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THE EMERGENCE AND SPREADING OF AN IMPROVED TRADITIONAL SOIL AND WATER CONSERVATION PRACTICE IN BURKINA FASO

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This paper is written in the context of a study carried out on the environmental rehabilitation of the northern part of the Central Plateau of Burkina Faso between 1980 and 2000. This study is carried out by a team of 13 Burkinabe researchers organized in 4 teams (a PRA team, a socio-economic team, a farming systems team and a remote sensing team). It is funded by the Netherlands Embassy in Burkina Faso, GTZ/PATECORE, USAID and the Vrije Universiteit Amsterdam. The National Council for Environmental Management (CONAGES) is responsible for the study. The support of all these organizations is gratefully acknowledged, but they are not responsible for the views expressed by the authors.

ABSTRACT

This paper describes the emergence of improved traditional planting pits (*zaï*) in Burkina Faso in the early 1980s as well as their advantages, disadvantages and impact. The *zaï* emerged in a context of recurrent droughts and frequent harvest failures, which triggered farmers to start improving this local practice. Despair triggered experimentation and innovation by farmers. These processes were supported and complemented by external intervention. Between 1985 and 2000 substantial public investment has taken place in soil and water conservation (SWC). The socio-economic and environmental situation on the northern part of the Central Plateau is still precarious for many farming families, but the predicted environmental collapse has not occurred and in many villages indications can be found of both environmental recovery and poverty reduction.

Keywords: soil fertility, soil conservation, water conservation

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1. THE CONTEXT IN WHICH *ZAÏ* EMERGED IN THE YATENGA REGION

In the 1970s the densely populated northern part of the Central Plateau faced an acute environmental crisis. Recurrent droughts led to frequent harvest failure. Between 1975 and 1985 this region witnessed substantial out-migration to less densely populated regions with better soils and higher rainfall[3]. Women had to walk longer distances to collect firewood. Vegetation was destroyed not only for firewood, but even more to expand cultivated land. Groundwater levels fell by an estimated average of 1 meter per year and many wells and boreholes fell dry just after the end of the rainy season. Average yield levels of sorghum and millet were in the order of 400 – 500 kg/ha only (Dugué 1989:119) with substantial inter-annual variations depending on rainfall. Because of frequent droughts, cultivation of upper and mid-slopes became difficult, if not impossible, and those farmers who had access to the lower slopes and valley bottoms concentrated cultivation in these parts of the toposequence (Stoop 1987). The surface of completely barren land increased dramatically.

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[3] Between 1975 and 1985 some of our study villages lost up to 25 percent of their families due to recurrent drought and the worsening economic and environmental situation.

These trends were particularly strong in the central part of the Yatenga region, which had average population of up to100 persons/km2. Around 1980, the Yatenga region had the reputation of being the most degraded region of Burkina Faso.

The French geographer Jean-Yves Marchal painted a gloomy picture of the situation in the Yatenga in the 1970s (Marchal 1977, 1979, 1984,1985,1987). Its population increased from 250.000 inhabitants in 1930 to 530.000 in 1975. This increase was accompanied by a strong reduction of fallow, a decrease in soil fertility, increasing erosion, a drop in agricultural production and a strong expansion of cultivated lands over soils marginal to agriculture. The area of cultivated land increased much faster than the population, which is an indicator of extensification. According to Marchal (1977:143) already in the 1970s, 80 percent of all cultivated land in the central part of the Yatenga was permanently cultivated with sorghum and millet. Fallow had practically disappeared as a means to restore soil fertility. About 70 - 85 percent of the village territories were cultivated and about 40 percent of this cultivated land was marginal to agriculture.

The Yatenga in the 1950s - 1970s presented an exception to the Boserup hypothesis. A process of agricultural intensification did not accompany the increase in population densities and the growing pressure on available natural resources. Instead, it induced a process of extensification. The specter of drought, poverty, famine and environmental degradation pushed many farmers in this region with their backs against the wall. They either had to migrate to other more favorable regions and many did so, or they had to learn how to cope with or overcome these problems.

Until 1980, the extension system had not been able to offer effective resource-enhancing technologies acceptable to resource-poor farmers. In the early 1960s a large-scale mechanized SWC project (GERES) was undertaken in the Yatenga, but it was stopped prematurely, because farmers did not maintain and sometimes deliberately destroyed conservation works. Marchal (1979:247) remarked that the objective of this project was to treat soils and not land cultivated and used by rural societies. In 1977 the Rural Development Fund (FDR II) started with the construction of graded earth bunds in the Yatenga. These were laid out on small blocks of cultivated village fields (30 – 60 ha). Their objective was to conserve rainfall and reduce erosion. Again maintenance was poor and many earth bunds were deliberately destroyed or breached by farmers, because they prevented runoff from non-cultivated fields to enter the cultivated fields. Also their maintenance requirements were considered too high (Reij 1983).

In this difficult context both farmers and NGO technicians started to experiment with SWC techniques. The farmers concentrated on improving traditional planting pits or *zaï* and NGO technicians concentrated on contour stone bunds. The combination of both techniques proved to be very efficient in the rehabilitation of strongly degraded land. In other words, agricultural intensification in this region started in the early 1980s when SWC technologies became available, which were simple, as they could be mastered by all farmers, and efficient in the sense that they immediately increased yields.

2. DEVELOPMENT AND DISSEMINATION OF THE *ZAÏ* TECHNOLOGY

THE ORIGIN OF ZAÏ

Around 1980, farmers in the village of Gourga, which is situated close to the regional capital Ouahigouya, started to experiment with traditional planting pits or *zaï*. Traditionally, planting pits were used on a small scale to rehabilitate rockhard, barren land (*zipélé*), in which rainfall could no longer infiltrate. These patches of barren land are not necessarily formerly cultivated fields, which degraded because of overcultivation. Most of them are created by the destruction of their vegetative cover. This is an ongoing process. The dimensions of the pits were increased (from a diameter of 10 – 15 cm to 20 – 30 cm and a depth of about 20 cm) and another innovation was that manure was applied to them. In this way the improved planting pits concentrated water and nutrients in one spot. The pits were dug during the dry season[4] and the organic material used attracted termites. These termites play a crucial role as they dig channels in the soil and by doing so they improve its 'architecture'. At the same time they digest the organic matter and make nutrients more easily available to the crops planted or sown in the pits.

One farmer, Yacouba Sawadogo, stands out as a key innovator in *zaï*. Though he may or may not have been the very first farmer to experiment with *zaï,* he has nonetheless clearly has played a decisive role in experimenting with traditional planting pits. The question is what triggered him to start experimenting and where did he get his ideas? His main motive appears to be the recurrent droughts and the associated food shortages, which made life very difficult. Many families had already left the region to settle in better parts of Burkina Faso or in Ivory Coast[5]. He preferred to stay on the land of his ancestors, but realized that something had to be done against land degradation. Yacouba may have picked up the idea for improving the traditional pits during a study

[4] This is a big difference with tied ridges, which are constructed during the cropping season. Although tied ridges have been promoted in the first half of the 1980s by SAFGRAD, they have never been adopted by farmers despite the claim of the researchers (Ramaswamy and Sanders 1989) that it is economically rational to invest in them .

[5] Many farm households have strong links with small plantations in Ivory Coast, which they own or which are owned by relatives. The importance of these links and their impact on the allocation of labor resources and on the transfer of funds has not yet been adequately studied.

visit to Mali organized by an NGO [6]. Upon return he started to try out on his fields what he had observed in Mali and in the process he added some of his own ideas.

THE SPREADING OF *ZAÏ*

The millet and sorghum yields obtained by Yacouba on land, which used to produce nothing, were remarkable and quickly perceived by other farmers in the village who started copying him. The OXFAM-funded Agro-Forestry project, which experimented in the Yatenga with different SWC techniques, immediately recognized the potential of the improved planting pits and started to promote this technology by bringing visitors to the village of Gourga. Other NGO's, projects and government agencies quickly became aware of the potential of this technique. In the first few years they mainly spread within the Yatenga region where they were often combined with contour stone bunds, which reduce the force of surface runoff and prevent destruction of the planting pits[7]. With some delay *zaï* started spreading to other parts of the Central Plateau.

Two farmers have played a key role in the dissemination of the technology. The first is the already-mentioned Yacouba Sawadogo, who started an "Association pour la Promotion des *Zaï*" (an Association for the Promotion of *Zaï*). He trained farmers in many villages in how to use this technique. Each year he organizes a so-called *zaï market*, in which representatives from about 100 villages come to Gourga to share their experience.

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[6] The study visit was organized by the OXFAM-funded Projet Agro-Forestier. Pitting can be found in the region between Djenne and Mopti, but also on the Dogon Plateau.

[7] The contour stone bunds are the outcome of a process of on-farm experimentation by the OXFAM-funded agroforestry project and farmers during 1979 – 1981. In 1982 this project designed an extension strategy for contour stone bunds (Wright 1983, Reij 1983). Contour stone bunds and zaï have become the most successful SWC techniques on the Central Plateau and are now widespread.

The other key farmer is Ousseni Zorome, who lives in the village of Somyaga, which is also close to the regional capital of Ouahigouya. In the early 1980s Ousseni was a small trader who borrowed a large piece of strongly degraded land on which only 9 trees had survived. He gradually treated the land with *zaï* and like many other farmers he started at the lowest point of his fields[8]. While doing so he systematically protected natural regeneration of trees and bushes. As a result he now has about 2000 trees on his fields. Ousseni created a so-called "*zaï school*" which is a group of farmers jointly learning to rehabilitate a plot of degraded land. His district association of *zaï schools* now has about 1000 members (Sawadogo, et al. 2001).

Both Yacouba and Ousseni have, at their own initiative, set up private extension services. To some extent, they replace the public extension service, which has become increasingly crippled by structural adjustment programs and has concentrated its activities more and more in cotton-growing regions.

SWC projects have played a key role in the spreading of *zaï* outside the Yatenga. They organized and funded study visits for their farmers, who upon return adopted and sometimes adapted the *zaï* on their own fields and their example was subsequently followed by their neighbors, who observed what they achieved. Farmers rehabilitate degraded land with *zaï* without any external support. They do all the work themselves. The key contribution provided through public funding is in the form of study visits and support for the transport of stones for the construction of bunds.

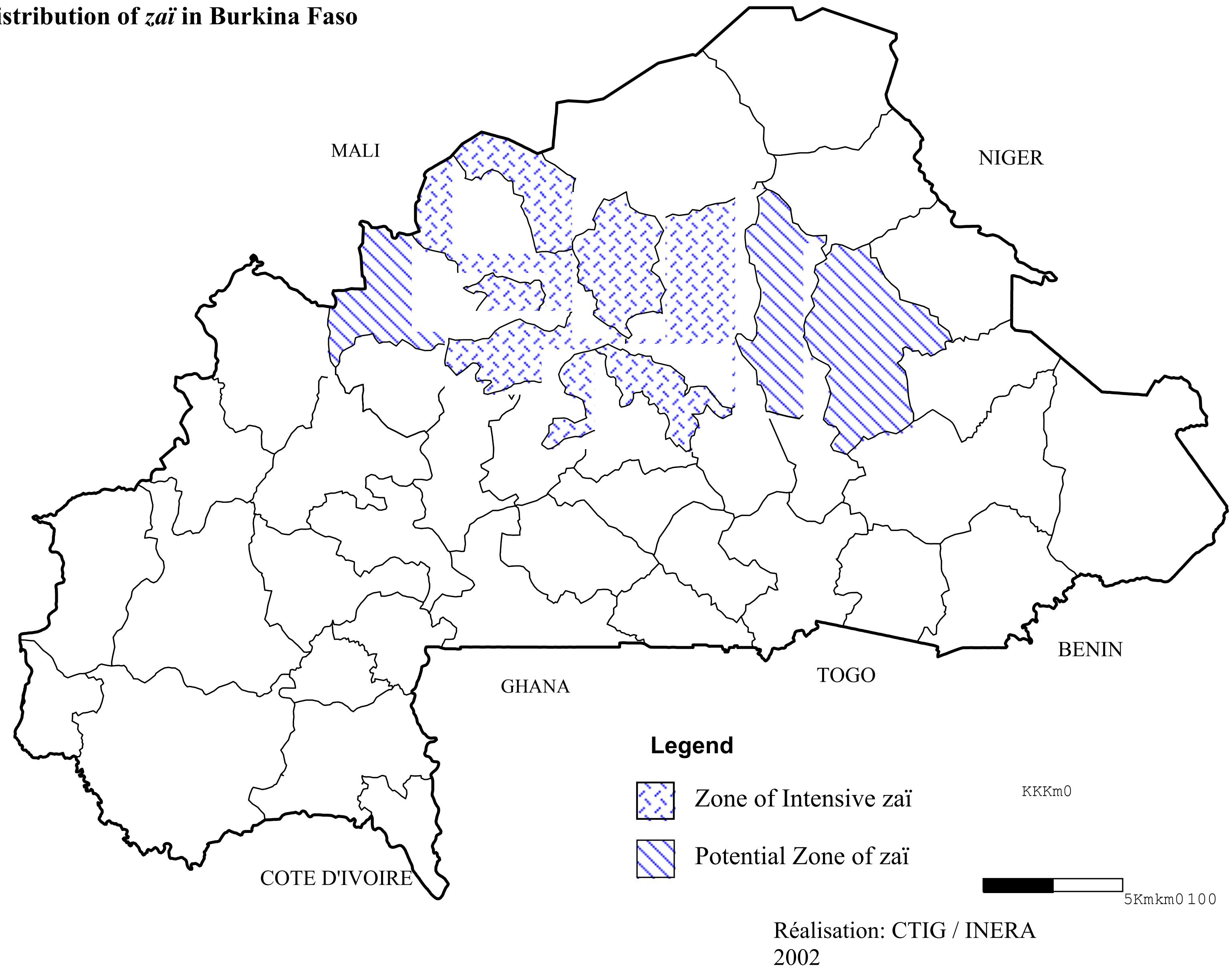
[8] The technical SWC manuals all advocate starting the treatment of land at the highest point of the catchment and to work downwards. Farmers in the Yatenga and in many other semi-arid regions, prefer to start at the lowest point in order to catch runoff from upslope, without which it would be difficult to get a harvest in drought years.

A good example of this is the visit to the Yatenga organized in 1989 by the IFAD-funded SWC project in Illela district (Niger) for 13 farmers. This has produced an impressive spreading of *zaï* (in *haussa* these are called *tassa*) in this region. Already in 1992 farmers in Illela District were actively buying and selling strongly degraded land to rehabilitate this with *tassa*.

THE AREA TREATED WITH *ZAÏ*

It is impossible accurately estimate the area in and outside the Yatenga which has been treated with *zaï*. Farmers treat their individual fields and often their bush fields, which are spread over the village territory. This means that one generally does not find big blocs of treated land. Nonetheless, our field work suggests that thousands of farmers in and outside the Yatenga have used this technique mainly to reclaim barren degraded land and sometimes also to improve the quality of their existing fields (Figure 1)

Figure 1--Distribution of *zaï* in Burkina Faso



Digging the *zaï* demands considerable quantities of labor, about 300 person-hours per hectare. And for that reason farmers treat their fields progressively. Each dry season they rehabilitate some land, but how much they do depends on available labor (family and/or hired labor) and on motivation. Some rehabilitate 0.2 ha/year and others do more. This progressive approach differs from actions planned by SWC projects, which tend to treat blocks of land through collective action using machinery.

Another reason why accurate estimates are difficult is that a considerable portion of land rehabilitated with *zaï* becomes normal land again after some years. Farmers dig *zaï* in year 1 and after 2 to 5 years they dig new ones in between the existing pits. In this way the entire field is rehabilitated and can be tilled again with the plough or the hoe[9]. The larger the sand fraction, the quicker the process of conversion to normal land. Farmers rehabilitating gravelly and shallow lateritic soils (*zegdga*) do maintain *zaï* on a quasi-permanent basis. They just clear the pits when needed.

Although it is impossible to accurately estimate the number of hectares treated with improved traditional planting pits, it is safe to say that on the northern part of the Central Plateau tens of thousands of hectares of land have been treated. A survey undertaken in 1998 in 5 provinces covering the northern part of the Central Plateau showed that 123 households who had undertaken SWC had reclaimed on average 1,33 ha per household using *zaï* and contour stone bunds (Société Africaine d'Etudes et Conseils, 2000:45).

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[9] This means that in most cases pits disappear over time, but as most pitted land is also treated with contour stone bunds this does not lead to increased erosion. In parts of Zambia and Tanzania pits are dug not to rehabilitate degraded land, but on cultivated fields. These are filled with manure and planted with, for instance, maize (Malley, et al. 2001).

THE ADVANTAGES OF ZAÏ

One farmer in the Sanmatenga region told a journalist of "Le Monde", who visited him in June 2000 on his fields that "*zaï* are the invention of the century" (Le Monde 18/19 June 2000). The question of why large numbers of farmers are adopting *zaï*, can only be answered by looking in more detail at their advantages and disadvantages.

1. They are used to rehabilitate strongly degraded land, which is of vital importance in a region characterized by high population pressure on limited resources[10]. It allows farmers to expand the size of their farms and to do this on fields where before nothing would grow. In the "without" situation, yields are 0 kg/ha and in the "with *zaï*" situation they range from 300 – 400 kg of sorghum in a year of low rainfall to easily 1500 kg/ha in a year of good rainfall.
2. According to conventional SWC wisdom, investments in SWC produce benefits in the medium or long-term. However, water harvesting techniques such as *zaï* produce a yield from the first year.
3. *Zaï* are labor-intensive, but they are dug progressively during the dry season. How many are dug, depends on available family labor and on the possibility of hiring labor[11].
4. Because more water infiltrates in the pits and the water retention capacity of the soils increase, crops suffer less from drought spells at the onset of the rainy season as well as during the rainy season.
5. Manure is concentrated in the pits and therefore used more economically, which is particularly attractive to farmers with few livestock. Besides this they capture wind-blown soil and litter (Ouedraogo and Kabore 1996: 83).
6. In particular in the first few years fields reclaimed with *zaï* are hardly infested by Striga and other weeds, which means that labor requirements for weeding are lower than on other fields.
7. The land is prepared during the dry season, which means that farmers can immediately sow their fields with *zaï* when the rains arrive. They need not first spend some days plowing the land. Some farmers gain even more days early in the season, because they practice dry seeding in April.

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[10] Population pressure is variable, but around 100 persons/km² in various parts of the Central Plateau.

[11] In Niger's Illela district the introduction of improved traditional planting pits appears to have contributed to a revival of traditional work parties as well as to an emergence of a labor market (Hassane, et al., 2000: 39,40)

8. Because more water is harvested and conserved and organic matter is used in the pits, conditions are improved for using some mineral fertilizers to increase yields and biomass production.
9. The manure applied to the pits contains seeds of trees or bushes, which have passed through the intestines of livestock, which facilitates their germination. This explains the sometimes spectacular regeneration of the vegetation and the increase in on fields treated with pits. The young seedlings also benefit from the concentration of water and manure (Roose et al. 1999: 351,352)

THE DISADVANTAGES OF ZAÏ

1. The labor requirements for digging of *zaï* are high (about 300 man-hours/ha)[12]. How high they are depends on the type of soils in which they are dug. Also the labor requirements for their maintenance depend on soil type. Pits dug in soils with a high clay fraction or with a lot of gravel require less maintenance than pits dug in sandier soils.
2. Mechanization is impossible. Pits are dug by hand and maintained by hand. Researchers have done some experiments to reduce labor requirements for digging. They used a pair of oxen for a "sous-solage croisé" every 80 cm. This took 11 hours of work. By digging the pits at the cross-sections, labor requirements are halved (Roose et al. 1992).

3. IMPACT ON FARM HOUSEHOLDS AND ON FARMLAND

THE IMPACT OF ZAÏ ON CROP YIELDS AND ON HOUSEHOLD FOOD SECURITY

Although improved traditional planting pits have been used increasingly since 1980, reliable yield data are not available. In Burkina Faso researchers have never measured its impact on yields on the same fields for more than two years. This means that the influence of inter-annual rainfall variability has not been captured adequately. It is also surprising that yields have not been measured in the heartland of the *zaï*, the Yatenga, but always in other regions. This is of some importance as farmers in the Yatenga often make fewer pits per hectare than farmers in

[12] Roose et al. (1995:257) express labor requirements in hours. They indicate 300 hours/ha. Slingerland and Stork (2000:63) found an average of 306 hours per ha for a sample of 15 farmers. Maatman (1999: 373) estimates that digging zaï on 1 ha requires 450 – 650 heures depending on soil conditions.

other regions. The number of pits in the Yatenga varies from 8.000 to 18.000/ha (Hien and Ouedraogo, 2001: 263). Elsewhere their numbers range from 23.000 - 31.000 in the village of Donsin (Kabore,1994) to 46.000 – 51.000/ha in 3 villages in the Yako region (Slingerland and Stork, 2000: 64).[13] The number of *zaï* per hectare and their dimensions determine how much water they harvest. The bigger the number and the smaller their size, the less water they harvest. Also the quantity and quality of organic matter used influences yields. Generally farmers use 3 – 5 tons/ha in *zaï*, but some farmer innovators used 5 – 12 tons/ha (Hien and Ouedraogo, 2001:263).

A vital question to be answered when dealing with the question of the impact of *zaï* is what would have happened on the same fields without zaï. Most studies use the cereal yields obtained on surrounding fields as the without situation or sometimes average yields obtained in a district are used as without situation (for instance, Hassane et al. 2000, do this in Niger). As *zaï* in Burkina Faso or *tassa* in Niger are mainly used to rehabilitate strongly degraded land the real without situation is 0 kg/ha. This is also how most farmers perceive the without situation. These fields are usually so degraded that also a long-term fallow would not have any positive impact.

The available data show that yields vary wildly from year to year, primarily because of variations in the volume and timing of rainfall. This variability is well illustrated by yield data collected in Niger from 1991 to 1996 on the same farmers' fields (Table 1).

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[13] Slingerland and Stork (2000) have not been doing research on *zaï*,as they assume, but rather on a small traditional pit used in the Yako region, called *guendo*.

Table 1--Impact of planting pits (*tassa*) plus manure and fertilizer on cereal yields 1991 – 1996 (kg/ha) in Niger's Illéla District

Rainfall	1991	1992	1993	1994	1995	1996	Average 1991-1996
Badaguichiri	726 mm	423 mm	369 mm	613 mm	415 mm	439 mm	
Illéla	581 mm	440 mm	233 mm	581 mm	404 mm	440 mm	
Sorghum yields							
T0	-	125	144	296	50	11	125
T1	520	297	393	969	347	553	513
T2	764	494	659	1486	534	653	765
YIELD GAINS							
T1-T0	520	172	249	673	297	542	388
T2-T0	764	369	515	1190	484	642	640
Average district yields	386	241	270	362	267	282	301

T0 = without situation
T1 = planting pits with manure
T2 = planting pits + manure + inorganic fertilizers

Source: Hassane et al. 2000:26

Planting pits alone offer several agronomic advantages over conventional plowing. First, water harvesting in the pits focuses available moisture on the cereal crops and enables plants to survive long dry spells. In addition, dry-season land preparation for planting pits enables farmers to plant early, with the first rains. They thus enjoy a longer growing season than under conventional tillage where farmers cannot begin land preparation until after the rains have begun. As a result, available evidence suggests that pits alone generate yield gains over conventional plowing, though these gains vary substantially across soil types and seasons. Amidst wide variation, Roose et al. (1993) find that *zaï* pits alone achieved an average gain of only 38 kg/ha in white sorghum yields over two seasons in two locations in Burkina Faso (Table 2). Using a regression analysis, Kabore (2000) found that *zaï* pits alone increased sorghum yields by 310 kg/ha compared to the non-*zaï* situation in the village of Donsin, which had recently adopted this technique. *Zaï* combined with contour bunds showed an even greater increase in yields (+ 710 kg/ha).

Table 2--Sorghum Yields on Conventional and Treated Fields in Burkina Faso

	Pouyango		Taonsongo		Average
	1992	1993	1992	1993	
SORGHUM YIELDS ***(KG/HA)***					
a. control	63	22	150	3	60
b. pits only	150	29	200	13	98
c. pit + compost	690	257	654	123	431
d. pit + compost + fertilizer	976	550	1704	924	1039
ABSOLUTE GAINS ***(KG/HA)***					
b-a	87	7	50	10	38
c-a	627	235	504	120	372
d-a	913	528	1554	921	979

Source: Roose, Kabore and Guenat (1993).

When combined with manure or inorganic fertilizer, the *zaï* pits typically generate even larger gains. In Niger's Illela district, for example, cereal yields on untreated fields (T0) averaged 125 kg/ha over a six-year period. Yields rose by an average of 388 kg/ha in pitted fields with manure (T1). The *zaï* pits with manure (T1) achieved systematically higher yields than adjacent untreated fields (T0) and also higher than the average cereal yields for Illéla district (Table 1). With an additional dose of inorganic fertilizer (T2), in combination with the pits and manure, average yields rose by 640 kg/ha compared to the control plots (Table 1). The additional gains due to the addition of inorganic fertilizer proved biggest in years of good rainfall (1994), though in other years (1996) the additional yield would not be sufficient to cover the costs of inorganic fertilizers. Similar trials over two seasons in Mali indicate that *zaï* pits plus manure increased sorghum yields by an average of 719 kg/hectare (Wedum et al., 1996). In

Burkina, *zaï* pits plus compost achieved yield gains of 372 kg/ha, roughly ten times the output gains under *zaï* pits alone (Table 2).

Are gains in yields due to the *zaï* or to the manure used? The answer is simple: on degraded lands one without the other gives much poorer results. It is the concentration of water and nutrients in the planting pits that makes the difference.

During an impact assessment of SWC, agroforestry and agricultural intensification in 5 villages on the northern part of the Central Plateau, farmers agreed unanimously that SWC and in particular *zaï* had had a positive impact on household food security (Reij et al. 2001). In years of good rainfall many farmers now produce a small surplus of grains, which provides a buffer in years of low rainfall. This picture also emerged in Niger where farm families with SWC produced an estimated surplus of 70 percent in years of good rainfall, while they had an estimated deficit of 28 percent in years with low rainfall (Hassane, et al. 2000:33).

An important question is whether yields can be maintained at a higher level over a longer period. Roose et al. (1993: 168/169) found a substantial decline in yields in the second year, which could not only be explained by a 100 mm lower rainfall. They related the decline to limited nutrient availability (mainly lack of nitrogen and phosphate). The use of a small quantity of mineral fertilizers substantially increases yields of grains and stover.

THE IMPACT OF ZAÏ ON SOIL FERTILITY

The ferrallitic soils of Burkina's Central Plateau are generally poor in nutrients and in water holding capacity. Average sorghum yields in the Yatenga have increased from an average of 594 kg/ha in the 1984-88 period to 733 kg/ha in the 1995-2001 period. For millet these figures are respectively 473 kg/ha and 688 kg/ha[14] (Reij and Thiombiano 2003:16). This increase is partially due to higher rainfall in the 1990s, but also to the considerable investment in soil and water conservation in the last decade. Despite this substantial increase, average yields are still low, reflecting poor soil fertility. High population densities make fallowing impossible and virtually all soils are cultivated continuously.

Mando (2003) compared soil fertility parameters of soils treated with *zaï* respectively 3 and 5 years ago. The data show a systematic improvement of all parameters. For instance, the organic matter content increased from 1 to 1.4 percent and nitrogen increased from 0.05 to 0.8 percent. Also the soil structure improved considerably with an increase in its clay content and a decrease in the sand fraction. This is no surprise as planting pits are dug on barren, crusted soils on which nothing can grow and which do not allow any infiltration.

The quantities of manure, compost and household waste applied to the fields are generally below 1 t/ha whereas agronomists feel that at least 5t/ha are needed to maintain soil fertility. Farmers usually apply manure or compost once every two years. In every second year they count on residual soil fertility. They observe their crops and apply organic matter where they feel it is most needed and in doing so they take into account differences in soils and in micro-topography. Some will also apply a small top dressing of NPK. In this respect they practice a form of precision agriculture. A key advantage of *zaï* is that the organic fertilizers are concentrated in pits and not spread over a field.

[14] These data are averages for fields with and without soil and water conservation. Villages with considerable investment in soil and water conservation systematically have higher yield levels than villages with little investment in this sector.

THE IMPACT OF ZAÏ ON FARM FORESTRY

The manure and compost used in *zaï* contain seeds of trees, shrubs and grasses. As a result, pitted fields show substantial regeneration of woody and herbaceous species. Farmers selectively protect species regenerating naturally. Protection of natural regeneration on treated fields contributes more to tree cover than planting of trees under village forestry projects. The species protected include: baobab (*Adansonia digitata*), *Acacia albida, Sclerocarya birrea, Piliostigma reticulatum.* Roose at al. (1999:351/352) identified after two years, on an initially barren field, 23 herbaceous species and 13 species of trees and shrubs. *Zaï* also contribute to the revegetation of bare land.

Ousseni Zorome, a farmer innovator living close to the regional capita of Ouahigouya, counted only 9 trees on 11 ha of degraded land he started to reclaim in 1983. Now he has about 2000 trees representing 17 species on these fields (Sawadogo et al. 2001: 41).

On what used to be barren land, which was reclaimed with a combination of *zaï*, contour stone bunds and vegetative techniques, Ousseni Kindo is now trying to grow some fruit trees, which can only be found in the Guinean zone (Ivory Coast). They include an orange tree, an avocado and a kolanut (personal observation January 2002). The fact that this experiment is possible indicates substantially improved soil conditions. His formerly barren fields now not only produce sufficient food for an extended family, but also sufficient firewood.

The earlier mentioned farmer-innovator Yacouba Sawadogo has used pits to systematically grow trees and shrubs on his fields. He deliberately puts grains of the species he wants on his fields in the pits. In this way he is able to determine which species he wants, where and in which numbers. This practice of so-called "forestry *zaï*" is not yet widely applied, but has considerable potential. It allowed Yacouba Sawadogo to create a forest containing more than 60 species where only 4 species could be found before he started (Sawadogo, et al. 2001: 41).

CHANGES IN LIVESTOCK MANAGEMENT

Many farmers on the northern part of the central Plateau, who have undertaken SWC, and in particular *zaï*, claim that they have invested more in livestock since they started these activities. Their reasoning is as follows: SWC has substantially increased the production of fodder (stover, herbs and pods), which makes it possible to increase livestock numbers; but this requires improved availability of water at village level (see next point). Food deficits are smaller and in good years small surpluses are produced. This has freed up money for investment in livestock and this in turn leads to the production of increased quantities of manure. Until recently it was common to ask Fulani herders to take care of the cattle during the entire year, now farmers increasingly want their cattle to stay on their farm during the dry season, so they benefit optimally from their manure (Reij, et al. 2001)

LOCAL IMPACT ON GROUNDWATER LEVELS

In the early 1980s groundwater levels on the Central Plateau dropped an estimated 50 – 100 cm/year (Reij 1983:10). Many wells fell dry immediately after the end of the rainy season and had to be deepened regularly. This led to a lot of extra work for women and girls whose task it is to fetch water. For instance in the village of Rissiam (Bam province) and in the village of Ranawa (Zondoma province) all wells fell dry at the end of the rainy season and women had to walk 5 – 6 km to respectively a lake and a well. Currently, all wells and boreholes in both villages have water during the entire dry season. In several villages included a study on long-term economic and environmental change on the northern part of the Central Plateau, though not in all, levels of water in wells have improved substantially during the last 10 – 15 years. This is not due to higher rainfall in the 1990s, but it is linked to the introduction of SWC measures, which lead to a control of surface runoff and better infiltration[15].

SOCIO-ECONOMIC IMPACT

Every farmer, rich or poor, can master improved traditional planting pits. Yet, the indications are that the "rich" and medium farmers use this technology more than the poor, simply because they have more family labor or are able to hire labor. Poor families are more likely to benefit from project-supported construction of stone bunds, which is usually done by groups of farmers on blocks of land selected for this purpose. Such blocks of land do include fields of small farmers as well as field cultivated by women[16].

The broader question is whether *zaï* and other SWC techniques have contributed to reducing rural poverty. Some micro-level studies appear to support this claim. Using their own criteria to define wealth, which are mainly related to the level of food security, the villagers of Ranawa (Zodoma Province) estimated that the number of poor families decreased by 50 percent between 1980 and 2001 (Ouedraogo, M. et al., 2002: 35)[17]. This was largely due to the wide range of SWC activities undertaken in this village since 1985, which has led to the progressive rehabilitation of about 600 ha of degraded land most of which had become unproductive. The environmental and socio-economic situation in this village was dire in the early 1980s. Due to

[15] A spectacular improvement of water availability has been found in villages with a long history in SWC, but not in villages with little or no SWC. This indicates that improvements in water availability are not due to slightly increased rainfall in the 1990s, but rather to different levels of SWC. Levels of water in wells are about 5 m higher now than in the early 1980s, but cases are known where this is much higher. A quick reconnaissance in 59 villages carried out in 2002 shows that the number of wells which have water the year round has not increased significantly since the start of SWC. This aspect needs to be studied in more detail.

[16] This is confirmed by preliminary data from the earlier mentioned Central Plateau study, which show that poor farmers benefit equally from SWC

[17] This figure should be regarded with some caution. It is justified to say that the number of poor families in Ranawa has decreased substantially. As one farmer explained " in 1985 only two families had livestock, but now all families have at least one head of cattle and most have more".

recurrent drought and important food shortages 49 families left the village between 1970 and 1980 (25 percent of all families) and settled in Ivory Coast or in more fertile and higher rainfall parts of Burkina Faso. All wells fell dry shortly after the end of the rainy season and women had to walk 5 km to fetch water in a neighboring village. Since SWC activities started in 1985 not a single family has left the village in this village. All wells have water during the dry season. Due to SWC more land is cultivated and yields have increased, which has led to a substantial improvement in household food security and a systematic protection of natural regeneration important stands of trees grow on what used to be barren land. Numbers of livestock have increased substantially and livestock management has changed from extensive to semi-intensive (livestock fattening and use of external inputs). Manure is collected systematically and used to fertilize the fields. These profound changes are not only due to SWC, but are also influenced by macro-economic policies, such as the devaluation of the West African Franc in January 1994, which increased the value of livestock and livestock products.

Is this positive evolution in the village of Ranawa unique or an exception? In terms of SWC Ranawa is above average compared to other villages. Even so, similar trends, though less pronounced, can be found in hundreds of other villages on the northern part of the Central Plateau.

THE MICROECONOMICS OF ZAÏ

According to some SWC specialists, economists and other scientists, SWC in semi-arid regions may prevent a yield decrease rather than bring about a significant yield increase (e.g.Brons et al. 2000: 32). If this were the case, then farmers in Burkina Faso would not be investing spontaneously in *zaï* and in other conservation practices. When asked about the impact of SWC on yields, farmers on the northern part of the Central Plateau systematically state that it leads not only to higher yields, but also to increased yield security, to more water in their wells, to a stronger growth of trees and to a higher production of fruit (Reij, et al. 2001). It appears that the farmers often have a more holistic view of the impact of SWC than researchers, who tend to be interested in impact on yields only.

Improved traditional planting pits make it possible to rehabilitate strongly degraded land. In the "without" situation yields on strongly degraded land are 0 kg/ha and every kilo of sorghum, millet, cowpea or maize harvested on this land is perceived as additional to what they would harvest otherwise. Strictly speaking this is not true, because the labor allocated to rehabilitated land may lead to lower use of labor on existing fields, and hence to lower yields on these fields. In fact, farmers who can afford it, re-introduce a short fallow on part of their existing fields in order to improve soil fertility and to facilitate regeneration of trees and shrubs.

Table 3 presents a production budget for one hectare of *zaï* in a year of average rainfall. Variable costs include the amortization of tools used to produce the compost, the cost of maintenance of compost pit, the cost of emptying the pit as well as the costs of transporting the compost to the fields[18]

[18] These costs are derived from Sidibe et al. (1994) who measured them in INERA research villages in the western part of Burkina Faso. Labor requirements for digging the zaï and putting crop residues and other organic material into the pits are based on Roose et al. (1999). Sidibe et al. (1994) measured the labor requirements for digging the compost pit and filling it. A compost of 10almost 11 m3 is needed to produce 2,5 tons of compost. Crop yields and prices vary from season to season.

Table 3--Crop Production budget with *zaï technique*, Burkina Faso

Crops		Units	Quantity	Price	Value
Sorghum	Grains	kg/ha	900	100	90,000
	Stover	kg/ha	1,665	12	19,980
Cowpea	Grains	kg/ha	150	212	31,800
	Fodder	kg/ha	248	15	3,720
A. Gross Revenue					**145,500**
Variable Costs					
	Equipment amortization	FCFA/ha	9,566		
	Pit maintenance	FCFA/ha	2,761		
	Emptying pit	FCFA/ha	739		
	Compost transportation	FCFA/ha	5,000		
B. Total variable costs		**FCFA/ha**			**18,066**
C. Gross Margin		**FCFA/ha**			**127,434**
D. Labor Investments					
Labor requirements for zaï					
	Digging zaï	Hrs/ha	450		
	Putting compost into the pits	Hrs/ha	150		
Labor for Compost pit					
	Digging	Hrs/ha	96		
	Filling	Hrs/ha	78		
Labor requirements for planting*		Hrs/ha	40		
Labor requirements for weeding*		Hrs/ha	95		
Labor requirements for harvesting**		Hrs/ha	50		
Labor requirements for transportation & storage		Hrs/ha	n.d		
Total labor		**Hrs/Ha**			**959**
Returns to labor/hour		**FCFA**			**133**

* Based on both ICRISAT crop production budget data and farmers' qualitative estimates: 1/3 of ICRISAT weeding data and 3/4 of the planting labor data.

** Only based on ICRISAT crop production budget data

The return to labor is an estimated 133 CFA/hour, compared to notional estimates of shadow wage rates of about 100 CFA/hour. Assuming a 6 hour workday this would mean a return to labor of 797 CFA/person day (about 1.15 US $/day). This figure will fluctuate from year to year depending on rainfall conditions. In reality the benefits are higher, because this budget does not take into account long-term benefits of zaï. Farmers on the northern part of the Central Plateau systematically state that SWC does not only lead to higher yields, but also to increased yield security, to more water in their wells, to a stronger growth of trees and to a higher production of fruit (Reij et al. 2001). *Zaï* are used to rehabilitate strongly degraded soils. This technique leads to the re-capitalization of soils.

POTENTIAL FOR EXPANSION OF THE TECHNOLOGY (POTENTIAL AND CONSTRAINTS)

The potential for expansion of *zaï* within Burkina Faso and in other Sahelian countries is considerable and expansion has already occurred. In 1989 an IFAD-funded SWC project in Niger's Illéla District sent 13 farmers on a study visit to the Yatenga region where they observed *zaï* and other conservation practices. Upon return some of them tried these out on their own fields and obtained impressive results. More farmers started trying *zaï* (or *tassa* as they are called in *haussa*) the next year. 1990 was a drought year and only fields treated with *tassa* produced a harvest. From this moment on *tassa* became increasingly popular and farmers started buying degraded land to rehabilitate these. Prices for degraded land doubled between 1992 and 1994. Buying and selling of degraded land is not an isolated phenomenon in Illéla and in neighboring districts; many farmers are involved in the land market (Hassane, et al. 2000). Since *tassa* was introduced in Illela District in 1989 they have spread not only to neighboring districts, but also to other parts of Niger.

What are the conditions governing prospects future expansion? According to Roose et al. (1993: 171) *zaï* function best in areas with a minimum of 300 mm and a maximum of 800 mm rainfall. With less than 300 mm the risk of crop failure becomes too big and with more than 800 mm the crop risks to get too much water. To this should be added that the soil surface should be barren, flat and hard, in order to generate sufficient runoff. Because the digging of *zaï* requires a substantial input of labor, this implies that a relatively high population density would facilitate its spreading. Freeman (1999) has tried to map the range of proven soil management practices in West Africa using digital maps and concluded that there also is a potential for expansion of *zaï* to, for instance, Eastern Senegal and parts of Nigeria.

4. FINAL REMARKS

According to Burkina Faso's National Action Plan to Combat Desertification the environmental situation on the Central Plateau continues to degrade. This view is widely shared, but ignores positive local development dynamics triggered by the serious droughts of the first half of the 1980s. In hundreds of villages on the northern part of the Central Plateau, a combination of farmer initiatives, public investment, efficient technologies and macro policies has led to a process of environmental recovery which is still timid, but promising. During the past 15 years, tens of thousands of hectares of strongly degraded land have been rehabilitated using *zaï* and projects have contributed to the construction of contour stone bunds on at least 100,000 hectares. The economic and environmental impact of investments in SWC practices has been under-estimated by researchers.

The World Bank and other donor agencies emphasize the need for the re-capitalization of African soils and in this context they usually advocate the use of mineral fertilizers. However, farmers on the Central Plateau of Burkina Faso (and in many other regions in Africa), are already re-capitalizing their soils usually without the use of mineral fertilizers, which are often considered too risky and too expensive.

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