. This zone encompasses a vast belt of land from the Atlantic coast of Senegal as far inland as Chad. The findings presented in this paper are from a study of D village, a Hausa village, located in the southern part of central Niger (Fig. 1). When the author began the survey with a period of residence in D village in 2000, the village had 41 households and 280 residents; in 2010, it had 65 households and a population of 504. Thus the population increased

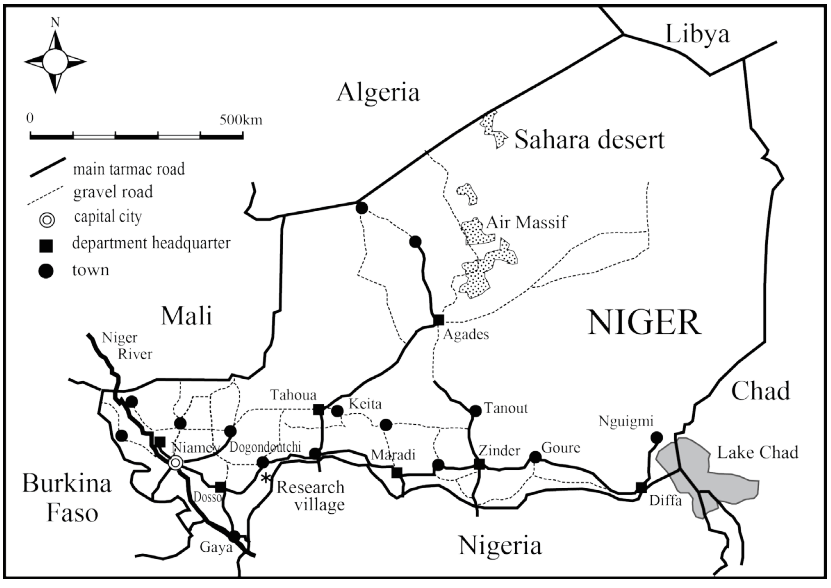

Fig. 1. Research site in southern Niger, West Africa

by 6.0% per annum during the intervening decade. Most of the village's residents are of Hausa ethnicity, but it also includes one Tuareg and two Fulbe herder households. Most residents are Muslims, and at dawn and dusk each day, Muslim men attend prayers at a mosque in the centre of the village.

II. The Harsh Climate of the Sahel

The soil around D village falls into the Arenosols category (FAO/UNESCO, 1971). This oligotrophic soil type, characterised by extremely small volumes of organic matter, nitrogen, and phosphorus, is distributed across a large area from central Mali to southern central Niger and northern Chad. The village lies approximately 240 m above sea level and is surrounded on all sides by pearl millet fields. Running north–south on the east side of the village is a series of inselbergs or isolated rocky hills, reaching around 50 m tall. The inselbergs are covered in an iron duricrust, underneath which are deposits of sandstone, mudstone, and other sedimentary rocks dating from the Miocene to Pliocene eras, with stratifications visible on the surface. The inselbergs are topped with a type of vegetation known by scientists as tiger bush, which, when viewed from the air, resembles the markings of a tiger (Galle et al., 1999; Malam Issa et al., 1999). It is difficult to cultivate crops on the duricrust, but the tiger bush is gathered for use as firewood, and the village women cultivate numerous small plots in which sand has accumulated, producing crops of Bambara nuts and

groundnuts in the rainy season.

The rainy season lasts from June to September and is known in Hausa as *damana*. There are *wadis* (dry watercourses) on the north and south sides of the village, through which water flows following the time of rain. The arrival of rain is preceded by strong winds with a velocity of more than 10 m per second. Sand is whipped up into storms, and there are also occasional lightning strikes. The wind, which can be followed by rain, blows from the south-southeast, east, or northeast, and brings sandstorms from the east and southeast. The arrival of a sandstorm does not necessarily herald rain, and when it does, rainfall volumes can vary from about 1 mm per hour to downpours in the order of 40 mm per hour.

The dry season runs from October to May and is divided into two parts: *dari*, which spans the cooler dry months from October to March; and *rani*, a hotter period from April to May. *Dari* is the cool part of the dry season, when overnight temperatures can fall to 15°C, although daytime temperatures can exceed 35°C. *Rani* brings even hotter conditions. Overnight minimums are about 25–30°C; maximums in excess of 35°C are common, and days over 40°C Celsius are not rare. An oppressive heat prevails throughout *rani*. A hot, dry wind, generally known as the Harmattan, blows from the north and northeast with gusts of 10 m per second or more. From May to June, the skies are filled with clouds promising the arrival of the rainy season; the days are hot and humid. This period is known in Hausa as *bazara*. Maximum temperatures often exceed 35°C, with a humidity ranging from 70 to 90%.

In the town of Dogondoutchi, 7 km northwest of D village, rainfall records have been kept since 1923, during the days of the French colonial government. The average annual rainfall for the three decades from 1981 to 2010 was about 460 mm, but there was considerable variance from year to year (Fig. 2). This variance is attributable to the activity of an intertropical convergence zone (ITCZ), formed when warm, humid air from the Gulf of Guinea (the 'Guinea monsoon') meets the dry continental air mass. This ITCZ moves north from July to September, bringing rain to the Sahel. Around the northernmost edge of the ITCZ, however, rain is unreliable, and annual rainfall fluctuates dramatically (Mortimore, 1998). Thus, the influence of the Guinea monsoon wanes as it moves northward; in inland areas, the dry season tends to be harsher and the rainfall is less predictable the further north one goes. For these reasons, Niger is prone to drought and low rainfall. An annual rainfall of 350 mm is considered the minimum for cultivation of pearl millet. Since 2000, there has been no period of drought with lower rainfall than this, but such droughts occurred repeatedly from the 1970s to the 1990s, bringing severe food shortages. In 2011, the annual rainfall in the area surveyed was 389 mm. Rain was particularly scarce from mid-August through September 2011, endangering the pearl millet and cowpea harvest.

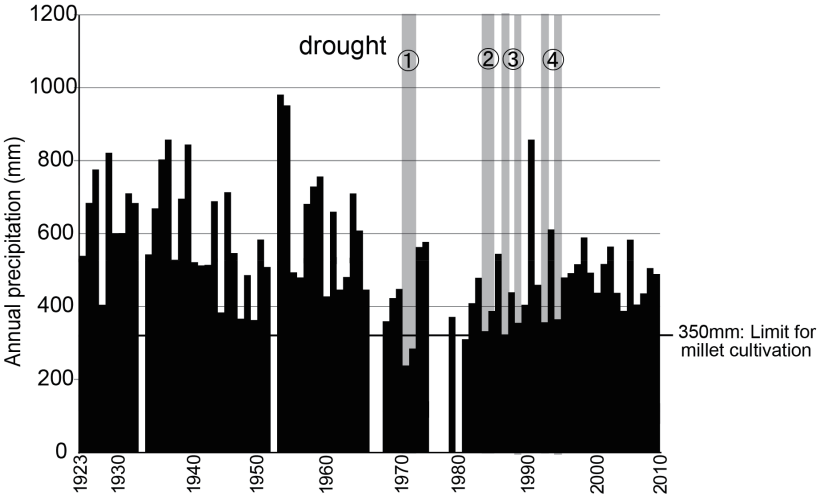

Fig. 2. Rainfall fluctuations and drought years in Dogondoutchi, Niger

LIFE IN A HAUSA VILLAGE

I. Extended Family Centred on the Household Head

The villagers' livelihood is based on the cultivation of pearl millet and cowpea; livestock are grazed as a subsidiary activity. Some villagers also earn extra cash income through side work as traders, butchers, blacksmiths, wood-turners, osteopaths and scribes, among others. The men of the village migrate to urban areas for work during the dry season when there is no farming work. In Hausa villages, due in part to the shortage of land, young men who have married and moved out of the family home tend to work on their father's land and take their meals together with their parents, siblings, and other members of their families. Below, the Bawa[(1)] household is presented as an example of the patterns of production and consumption in rural Hausa societies (Fig. 3).

In 2003, Bawa owned a 6.19-hectare plot of land, which was farmed by seven family members: Mohamad, the first-born son of Bawa's first wife Bangu; Yusuf, Zakari, Alio, and Djibulina, respectively the second, third, and fourth sons and a grandson of his first wife; and Tahil and Hasan, the second and third sons of his second wife Beiwa. Beiwa's first-born son, Asumana, is unable to work on the farm, due to a leg problem. Mohamad, Zakari, and Asumana also work alongside their father as blacksmiths, producing agricultural thrust hoes every day during the rainy season. Six of these family members tend the household's plot daily: Yusuf, Zakari, Alio, Djibulina, Tahil and Hasan. The head of the household, Bawa, struggles to make the household food supply last for the entire

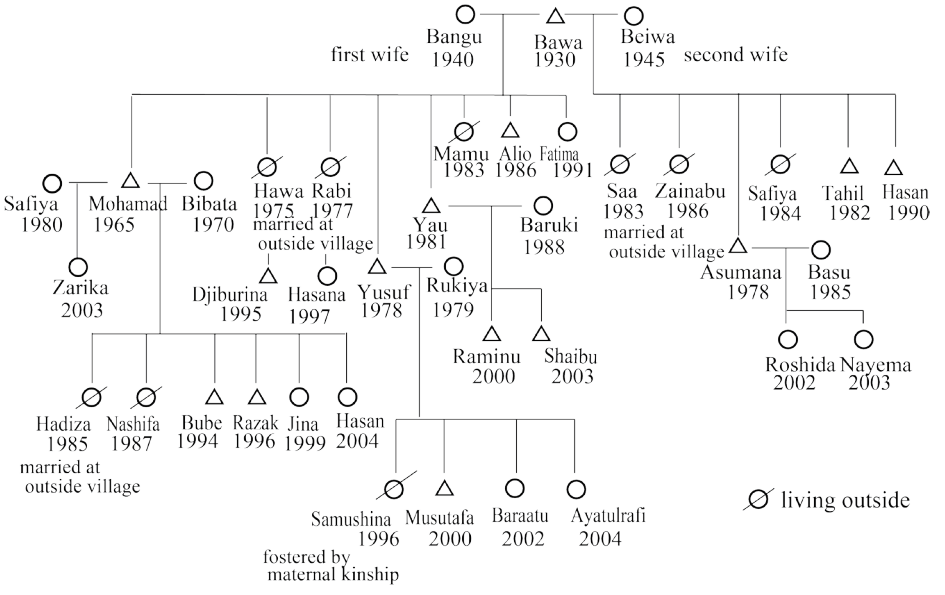

Fig. 3. Family tree of Bawa in 2003
(All names of individuals are fictitious.)

year, taking into account both the pearl millet harvested from his own plot and the income derived from his blacksmithing business. Hausa men see their ideal existence as one in which, as head of the household, they can balance food supply, cash income, and labour to achieve a comfortable existence for their wives and children, as well as their sons' families. Meals in the Bawa household begin with division of the millet porridge into five plates. The first plate is eaten by Bawa himself and his youngest son and grandson (Hasan and Djibulina), who are 10 to 15 years old, respectively; the second plate is for the older sons (Mohamad, Yusuf, Zakari, Alio, Asumana, and Tahil), both married and unmarried; the third is for Bawa's two wives (Bangu and Beiwa) and daughter (Fatima); the fourth is for Bawa's sons' wives (Bibata, Rukiya, Baruki, and Basu); and the fifth plate goes to the children under 10 years old. With a total of 22 mouths to feed, the household consumes approximately 100 kg of pearl millet grain weekly.

II. Ongoing Food Shortages

In 2005, the Bawa household's plot yielded 80 bundles of pearl millet (Fig. 4). Each bundle ranged in weight from 10 to 18 kg depending on the quantity and size of the grain therein, which was in turn determined by soil conditions and rainfall. Even if each bundle harvests yields the maximum grain volume of 18 kg, this is only 1,440 kg in total—barely enough to feed the household for 4

Fig. 4. Millet harvest
The farmers make bundles of 300 to 500 millet panicles and place them at the front of the grain stockade to be counted. The head of the household formulates a 1-year consumption plan to prevent members of his family going hungry.

months of the year. The household's work in manufacturing and repairing hoes for other farmers in the village brings in an additional one-half to one bundle of pearl millet per farmer. The payment received from each farmer depends on the number of hoes repaired during the farming season. In all, this blacksmith business brings in about 40 bundles per year—enough for 2 months.

Even when the harvest is combined with earnings from the blacksmith business, the food supply of the household tends to run low as sowing time approaches. Such shortfalls are addressed by selling livestock. Approximately 10 goats and sheep are kept in the Bawa household compound, together with 1 donkey for carrying goods. There are also two cows, which the household tends for a Fulbe herder who lives in the same village. The Fulbe herders care for the farmers' cows, goats, and sheep. In March 2006, the Bawa household sold a 6-month-old calf born to one of these cows, and used a portion of the income from the sale, which totalled 40,000 CFA francs (US $80), to purchase 150 kg of pearl millet (at 18,000 CFA francs per 100 kg). This purchase met the household's staple food needs for 2 weeks. Cattle aside, goats, sheep, and poultry are also sold off to the village butchers or periodically at weekly markets to earn cash to purchase more grain. Cash income to offset food shortages can also be earned through the sale of firewood. Adult women and children gather firewood from the surrounding scrubland, and each morning carry it on their

heads for 7 km to the town of Dogondoutchi, where a one-person load sells for 50–200 CFA francs. In recent years, some young villagers have also started collecting and selling building materials, such as clay and rock, in response to demand generated by a construction boom in urban areas. This is not a reliable source of cash income, however, as the arrival of trucks to collect the materials is unpredictable. The sale of items such as firewood and clay is considered a last resort for households unable to obtain food through other means.

If food runs out despite these extra efforts, villagers approach one of the rich households, known as *mai-kudi*, to request a cash loan with which to purchase more food. Because the price of pearl millet drastically increases in the sowing season, many villagers use this cash to purchase cheaper cassava instead. In its dried form, cassava is roughly crushed and sprinkled with salt for a makeshift meal. Debts are repaid through weeding work undertaken in the lender's plots during the following season. In the Bawa household, this labour is mainly performed by the unmarried sons—Alio, Djiibulina, Tahil, and Hasan. In 2006, the daily wage for this work was 1,150 CFA francs, but the amount varies depending on the food supply in the village each year, decreasing as food becomes scarcer. The workers weed the rich household's plots from just after 8:00 a.m. to after 4:00 p.m. in temperatures that can exceed 40°C. Wages are not usually directly paid to the labourers, but instead, are marked down against the household's debt to the wealthy family.

By mid-September, the pearl millet panicles are still not completely dry, but they are edible nevertheless. When harvested at this time, fresh pearl millet is known as *tumu* and is eaten either simply roasted or mixed with dried leaves of the Aduwa tree (*Balanites aegyptiaca*; a zygophyllaceous plant) known as *dubagara*, vegetable oil, sugar, and *bakuru*, a condiment made from groundnut oil meal. When household finances are running low, it is sometimes necessary to omit the sugar, oil, and *bakuru*. Thus, what the villagers eat varies depending on rainfall. Villagers reported that crop growth was particularly poor in 2004 and 2005, leading to food shortages in the subsequent years and making *dubagara* a precious commodity. When the author visited the village for research in July 2006, few residents had food left; they were thin, and the veins on their faces were prominent. This physical condition is known in Hausa as *yarami*. In the 2005 season, the villagers faced a poor millet yield; 27 households, representing about two-thirds of the total village population, had exhausted their stocks of pearl millet before the next sowing season (June 2006); and 24 of these households were using money borrowed from the three wealthy villagers to purchase food.

In the Bawa household, and indeed in other households in the village, the last resort if food remains scarce after going into debt is to eat *dubagara* boiled in salted water. The *Balanites* leaves for *dubagara* are gathered when they are young and green in April and May by the women of the household, who decide how much to gather based on their household's food stores at that stage of the year. If the pearl millet harvest is good or if they have secured some wheat or maize flour through U.S. aid projects, they will gather fewer *Balanites* leaves; if conditions are tough, they will gather more. The leaves are dried and stored

indoors. Other precious sources of food during the rainy season include leaves from the cowpea plants harvested at that time of year and herbaceous plants such as *Corchorus tridens*, *Cassia obtusifolia*, *Nothosaerva brachiata*, *Gynandropsis gynandra*, and *Amaranthus* spp., which grow naturally during the rainy season. These are mixed with small quantities of pearl millet, boiled in salted water, and eaten to tide the household over until harvest time. Sometimes pearl millet is not added to this mix if supplies have been exhausted, but villagers say that without any at all, the bitterness of the *Balanites* leaves burns the throat. The leaves are gently simmered for 7 to 8 hours, left overnight in the salted water to cool, and then consumed. In times of more severe famine, *Jacquemontia tamnifolia* and *Indigofera prieureana* leaves, which are apparently used as livestock feed under normal circumstances, may also be added. The author has personally sampled both of these plants; under no circumstances can they be described as appetising. The village women reported that they were reduced to eating livestock feed four times in the past 10 years: 2004, 2005, 2007, and 2011.

III. Severe Drought and Collective Memory

The people of the Sahel take various actions in response to crop failures caused by drought (Swinton, 1988). These actions are as follows: selling cattle, sheep, goats, and poultry; short-time migration to work in urban areas, both domestic and international; engagement in wage labour or procurement of supplementary food supplies; and borrowing money. Through these actions, people procure cash and food to provide for their daily needs. However, the Hausa people have experienced droughts so severe, that such actions were inadequate to address the food shortage.

In D village, each severe drought is given a name in Hausa and remembered by villagers, particularly the elders. The 1972–1973 drought, (1) in Fig. 2, is referred to as *nyunwa garin rogo*, the ‘cassava flour famine.’ During this drought, which is known in the Hausa society of northern Nigeria as *kakaduba* (Mortimore & Adams, 2001), no pearl millet was available for purchase, so people were forced to make do with cassava flour, the cheapest food available. Cassava is usually considered a famine food, to only be eaten when nothing else is available. Village elders recall that during the drought, their stocks of pearl millet were exhausted, leaving no seeds to sow for the next season even after the drought ended. Thus, this food shortage continued for 2 years.

The name given to the drought of 1984–1985, (2) in Fig. 2, is *nyunwa maizobe*: the ‘ring famine.’ In a ring of territory extending across West Africa, famine prevailed following drought-induced crop failures and livestock losses. Cattle grew so weak that their Fulbe and Tuareg herders were unable to move them south in search of pasture, and many perished as a result. There was no pearl millet in the markets, so even those with cash reserves were unable to purchase food. *Nyunwa kanchikarage*, the ‘famine of the food-seekers,’ took place from 1987–1989, (3) in Fig. 2. Rainfall was unevenly distributed during this period;

thus crop yields varied from region to region. Each locality experienced the famine differently. Where there were severe shortages, people could not purchase pearl millet even if they could afford it and had to make do with cassava flour instead. In other areas, crops performed well, but this did not mean that the residents were happy; they were inundated by people from less fortunate areas seeking food, and had no choice but to share their own valuable supplies with them. The 1993–1995 drought, (4) in Fig. 2, is known as *nyunwa mayahi* or the 'scarf famine.' Drought conditions extended across a wide area, with marked regional differences in food supply. People hid their food stores in scarves in a desperate attempt to protect them from beggars and job seekers.

LAND DEGRADATION AND RESTORATION OF FARMLAND

I. Growing Degradation of Farmland

Aerial photographs taken in 1950 show pearl millet plots dotting a grassy landscape of uncultivated and fallow land (Oyama, 2012). Elderly villagers recall that 40 to 50 years ago, there was still land to spare around the village, much of it untouched. Subsequently, however, the population grew rapidly, and an increasing area of land was farmed. Soon, all arable land was put to use for pearl millet cultivation. All of the plots are privately owned, although the government does not maintain official land ownership register. In recent years, land suited to cultivation has been in short supply, and it is difficult to find new land for farming. Village women have even attempted to cultivate Bambara nuts and groundnuts in the small sand hills found on the iron-crusted inselbergs. The land is not left to lie fallow; pearl millet and cowpea are grown in succession year after year. Under continuous cultivation, soil fertility drops, and the land drastically deterioates. Pearl millet crops do not grow uniformly even within the same plot, and the differences among neighbouring plots is often striking.

Hausa villagers use three terms to classify the state of the soil in their plots: *kasa*, *leso*, and *foko*. *Kasa* denotes productive soil, and *leso* is the early stages of soil degradation when nutrients have leached out. *Foko* areas are in an advanced stage of degradation, as the fertile soil has been eroded and the base sedimentary rock exposed (Fig. 5). The Hausa people use the categories *kasa*, *leso*, and *foko* to express their assessment of the degree of decline in soil fertility and productivity (Oyama, 2009). *Kasa* areas have blackish sandy topsoil containing organic material mixed with what is known as 'termite soil.' This soil, which has a loose aggregated structure, is produced when termites combine their saliva with soil particles to create a material used in the construction of their nests. This type of aggregated structure is necessary for soil to support plant growth and root development. *Leso* soil, in contrast, consists of coarse, white, sandy particles; it has a high proportion of sand, little organic matter, and a non-aggregated structure. *Foko* denotes areas of exposed reddish sedimentary rock, which is so hard that it can only be broken by blows with

Fig. 5. Rapid land degradation of millet fields
Leso is white sand, and it refers to the early stage of land degradation at which soil nutrition is decreased by plant growth and leaching. The composition of sand is high (more than 85%), and the sand can be easily eroded by rain water (left). The erosion of the topsoil results in exposure of the solid sedimentary rock beneath. This rock is called *foko*, and it signifies an advanced stage of land degradation (right).

a pick. *Foko* soil is poorly suited even to pearl millet; the seeds germinate but all of the plants eventually die. Soil that begins as *kasa* will be transformed through continuous pearl millet cultivation into *leso* within 3 to 5 years, and to *foko* in a further 3 to 5 years.

II. Two Approaches to Land Restoration

The villagers are not standing idle in the face of this ongoing degradation of their land. Two strategies are being employed to address land degradation and declining crop harvests: encampment contracts with livestock herders, and the use of household waste. The choice of strategy is determined by the condition of soil degradation.

1. Encampment contracts with herders

First, let us examine the encampment contracts between farmers and herders. Hausa villagers enter into these contracts with Fulbe and Tuareg nomadic herders who move into the area with the coming of the dry season (Oyama, 2017). Under these contracts, the herders are invited to establish grazing camps on villagers' land where the soil has deteriorated (Fig. 6). Fulbe herders mainly raise cattle and Tuareg camels; other stock may include goats, sheep, and donkeys. The herders actively seek out farmers with which to enter into encampment contracts. The preference is naturally to contract with the wealthy villagers (*mai-kudi*) who are able to pay well. The herders will not deal with *talaka*, poor farmers who find it difficult to feed themselves and may end up not even paying for the enrichment of their pearl millet plots by the herders' livestock. To ascertain a farmer's wealth and financial circumstances, the herders use methods such as calculating harvest volumes based on the post-harvest stubble in the

Fig. 6. Encampment contract
The farmers make contracts with Fulbe and Tuareg herders during the dry season. The herders establish grazing camps on the farmers' millet stubble fields and their livestock provides dung to the farmland. The dung serves as crop fertiliser, but such contracts are limited to wealthy farmers (Oyama, 2017).

farmer's pearl millet plot and the size and number of grain sheds erected in the plot. Once they have estimated the financial resources of the farmers, the herders set up camp in plots that they judge to be owned by wealthy villagers. They sleep in these camps alongside their livestock. Soon, the villager who owns the plot, or one of his relatives, will come to check on the plot and will assess the situation upon seeing the Fulbe or Tuareg herder. At this point, the head of the household who owns the plot will begin to negotiate the terms of an encampment contract with the herder. The aim of the negotiation is to determine the encampment contract period and the price that the herder will be paid over this period. The herder will show his herd to the villagers, but will not under any circumstances disclose the number of animals. The owner of the plot must estimate the size and composition of the herd by visual inspection, and on this basis, negotiate the encampment period and fee, which is paid in pearl millet and cash. Negotiations are conducted in Hausa. Some herders cannot speak Hausa fluently, although they can engage in simple negotiations. When the parties have reached agreement on the terms of the contract, the Fulbe or Tuareg herder sets up his grazing camp together with his family, herd, and household possessions at the agreed upon location. The villagers usually require the camps to be set

up on sand-covered *leso* land, because livestock prefer to sit and lie on sandy ground at night.

The following is an example of the contracting process. In February 2011, a villager named Yusuf observed that a Fulbe herder was grazing livestock around a camp set up on his land. The herder was about 30 years old, and his wife and children were also present at the camp. The herder told Yusuf that he had two wives, but only one was at the camp. Yusuf proposed that they enter into an encampment contract; the herder assented, and they agreed to negotiate the details that same evening. The herders' animals return to their camps in the evenings, which makes it possible to assess the size of the herds. When evening came, Yusuf assessed the herd visually and judged that were approximately 25 cows, 6 sheep, and 3 donkeys. Then he proposed to the herder an encampment period of 1 month, but the herder responded that there was almost no pearl millet stubble left on the plot to feed his herd and suggested a period of 1 week instead. Yusuf consented to this suggestion, and payment negotiations began. The herder requested payment in cash rather than pearl millet, so the negotiations focused on settling a cash price. The herder's asking price was 6,000 CFA francs, but on the basis of the type and number of animals in the herd, Yusuf believed that a fair price was 4,000 CFA francs. In February, when the negotiations took place, the volume of herbaceous plants and pearl millet stems on the plots dwindled, resulting in lower manure production by the herd, and as such, less effective fertilisation. Then the herder proposed a reduced price of 5,000 francs, and finally a price of 4,500 CFA francs was agreed upon—1,500 CFA francs less than the original asking price.

The villagers assess the fertilising effects of the manure as follows: camel 5 years, goat and sheep 3 years, cow 2 years. This means that cattle manure decomposes rapidly, providing nutrients for only 2 years, whereas camel manure provides up to 5 years of fertilisation. This notion of the effectiveness of different manures held by Hausa villagers is in accordance with the findings of an empirical study (Brouwer & Powell, 1998). That study found that sheep manure is highly effective for correcting soil pH, whereas much of the nitrogen and phosphorus in cattle manure is leached out by rainfall. In line with this assessment, villagers wishing to enter into contracts with herders who have many camels must pay a high price in cash and pearl millet. The animals nourish the soil in the vicinity of the camp by producing great quantities of manure. At the end of the contracted period, the herder receives his payment from the farmer in cash and pearl millet and then leaves the village. These contracted herd encampments are only conducted on sandy *leso* soil from which nutrients have been leached out or taken up by crops. Thus, farmers use the encampments to add nutrients back to the soil.

2. Addition of household waste to degraded land

The villagers accumulate composted household waste and transport it to their farming plots. The waste is placed in unproductive areas of the plot to rehabilitate *leso* and *foko* soils (Fig. 7). In *foko* areas, the villagers deposit plant residues of

Fig. 7. Indigenous knowledge and local practice for land restoration
When Hausa farmers recognise soil degradation in a portion of a crop field, they transport household and urban waste to the land. Farmers emphasise the importance of termite activity for land restoration. Plastic bags provide shelters for termites and prevent water evaporation from the ground. Metal dishes and pans are also important for trapping and accumulating blown sand (Oyama, 2012; 2015).

pearl millet stalks and crop residue; leaves and branches left uneaten by livestock; discarded clothing, cookware, baskets, mats and other items; all of which traps the sand blown in by the wind and facilitates the development of sandy topsoil. The amassed waste can be viewed as soil dressing for inferior, denuded areas of land, and can return deteriorated soil to productivity (Oyama & Mammam, 2010). Field experiments conducted by the author since 2003 have revealed that adding waste enables restoration of land through the combination of eight effects (Oyama, 2012; 2015): (1) trapping windborne sand; (2) preventing erosive wind and water; (3) attracting termites to feed on the waste and build nests, allowing rain water to penetrate the soil through termite tunnels; (4) mixing fine particles brought up by the termites with windborne sand; (5) developing an aggregated soil structure through the workings of the termites; (6) neutralising soil acidity (pH 4.5) of the degraded land; (7) adding nitrogen, phosphate, and potassium to the soil; and (8) enabling the germination of seeds of useful plants contained in the waste (Fig. 8). The process of adding waste to farming plots continues year-round, irrespective of the farming cycle. The volume of waste transported to the plots from each household varies, depending on the number of household members and the number and type of livestock kept in the household compound, but averages 10 to 40 kg per day. In households that own an ox cart, the men of the family

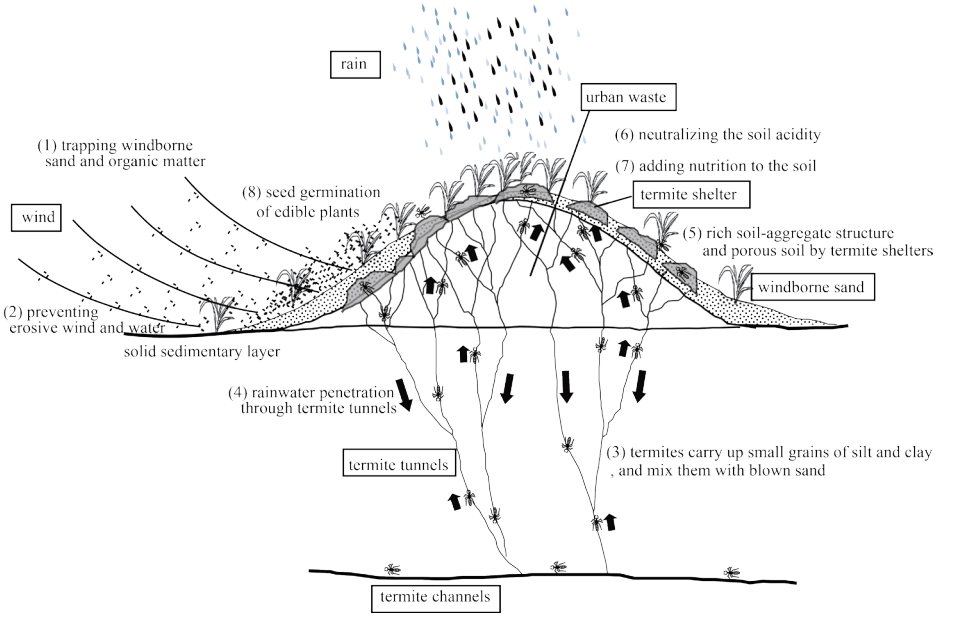

Fig. 8. Eight effects of urban waste input and methods of land restoration (Oyama, 2015)

load the cart with 200 to 400 kg once every 7 to 10 days; in households that do not have a cart, the men and/or women carry loads wrapped in cloth weighing about 10 to 15 kg each on their heads to their household plot.

GREENING TECHNIQUES BORN FROM THE HARDSHIP OF DROUGHT AND FAMINE

As of 2012, the Hausa have mostly used waste generated within their household compound, primarily, leftover feed and manure from livestock and crop residue. However, those dwelling in villages on the outskirts of cities collect waste discarded in the cities for use on their own plots. The waste tends to be heavy, so it is mostly transported in ox carts; the maximum distance from where the waste is collected to where it is used is usually about 2 km. In recent times, particularly since about 2008, some wealthy city dwellers have started to load waste onto their tractors and trucks, and transport it to their farming plots to improve the soil. The idea of spreading waste on denuded land and farming plots is difficult for outsiders to comprehend, but it is a perfectly ordinary practice in Hausa societies.

Elder members of the community said that this practice, which is a distinctive aspect of Hausa life, began in the drought of 1973–1974. As previously noted

in this paper, that drought resulted in failure of the pearl millet crop. After the drought ended, farmers' stocks of seeds were exhausted, so they were unable to cultivate their crop in the following year. At that time, one man in the village took the waste that had accumulated in his household compound, namely animal manure and plant residue, and spread it over his farming plot. This man, named Sikaro, has since passed away, but his sons said that Sikaro reasoned that if pearl millet harvests improve in areas around Fulbe and Tuareg herders' camps, where livestock have left behind large quantities of manure and millet seed, then harvests should also be improved by adding manure and plant residue from his own compound to the soil. This strategy proved to be highly effective, because domestic animal manure contains many crop seeds, which the animals particularly enjoy, and because household waste contains large quantities of pearl millet seeds left over after hulling (Oyama, 2012). As he added the waste to his soil, Sikaro is said to have thought, 'I don't have any seeds left to sow, but if I spread my plot with waste that is full of seeds and nutrients, I am sure to get a harvest.' He did not own a cart at the time, so he wrapped the waste in cloth and carried it on his head. Repeating this chore daily was far from an easy task, but when the rainy seasons came, his plan came to fruition.

Aided by good rainfall, the pearl millet seeds in the manure germinated naturally, grew well, and seeded successfully. The harvest of pearl millet thereby obtained was not sufficient for meeting all of his household's needs, but it was a valuable source of food nonetheless. Observing Sikaro's success, neighbouring villagers, such as Andy, Chida, and Tankari, followed suit the next year, spreading household waste onto their plots and harvesting and eating the pearl millet that grew from the waste. Elders recalled that the famines following the droughts of 1973–1974 and 1984–1985 were particularly severe, and it was difficult to procure pearl millet seeds. They said that these famines prompted many villages to begin using household waste on their plots, and that some urban dwellers who owned land nearby also started to use urban waste in the same way.

Irrespective of whether the waste was sourced from villages or towns, adding it to the soil markedly improved the yields of crops such as pearl millet and cowpea. This realisation spread rapidly, and the use of waste quickly became routine practice. In recent years, an increasing number of farmers have began collecting waste in urban areas and transporting it by ox cart to use on their land. Some wealthy households even transport urban waste by tractor to plots fenced in with wire, where it is used to help establish mango orchards. Urban waste contains many plastic bags, plastic containers, and metal scraps, but it is still considered an effective resource for revegetation in rural Hausa society.

HARKUKI: LOCAL LOGIC BACKING DESERTIFICATION AND REVEGETATION

Land degradation, and the restoration of degraded land for farming, is known in Hausa as *harkuki*. Hausa–English dictionaries define *harkuki* as 'movement'

or ‘news.’ The word thus denotes motion and change. Land degradation and restoration entail ‘movement’ in the condition of the land and are closely interconnected with the movement of humans. Let us look a little more closely at how the concept of *harkuki* is used in Hausa society. Hausa people, whether young or old, consider *harkuki* to be important. It is said that African greetings tend to be lengthy; this is certainly true in Hausa society. People question each other about how they sleep and how they feel, about the health of their wives, children, and families and about goings-on in their respective villages, and they also enquire about each other’s *harkuki*. The Hausa consider it important to generate *harkuki* or movement in one’s everyday existence and across the span of one’s life. Local villagers not only farm the land, tend livestock, and travel to undertake seasonal work but also engage actively in a range of other pursuits, in the belief that these activities will give their lives purpose and bring wealth. They consider that both their daily existence and lives as a whole hinge on *harkuki*. This is one reason that people enquire about each other’s *harkuki* in the course of greetings.

It is important to try many different things during the span of one’s life. For example, it is common for 10-year-old Hausa children to operate stalls at the regular markets held within or near the village. From about 15 years old, they travel to work in unfamiliar cities, even beyond the national borders, selling goods, finding mentors to teach them skills in commerce or manual trades, and ascertaining their own aptitude for such work. They search for their own foothold in life (*bida*) and decide on the path they will follow into the future. In this way of thinking, it is through movement that people find their foothold and gain *harkuki* and wealth. As children grow into adults, they learn to farm the land, keep livestock, and help their fathers, brothers, and other people around them; they may go to the city to work and may even return with a fortune. They are educated at school and may go on to earn a salary in a stable city job. Children are considered the wellspring of *harkuki*. People who are ill, have few children, or are lazy are said to be lacking in *harkuki*, thereby being unable to find a foothold, a reason for living and future wealth.

Illness drains one’s vitality and restricts one’s movement. Having few children means there are less people to do the work that supports daily life and economic activity in one’s household such as fetching water, collecting firewood, tending to livestock and gathering feed, making the household’s capacity for movement (*harkuki*) limited. Therefore, in Hausa society, to acquire more *harkuki*, people proactively engage in adoption (*adani*) and raise adopted children as their own. Monogamy is not frowned upon, but it is considered better for men to have two or three wives, as a larger number of children will increase *harkuki* and bring more vitality. Movement will not always lead to success, but without movement, finding a foothold in life is impossible; this is the belief of most Hausa people dwelling in rural villages.

Livestock can also generate *harkuki*. Livestock produce offspring, and the offspring grow as they consume vegetation. Upon reaching maturity, they can be sent to market for sale. Cash from the sale can be used to purchase food

for the household during dry season shortages, pay for children's education, or fund the marriage of a son. Such expenditure generates a new cycle of movement. Proceeds from livestock sales can also be used for repairs in the household dwelling and clothing for family members. Livestock manure, pearl millet residue, and waste accumulated in the household compound are taken to the farming plot by members of the household. The application of these compost materials to the soil, together with activities such as cutting vegetation and gathering livestock feed enable pearl millet and cowpea to grow, leading to a successful harvest the following year. This is considered *harkuki*, the movement that gives purpose to the lives of Hausa people.

Naturally, money can also be a source of *harkuki*. A young villager who goes to the city to work and earns a reasonable income usually returns home not with food, gifts, and other purchases, but with the cash he has earned. This cash does not lie idly in its owner's pocket or home for long; it is quickly spent on acquiring livestock, paying for encampment contracts, purchasing farmland, and other such investments. Since 2005, mobile telephones have rapidly gained popularity in the village. These can also be seen as a form of *harkuki*. By 2016, it was entirely normal for villagers to use mobile telephones to greet and talk with their friends and acquaintances. The use of telephones has enabled instant access to important information, although this does not mean that villagers are presented with a succession of attractive propositions, they are now able to communicate with relatives working in cities both within and beyond the country, and to ask how they are and obtain information on matters such as economic trends in urban areas. Men in Hausa society are expected to find a foothold in life and to use all means and capacities at their disposal to work for their families. Hausa men keep working and continue their 'movement' together with their wives, to build a fulfilling life for their families.

LAND RESTORATION AND GREENING TRIALS BASED ON LOCAL PRACTICES

In 2011, due to an inadequate local government budget under the military regime in Niger, there was no civil waste-collection service in the town of Dogondoutchi. The author made an agreement with the Dogondoutchi mayor to collect some of the urban waste. This agreement was intended to support a civil waste-collection service in urban areas and land restoration using urban waste in rural areas. After understanding the effects of urban waste on land restoration, the author started a social experiment with local residents, which could be used to restore degraded land and prevent conflicts between farmers and herders in the future. With the co-operation of local residents, the author transported 150 tons of urban waste in hired tractors and piled it on a 50 × 50 m fenced plot of degraded land. Urban waste can improve soil fertility and plant growth productivity. In the 2012 rainy season, 42 plant species were found in the fenced area (Fig. 9). Most of these were crops or useful plants including pearl millet,

Fig. 9. Plant growth from urban waste
We piled 150 tons of urban waste on a 50 × 50 m fenced plot (February 24, 2012). We placed sand and stones politely onto plastic bags to avoid scattering (left) and found 42 plant species in the first year (September 5, 2012) (right).

cowpea, amaranthus and pumpkins growing from the urban waste (Table 1). We herded livestock onto the rehabilitated land, which fed on the grass within the fenced area during the crop-harvest season. This practice was intended to avoid proximity of grazing livestock and farmland and to prevent livestock-induced crop damage and farmer–herder conflicts. The Fulbe herders were pleased with the species of grass created from the urban waste. In southern Niger, livestock are owned by both herdsmen and farmers. Both groups can enjoy the benefits of new pasture land. We continued to keep the animals within the fenced area for at least 2 weeks, even after all of the grass had been consumed. The livestock dung maintains soil quality.

In the second year, December 2013, surprisingly, we found 13 tree species germinating from the livestock dung and shrubs were growing within the fenced area (Table 2). These tree species could be used for livestock fodder, famine relief food for the residents, or in cooking local dishes. According to the Hausa people, baobab provides soup material and can be sold for cash, and *Balanites aegyptiaca* and *Zizyphus mauritiana* serve as food for people and livestock. The leaves of *Balanites aegyptiaca* are a well-known relief food for the local residents. *Phoenix dactylifera* (date palm) is produced in the Sahara region and is transported to local markets in the Sahel region. Dogondoutchi residents consume date fruits and the waste is added to the urban waste. According to Tybirk (1991), *Acacia* and *Tamarindus* seeds in the Sahel region are transported by livestock and readily germinate after being digested and ruminated by livestock. Therefore, the tree species germinated from urban waste and livestock dung were useful for both humans and livestock. The Fulbe herders worked to maintain straight tree growth. Trees can be used by the herders for shelter during storms and as a source of shade during hot days. In the fourth year, May 2016, trees continued to grow in the severe dry season. Shrubs also grew from urban waste input, and the herders fostered forest growth in the fenced area using their livestock.

Table 1. Plant species that germinated from urban waste in the first year (September 2012)

Family name	Scientific name	Hausa name	Plant coverage
Malvaceae	*Borreria radiata*	*kumuguduwa*	2
	Hibiscus sabdariffa	*sure*	+
	Hibiscus sabdarrifa	*ware*	+
	Sida cordifolia	*garumani*	+
Poaceae	*Andropogon gayanus*	*gamba*	+
	Brachiaria xantholeuca	*hatsin tsutsu*	+
	Cenchrus biflorus	*kalengia*	+
	Cymbopogon giganteus	*sabre*	+
	Cynodon dactylon	*halkiya*	+
	Dactyloctenium aegyptiun	*atuku*	1'
	Digitaria longiflora	*birbirwa*	+
	Echinochloa colona	*garaji*	+
	Pennisetum glaucum	*hatsi*	2
	Pennisetum pedicellatum	*janbako*	+
	Schizachyrium exile	*kyasuwa*	1
	Sorghum bicolor	*dawa*	+
Cucurbitaceae	*Citrullus vulgaris*	*guna*	1'
	Cucurbita maxima	*kubewa*	1
Pedaliaceae	*Ceratotheca sesamoides*	*ramuti*	+
Tiliaceae	*Corchorus tridens*	*koku*	1'
Portulacaceae	*Portulaca oleracea*	*halusin sa*	+
Commelinaceae	*Commelina benghalensis*	*balasa kura*	+
	Commelina forskalaei	*balasa*	1'
Solanaceae	*Solanum lycopersicum*	*tomate*	+
Zygophyllaceae	*Trubulus terrestris*	*tsaida*	+
Amaranthaceae	*Amaranthus* spp.	*rukubu*	1
	Celosia trigyna	*nannafa*	+
Convolvulaceae	*Ipomoea vegans*	*walkindam*	1'
	Jacquemontia tamnifolia	*kukumbara*	+
	Merremia tridentata	*yambururu*	+
Capparaceae	*Gynandropsis gynandra*	*ranje daji*	+
Leguminosae	*Alysicarpus rugosus*	*gadagi*	+
	Arachis hypogaea	*korenshe*	+
	Cassia mimosoides	*bagaruwa kasa*	+
	Cassia obtusifolia	*tafasa*	+
	Indigofera prieureana	*kyamuro*	1
	Indigofera tinctoria	*baba*	+
	Zornia glochidiata	*maras*	+
Not identified	Not identified	*masun katangari*	+
	Not identified	*kasaura*	+
	Not identified	*gidagiri*	1'
	Not identified	*tonka daji*	+

Notes:
1) The plot was a 50 × 50 m fenced plot.
2) Plant coverage is rated as follows 4 for 4/4–3/4, 3 for 3/4–2/4, 2 for 2/4–1/4, 1 for 1/4–1/20, 1' for 1/20–1/100 and + for less than 1/100.

Table 2. Perennial and tree species that grew in the second year (December 2013)

Scientific name	Hausa name	Number of plants
Cassia obtusifolia	*tafasa*	1,122
Balanites aegyptiaca	*aduwa*	150
Borassus aethiopium	*kaba*	110
Indigofera tinctoria	*baba*	90
Antidesma venosum	*magariya*	55
Phoenix dactylifera	*dabino*	48
Adansonia digitata	*kuka*	15
Guiera senegalensis	*sabara*	15
Acacia nirotica	*bagaruwa*	5
Combretum nioroense	*geza*	5
Pergularia tomentosa	*fataka*	5
Detarium senegalense	*takowasala madawa*	4
Boscia senegalensis	*anza*	2
Piliostigma reticulatum	*kalgo*	2
Faidherbia albida	*gawo*	1
Bauhinia rufescens	*dirga*	1
Acacia laeta	*akura*	1
Tamarindus indica	*tsamya*	1
Calotropis procera	*tumfafiya*	1
Total		1,633

Note: 50 × 50 m fenced plot.

CONCLUSION: AFRICAN POTENTIALS TO COMBAT DESERTIFICATION

In the Sahel, farmers have been implementing traditional soil management practices such as the application of dry farmyard manure and household waste, livestock corralling, and fallows (Orr, 1995; Harris, 1999; Gandah et al., 2003; Shinjo et al., 2008; Suzuki et al., 2014). Hausa farmers' cultivation and grazing activity cause the soil to deteriorate, and also restore it to enable these activities to continue. Waste is transported promptly to denuded areas of farmland. In these areas, waste is the driving force for *harkuki*: the restoration of the land's productivity. Since 2002, when this author first developed an interest in the use of waste by the Hausa for environmental restoration, the practice appears to have become more widespread and frequent (Oyama & Mammam, 2010; Oyama, 2012; 2015). Natural conditions in the Sahel are changeable; these changes are known in Hausa as *harkuki*, or movement. The *harkuki* generated by humans causes the land to deteriorate, and also enables its restoration. The Hausa people's practice of using waste for degraded land could be seen as emerging from their outlook on life in relation to the changeable natural environment around them, an outlook combined with a work ethic that involves actively generating *harkuki* to overcome difficulties and safeguard one's livelihood. According to Moyo &

Mine (2016), the concept of "African Potentials" is defined as the capability Africans have to achieve solutions to contradictions among people utilizing indigenous knowledge of human relations that has been continuously transformed and has accumulated on the level of everyday life. This practice of urban waste input based on local concept of *harkuki* is a typical African Potentials, taking measures against the ways desertification is promoted in everyday life.

Current approaches to addressing desertification tend to be directed at technological development and permanent forest creation, involving expensive equipment and consuming vast quantities of energy and capital. Most of these approaches have failed due to shortages of finance, labour and suitable land, together with unstable foreign aid policies. The practices of the Hausa suggest the need for understanding the changeable natural environment induced by variable climate and human activity in the Sahel region. In densely populated areas of the Sahel, working against the popular belief that human activity and livestock destroy the land, for combating desertification, urban waste and livestock can instead be used to restore the degraded land, which makes this practice a kind of reverse thinking, which uses urban waste in an opposite manner to human activity and livestock that are exacerbating desertification.

ACKNOWLEDGEMENTS This article is based on my paper presented at 'Land, the State and Decolonising the Agrarian Structure in Africa: A Colloquium in Honour of Professor Sam Moyo,' organized at the University of Cape Town, South Africa, on November 28–29, 2016. This colloquium was sponsored by the Japan Society for the Promotion of Science, Grant-in-Aid for Scientific Research (S) "'African Potential" and Overcoming the Difficulties of Modern World: Comprehensive Research That Will Provide a New Perspective for the Future of Humanity' (KAKENHI 16H06318 headed by Motoji Matsuda, Kyoto University), as well as by the University of Cape Town's Research Office (URC). The author would also like to express my gratitude for the financial support of the Japan Society for the Promotion of Science, Grant-in-Aid for Scientific Research (KAKENHI 23221012, 25300011, 15H02591, 17H04506 and 17H02235).

NOTE

(1) All names of individuals are fictitious in this paper.

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Accepted *March 11, 2018*

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