MOTORIZED SOIL TILLAGE IN WEST-AFRICA

A survey on the current use and consequences of tillage done with engine-driven machinery

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May 1998

1. Introduction

1.1 General

Whenever a new, alien technology is introduced in a system, new risks and dangers are also introduced. Agriculture in Sub-Saharan Africa has had more than its fair share of introduction of inappropriate technologies that either did not serve their purpose at all, or had too many unwanted and unforeseen side effects. There have been numerous efforts to introduce mechanization in African farm practices, but most met with limited success, and some with complete failure. All in all, the mechanization issue is one of controversy.

One of the major forms of mechanization is the use of engine powered machines for tillage. Tillage is a process that generally requires a lot of power input and the lack of farm power is often argued to be one of the main constraints for the growth of agricultural production. On the other hand, there is the argument that the adverse environmental effects of intensified soil tillage as a result of mechanization are crucial. The main drawbacks are the potential for increased erosion and soil degradation, problems which are already rampant over many of the fragile African soils. In addition, tractor use has been criticised for its undesirable social impact, particularly for the displacement of labour in conditions of general unemployment. The sustainable introduction of tractors has been, more often than not, hindered by poor institutional support, poor spare part supplies and high maintenance costs for low-income farmers. As the issue of tractorization and the resulting intensification of tillage becoming increasingly controversial, tillage systems that aim at minimizing soil disturbance have gained popularity rapidly. Conservation tillage, minimum tillage and zero tillage are now being researched and promoted worldwide.

Currently, the scale on which mechanical power is used for tillage is still limited. In Africa, 80% of the cultivated land is currently prepared by hand, using human muscle power to do the work. On 16% of the land animal draught power is used and only 4% is prepared with mechanical power (Mrema, 1996). The number of tractors has been growing over the last decades and this small percentage is likely to increase, with or without the aid of donors and governments. With the advantages, and more importantly the risks and drawbacks in mind, the process of tillage mechanization is one that needs to be monitored and guided closely to judge whether or not mechanization in its current form is the path that leads to a sustainable increase in production. This study seeks to investigate the current status of motorized tillage in West-Africa and the pros and cons of it, as perceived by specialists working in this field.

1.2 Terminology in mechanisation

In the terminology in the area of mechanization, motorization and tractorization there is reason for confusion. Mechanical tillage can comprise both tillage with animals and with engine power. Mechanical power however, is always provided by an engine. In accordance with the most widely used terminology, this report uses the terms as follows:

> Mechanization: introduction of machines into a system; here it comprises the introduction of implements for both motorized and animal traction
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> Motorization: introduction of engines into a system, it comprises the introduction of engine-powered machinery

Tractorization: introduction of tractors into a system

Mechanical traction: traction provided by motorized machines (power tillers and tractors)

Animal traction: traction provided by animals

Mechanical tillage: tillage with implements being drawn by either motorized machines or animals

Thus agricultural motorization concerns the use of engine powered machinery for carrying out agricultural activities. In more detail, it comprises:

1. tractors and their implements and equipment and other self-propelled machinery
2. power tillers and other specialized engines
3. engines used for propelling stationary machinery or carried on a person's back

This paper however, concentrates on motorization for tillage. Since only tractors and power tillers are used in West African practice for motorized tillage, the other forms will be left out of consideration.

1.3 Methodology of study

The basis of this research derives from a questionnaire. The Agricultural Engineering Branch of FAO has created a questionnaire that was sent to 110 addresses in 17 countries in West Africa.

The addresses used were obtained from various sources, including: participant lists of various workshops and seminars, the SPAAR directory of Agricultural Research Institutions in Africa published by the Worldbank, the International Directory of Agricultural Engineering Institutes elaborated by FAO and various other sources. An effort was made to include the relevant departments and units of respective Ministries of Agriculture in the mailing list.

The processing of the completed questionnaires was done by hand. In total 14 questionnaires out of 110 were returned, representing a 13% response rate. From 7 out of the 17 countries, at least one questionnaire was received. The countries that did not respond are: Niger, Guinea-Bissau, Cap Verde, Burkina Faso, Sierra Leone, Nigeria and Liberia. The results of the questionnaire have been combined with a literature study.

2. Status of mechanization and motorization

2.1 General

The percentage of the productive land that is tilled with motorized traction remains very low in Sub-Saharan Africa. Estimates range from 1% (FAO, 1987 and Gifford and Rijk, 1980 in FAO, 1995) to 4% (Mrema, 1992). Taking into account that more than half (FAO yearbooks, as in Caumont, et al., 1995) of the tractors are used in Southern Africa, the percentage of the total area cultivated with tractors in West Africa is practically negligible. Animals provide the power to an estimated 9% (FAO, 1987 and Gifford and Rijk, 1980 in FAO, 1995) to 16% (Mrema, 1992) of the area. This leaves 80 to 90% for cultivation by hand. The African farmer is generally referred to as a "hoe farmer. "Although a controversial claim, it is sometimes said that the degree of mechanization signifies the technological state of agriculture.

The questionnaire shows a similar result with the number of tractors being very low. Whereas Mrema (1992) estimates the area of cultivated land per tractor to be as much as 1094 ha in SSA, in West Africa it is even higher. For the countries that information was obtained from, this number is about 4,000 ha per tractor.

Table 1: Data on Tractorization in West-African countries

Country	area under cultivation ('000 ha)[1])	number of tractors	area per tractor (ha)
Benin	1,398[6])	109[6])	12,825
Burkina Faso	6,833	1933[4])	3,535
Cap Verde	67	16[4])	4,187
Cote D'Ivoire	7,193	3000[3])	2,398
Gambia	334	175[3])	1,909
Ghana	4,876	3299[5])	1,478
Guinea	4,592	100[3])	45,920
Guinea-Bissau	1,420	19[4])	74,737
Liberia	639	325[5])	1,966
Mali	8,318	280[3])	29,707
Mauritania	1,079	100[3])	10,790
Niger	11,097	180[4])	61,650
Nigeria	32,474	11,900[4])	2,729
Sao Tome and Principe	42	60[3])	700
Senegal	5,422	500[3])	10,844
Sierra Leone	1,931	550[4])	3,510

Togo	1,998	55[3])	36,327
Total			**3,969**
Average for SSA[2])			1,094

[1]): Alexandratos (1995)

[2]): Mrema (1996)

[3]): this study

[4]): FAOSTAT

[5]): FAO 1994

[6]): Direction du Gènie Rural Bènin

Table 2, shown below, shows that the overall prevalent form of motorization in West Africa is the tractor with the disc plough, used in irrigated rice for primary tillage. The second most frequently used is the disc harrow, which is also used for upland cultivation. In most cases primary tillage is the only tillage operation before planting.

The agro-ecological variations in the region may influence the mechanization patterns found in the various countries. The climates in West Africa range from humid tropics and subtropics in the southern coastal regions to arid in the northern regions towards the Sahara Desert. In general terms, low precipitation and high temperatures increase the difficulty to achieve a sustainable soil/cropping system that preserves the soil (FAO, 1995b). This implies that, preferably, different tillage systems, using different means of mechanization and implements, should be used in the various agro-ecological zones of West Africa. The qualitative results of this study are not detailed enough to determine whether or not there are major regional differences in mechanization patterns. The data from Table 2 does not suggest any particular pattern, i.e., the preferred use of tractors in one region versus the use of power tillers in the other, or disc ploughs versus disc harrows for primary tillage. Togo reports the use of animal traction on fragile, shallow soils and mechanical traction on other soils. In Mali the choice between a disc plough and disc harrow is reportedly dependent on the type of soil.

Table 2: Prevailing means of motorization

Country	Prevailing means of motorization
Benin	• Tractor and disc plough for primary tillage in maize and cotton
Côte D'Ivoire	• Tractor and disc plough for primary tillage in rice • Power tiller and rotary cultivator for both primary tillage and secondary tillage in wetland rice
Gambia	• Tractor and disc harrow or disc plough for primary tillage in dryland staple crops
Ghana	• Tractor and disc plough for primary tillage in maize, cowpea and soybean
Guinea	• Tractor and disc plough for primary tillage in rice
Mali	• Tractor and disc harrow or disc plough for primary tillage in irrigated rice
Mauritania	• Tractor and mouldboard plough or disc plough for primary tillage in irrigated rice • Tractor and disc harrow for secondary tillage in irrigated rice and dryland crops
Sao Tomé and Principe	• Tractor and disc harrow for primary tillage in maize • Tractor and weeding harrow for secondary tillage in maize
Senegal	• Tractor and disc plough for primary tillage in rice and in dryland and wetland cash crops
Togo	• Tractor and disc plough or disc harrow for primary tillage in maize, sorghum, sesame, cotton and millet • Power tiller and mouldboard plough for staple crops, or rotary cultivator for rice and vegetable crops

2.2 Primary tillage

Primary tillage is the main tillage operation that is done in the beginning of the growing season. In the West African setting it is often the only operation done to prepare the seedbed , and in some cases sowing is done without any preceding tillage.

The standard agricultural tractor dominates motorization for primary tillage. In most cases they are of European origin and of medium output of between 45 and 65 hp. Tractors are used in both dryland and wetland settings. To a lesser extend one-axle power tillers are used. Power tillers are most often used in irrigated and wetland rice production and in vegetable crops.

The implement most often used for primary tillage with tractors is the disc plough, followed by the disc harrow and the mouldboard plough. Less common are rotary cultivators and ridging ploughs. In most cases power tillers are mounted with a rotary cultivator or a ploughing body.

2.3 Secondary Tillage

Secondary tillage implies the preparation of a seedbed after the first coarse primary tillage. Normally an implement that is used for primary tillage will not be used again for secondary tillage. The questionnaire showed that secondary tillage is rarely practised and if it is, it is usually done with the same implements that were used for primary tillage. This implies that the concept of secondary tillage has created some confusion. Most likely some respondents assumed that doing the same operation on one field twice is referred to as secondary tillage.

Again, tractors, and to a lesser extent power tillers, are used with a wide range of implements, of which some are designated for secondary tillage, (i.e. spike harrows, disc harrows and multi-purpose toolbars) and some are not (i.e. disc ploughs, mouldboard ploughs, rotary cultivators and weeders). One respondent reported the use of tree branches pulled behind a tractor.

2.4 Weeding

Only three respondents reported the use of tractors for weeding. In two cases weeders were used, in one case a disc plough was reportedly used. The primary method for weeding is using a weeder/cultivator with animal traction, followed by hand labour (hoeing).

2.5 Destumping and clearing of fields

A wide variety of equipment is used for destumping and clearing of fields. This process generally requires considerable force and so heavier tractors (around 100 hp) and bulldozers are used. The implements reported were subsoilers, heavy chisel tines and heavy-duty disc harrows.

2.6 Crops

The most heavily motorized crop is rice. Both in dryland and wetland production power tillers and tractors are widely used. Percentages of the area for rice production that is motorized vary from 4% in Senegal and 30% in Guinea to 50% in Mauritania. Vegetable

crops are also motorized but on a lower level. Senegal reports 2-3% of the vegetable crops to be motorized. The staple, mostly dryland, crops are the least motorized, less than 5%, although Benin reports that 45% of primary tillage in cotton and maize is motorized.

3. Perceived benefits of motorized traction

Motorization has many advantages. The characteristics of an agricultural system will determine what are the main advantages that would persuade a farmer to use motorized inputs on his farm.

The most obvious benefit is the work potential of tractors versus hand labour and animal traction. This is most advantageous in communities where labour is scarce or expensive. The labour requirements for preparing one hectare of land for planting using draught animal power are only 12% of that required when using hand labour. When using a tractor with a plough, this falls to less than 1%, increasing labour productivity tremendously. As labour is a constraint in many farming communities, the use of animal traction and tractors brings the opportunity to expand the acreage. The holdings of cotton farmers using animal traction in Burkina Faso, Mali and Togo are 1.3 to 3.6 times bigger than the holdings of those relying solely on hand labour (Caumont, 1995). Motorization is likely to have an even greater potential for area expansion as long as land is available. Labour productivity will increase considerably. A farmer owning a tractor would normally be able to increase his income through increased production and by doing contract work for other farmers.

The author's work on the spontaneous tractorization in rural communities in The Gambia supports the idea that farmers view saved labour and reduced drudgery as motorization's main advantages. (Van der Meijden, 1994) A village chief voiced a widely held opinion, confirming that "owning a tractor makes farming easier and since there are tractors more work is done and more is grown than one person could ever do. People work more. That is good, we have higher production now." The tractor owner can often generate considerable income from doing contract work, such as tillage and transport for others. Although farmers in the village are aware of the increased risk of erosion that tractor use has caused, they are still very much in favour of tractorization. So, despite the fact that tractorization in this particular village is a spontaneous process, it is no surprise that it seems to continue without any external support or promotion. This indicates the likelihood that further tractorization and an increase in the degree of mechanization will take place, as a spontaneous process, where and whenever farmers have enough purchasing power to buy tractors and governments do not limit mechanization through import duties or other measures.

Labour shortages, most crucial during the period of land preparation at the beginning of the rainy season, (FAO, 1995a) result in untimely operations and limits both area expansion and total food production. This is especially true in cases where the cropping season is short. This explains why farmers often mechanise only land preparation, as it is the operation in the cropping cycle that has the highest labour demand; they rarely invest in other machinery since hand labour for those operations is still less costly and usually abundant. This 'incomplete' mechanization pattern is seen in the Gambia as much as it is elsewhere in West Africa. Some Gambian farmers have invested in two tractors for primary tillage only, rather than using one tractor with an extended implement package to include planting and weeding. (Van der Meijden, 1994) One farmer explained, "I have never had the 'complete' package. The reason I have two tractors instead of for instance one tractor

and a sowing machine and a weeder is the demand for labour in the first two or three weeks of the rainy season. You have to do the ploughing and the sowing as quickly as possible. With one tractor I would be able to do only half of what I do now."

Questionnaire results confirm that the work potential/increased productivity aspect is the main advantage of motorized tillage. Two thirds of the respondents mentioned this aspect. Closely related to it is the extension of the area cultivated, which was mentioned by half of the respondents. An increase in yield per hectare was not mentioned, though it might be linked to increased productivity. One fourth of the respondents found reduced drudgery to be important. Other aspects that were mentioned are: good work, better tillage, increased living standard, increased income, increased export, urbanisation of rural areas and timeliness in rain dependent agriculture. A remarkable response came from The Gambia: less soil erosion potential. The suppression of weed growth, considered a major advantage of motorizing tillage, was not mentioned as an advantage.

Whether the intensification of tillage resulting from motorization has a positive effect on yields is very much dependent on the cropping system that is used, the agro-ecological zone concerned, etc. Assuming that motorization of tillage operations increases the soil volume disturbed by it, it is important to note that there is a positive and significant linear regression between the crop yield of maize and the total volume of soil disturbed by primary and secondary tillage in West African semi-arid conditions (Dunham, 1988, in Van der Meijden, 1994). However, the question is, how very sustainable this yield increase can be for soils that often have low natural fertilities and to what extend a short term increase in production will be undone by the long term degrading and destabilizing effect of intensive tillage. Farmers themselves mostly state that the use of tractors increases crop yields (Van der Meijden, 1994).

4. Perceived problem areas in motorized soil tillage

The disadvantages and risks of motorized soil tillage are more complex and sometimes less obvious than the advantages. Therefore this subject was elaborately examined in the questionnaire. The specialists who responded found that the degradation of soil resources was the main risk of using motorized tillage. Others found the low level of mechanization itself to be the main problem and concentrated on the causes and results of this. Table 3 lists the problems raised by the respondents.

Table 3: Issues raised when asked for the main problem areas in mechanized soil tillage

Issues and frequency reported:	Most often mentioned (in order of importance):
Soil resources (reported 30 times by all respondents)	• erosion • degradation of structure (especially on light soils) • soils are unstable • organic matter contents decreases • depletion of soil/low fertility • wind erosion • compaction • formation of plough soles • fertility depletion on uplands and sedimentation on lowlands • lack of soil resources management (no soil cover, no wind hedges) • decreased water retention
Use and management of mechanization (reported 17 times)	• mismanagement and misuse of equipment • frequent breakdowns/under-utilization of equipment • tillage in direction of slope • tillage too deep • drivers are insufficiently trained • reduced life span of equipment • low quality of work • ploughing done at incorrect moisture content
Support to mechanization (reported 13 times)	• drivers are insufficiently trained • mechanics are insufficiently trained • poor spare parts delivery/insufficient after sales services • general ignorance of mechanization • mistrust of farmers towards mechanization of their crops • low accessibility of equipment • no support from specialists and government
Given constraints (raised 13 times)	• scattered, small parcels • fields are not fully cleared or destumped • high percentage of non-productive usage • smallholder farms • steep slopes • bad access roads and not fully cleared fields result in high breakdown rates

Financial issues (reported 13 times)	• lack of credit • high costs of equipment • low income/lack of capital
Low level of mechanisation and results (reported 10 times)	• low mechanisation • low exploitation of arable land • untimely operations • next to mechanised tillage, other operations are still manual • not sufficient equipment available
Effects on yield, income and productivity (reported 10 times)	• low yields resulting from soil degradation • low income • low productivity • malnutrition • more work • abandoning of land due to erosion or weed growth
Non adaptation of means of mechanization (reported 6 times)	• usage of equipment that is not or poorly adapted to local situations • no needs assessments done before introduction • using discs for tillage (disc ploughs and disc harrows)

[1]): Respondents generally concentrated on motorized tillage (engine powered) rather than mechanized tillage (also including animal power).

4.1 Degradation of soil resources

The predominant concern when discussing motorization is the degrading effect on soil and water resources. In general, motorization of tillage entails an intensification of the disturbance of the soil. This results from both an increase in the intensity of movement and crumbling action when high power tractors are used and from an increase in the volume of soil that is disturbed because of greater working depth. Because of this intensification of tillage the use of motorized tillage is likely to increase soil and water losses, increase erosion and degradation of soil resources. Eventually this can result in loss of soil fertility, soil stability and other soil properties favourable to plant growth. FAO estimated in 1984 that if soil erosion continues unchecked between 1975 and the year 2000, about 18% of the rain fed cropland of the developing tropical countries will be lost and that rain fed crop productivity will fall by about 29% (FAO, 1984).

Respondents considered soil-related issues to be the main concern when using motorized tillage. Nearly all respondents mentioned the degradation of soil resources resulting from motorized tillage: erosion, degradation of soil structure, decrease in organic matter content, depletion of soil fertility, wind erosion, etc. Soil compaction and the formation of plough soles, both more serious problems than generally believed, were mentioned only a few times.

The causes most listed for soil degradation were the misuse and bad management of the equipment. Most respondents reported a general misuse, but others gave more detailed insight into the problem: tillage done not on the contour, too deep, maladjustment of implements or ploughing done at incorrect moisture content. Insufficient training of the tractor drivers was often attributed to these problems.

However important the adoption of a non-indigenous technology to match local circumstances is, it appears to be non existent in motorized tillage. It is true that disc ploughs are, in most cases, a better match for West African circumstances than the mouldboard plough because of easier use and sturdiness. And the fact that disc harrows are used for primary instead of secondary tillage also represents a kind of adaptation. But given that most of the implements and tractors seen in West Africa are second hand items designed for and used in other cropping and tillage systems, means that the rate of adaptation is low. Although not mentioned very often, the respondents confirm this to be a problem. In addition, in the cases of large scale government or sponsor driven introduction of tractors and implements, needs assessment studies are rarely done ,and there are numerous examples of failure because of this very reason. For example, one respondent found disc implements such as the disc plough and disc harrow to be inappropriate because they spread weeds with rhizomes.

4.2 Low level of mechanization

Several respondents found the low level of mechanization in their country to be a problem in and of itself. Direct consequences are the under-exploitation of arable land and untimeliness of operations. One respondent mentioned that operations such as planting, weeding and harvesting are not mechanized, which results in a higher workload for these activities.

The lack of support to mechanization is seen as the main reason for the limited use of mechanized inputs. Farmers face difficulties in obtaining spare parts and after sales services. The scarcity of well-trained mechanics increases the breakdown rate of machinery. On the field level there is reportedly a general ignorance and mistrust towards mechanization. Institutional support to mechanization from government or other institutions, except for a few cases where large scale tractorization is in place, is generally non-existent.

Mechanization requires a certain farming system that is not often found in West Africa. The first major constraint in this matter is the size of the holdings per farmer and the size of each field, which hampers the effective use of tractors and results in a high percentage of non productive usage. Secondly, field clearing is a problem. Even when disc implements that can more easily overcome stumps and stones are used, fully cleared fields are rare. Steep slopes were mentioned as another constraint. Lastly, poor or non-existent access roads were found to contribute to the high breakdown rates of machinery.

Mechanization represents a high-cost, and often a high foreign exchange technology that low income farmers with limited capital can rarely afford. Together with the issues listed above, this is a paramount constraint for mechanization. Under mechanization programmes, farmers have often been provided with tractors for far less than the actual prize or under a credit scheme which invariably has very low recovery rates. Once confronted with the ‘real’ market prices of spare parts and maintenance, farmers will not be able to sustain their machinery. Prices for fuel and lubricants may also render tractorization unsustainable.

4.3 Extent of problems

Notwithstanding the low level of motorization in West Africa, the specialists working in the field of tillage all consider the drawbacks of motorized tillage to be very important and serious. Most respondents said that mechanization is indispensable to increase productivity, production and meet the growing demands for food. At the same time they realize that current methods of motorized tillage are damaging the natural resources to the extent that there are irreversible environmental

effects that will negatively affect food production, food security and food self-sufficiency. To avoid this, a careful and well considered guidance of the motorization process is needed, with special attention given to soil and water conservation.

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5. Mechanization and tillage on a national level

Little attention is paid to mechanization and tillage on national levels, which represents a problem in all west African countries. The efforts to support farmers with training, to research the effects of motorized tillage, and to put in place units that actively and effectively deal with mechanization issues are there in some cases, but generally have insufficient impact on the field level.

There are, however, some examples of institutional support in the following countries:

- Ghana's Soil Research Institute has runoff plots in all the agro-ecological zones of the country to compare different tillage practices;
- In Senegal credit is given for purchase of tractors in riziculture;
- In Mali extension centres are being revitalised, and organisations such as Compagnie Malienne de Développement de Textile and Office du Niger have units dealing with mechanization aspects;
- In Togo, the Université du Bénin uses questionnaires to research erosion and soil degradation in animal traction and motorized tillage.

Extensive research in the area of both motorization and mechanization (including animal traction) is non existent in most countries. Cote D'Ivoire reports that there was once research on mechanization issues done on the experimental farm of the 'Centre Ivoirienne de Mécanisation Agricole' (CIMA), but due to insufficient funds the program collapsed.

Systems of reduced tillage, such as minimum-tillage, zero-tillage or conservation tillage generally reduce soil and water losses, and decrease erosion and degradation of soil resources. These methods may be used to reverse the process of accelerated erosion. Although research on various tillage systems has been conducted in the region in the past (i.e. Baffoe-Bonnie, 1975), only two respondents report current activities on conservation tillage. Mauritania and Ghana report that trials are ongoing at this time, but only at the experimental level. Togo plans to launch a pilot programme in this area.

Respondents specifically stressed that there is a general neglect of agricultural mechanization issues on a national level, and the results of the questionnaire support these statements. Reliable data on the number of tractors and the area that is mechanized are rarely available, research and extension on mechanization issues is lacking, and there is a need for clear national policies and strategies on agricultural mechanization that need to be implemented. This is of particular concern because, as stated before, mechanized inputs will find their way to African farms with or without the support and intervention of governments and other institutions. Research institutions, extension systems and government bodies should be strengthened and urged to include mechanization issues in their mandate.

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6. One specific implement: the disc harrow

The disc harrow plays, next to the disc plough, an important role in motorized tillage. To investigate how specialists perceive the relation between the use of disc harrows and soil degradation, questions were asked on this subject specifically.

Most respondents identified a direct relationship between the use of disc harrows and an increase of chances that erosion takes place. Motorization of tillage generally results in intensified soil disturbance at a greater depth in comparison with hand labour and animal traction. Secondly, there is the inappropriate use, misuse and maladjustment of the implement that add to the harmfulness. The use of disc harrows on soils that are too light and fragile, and tillage in direction of the slope are particularly harmful practices. The Gambia reports gravely soils becoming more gravely on the surface under the use of disc harrows. In general, the use of disc harrows on light fragile soils is dissuaded.

The drawbacks mentioned in the last paragraph are however not exclusively reserved for the disc harrow; they apply to most forms of motorized tillage. This also explains that other respondents find the disc harrow to be less harmful; it depends on what it is compared with. In comparison with the disc plough or powered implements such as rotary cultivators and powered rotating harrows the disc harrow is less harmful. In general the belief is that implements that pulverise the soil too much cause erosion in light, fragile soils, but may be suitable for other soils. The disc harrow is believed to be an appropriate implement for both primary and secondary tillage on soils that are stable enough, such as soils with high loam or clay content, and rice plains.

The question of whether the disc harrow is the appropriate implement in some circumstances in West Africa or merely the best implement available remains unanswered. It is clear however that the choice of implement has great consequences for soil and water conservation aspects.

7. Conclusions and recommendations

The level of mechanization

The level of mechanization in general and motorization of tillage more specifically is low in West Africa. The average area of cultivated land per tractor is about 4,500 ha for West Africa, as compared with about 1,000 for Sub-Saharan Africa and 278 and 116 for 'Green Revolution' nations of India and China, respectively (Mrema, 1996). It remains a fact that only one quarter of the land area of Africa capable of sustained production of rain fed crops is being used at this time (Kaul, 1991). The low level of mechanization could be seen as a major constraint to agricultural growth on the one hand. On the other hand, taking into account the misuse of motorized inputs for soil tillage and the inherent hazards, it limits the damage done to natural resources.

Forms of mechanization

The overall prevalent form of motorization is the standard agricultural tractor with the disc plough for primary tillage in irrigated rice, closely followed by the disc harrow, which is also used for upland cultivation. Power tillers are used to a lesser extend and mostly in wetland rice.

Although some respondents reported the use of specific implements for specific soil types, no distinct mechanization patterns for the various agro-ecological zones within West Africa could be distinguished from the results of the questionnaire. This may indicate that the types and means of mechanization are imported and used without regard to local circumstances and the appropriateness of the equipment. In spontaneous, small scale mechanization, but moreover in large scale government or donor led mechanization, literature reports numerous examples of importing machinery that was not adapted to fit local circumstances. In too many cases it has been the donor that determined what equipment was donated (i.e. products from the donor country) rather than having made funds available to purchase the make and type of equipment that would match local circumstances best. More insight in the mechanization patterns that prevail in the various agro-ecological zones of West Africa is needed to find the link between forms of mechanization and the climatic and agricultural circumstances. Systems of reduced tillage such as minimum-tillage, zero-tillage or conservation tillage do not necessarily exclude the use of tractors and should in any case be considered as they may be used to reverse the process of accelerated erosion.

In most cases no secondary tillage is done after primary tillage. Especially where soils are light and sandy only one tillage operation is applied to prepare the seedbed. Weeding is hardly ever done with a tractor or power tiller. The most mechanized crop overall is rice, both in dryland and wetland production. The least mechanized are the staple crops, mostly in upland production.

Incomplete mechanization

With the knowledge that practically all operations in the cropping cycle could be mechanized, one could state that the capital intensive, motorized equipment is heavily under-utilized and therefore has a high capital cost per hour of work. In West African practice primary tillage is the only operation in the cropping cycle that is mechanized. Land preparation has the highest labour peak and pressure to get the sowing done in the first weeks of the growing season after the first rains, is very high. After primary tillage the labour shortage seems to be less stringent and farmers hardly ever extend the equipment package of a tractor to include planting and weeding. Next to the fact that farmers do not feel the need to mechanize these activities because of having enough labour

available for it, there is also the investment needed for yet another set of implements. Moreover, for weeding to be mechanized, planting has to be done in rows, most likely using a tractor drawn seeder. All in all this represents a considerable change in the farming system.

Advantages and disadvantages of motorization

The main advantage of motorization as seen by the respondents is the work potential/increased productivity aspect. Increased productivity stems from both an increase in acreage and increased yields. Most respondents find that mechanization is indispensable for increased productivity, increased production and for meeting the fast growing demands for food. The risks and disadvantages, however, are well recognized by both the specialists working in the field and by the farmers. The degradation of soil resources is seen as the most perilous risk of motorized tillage. In methods currently practised, motorization damages the natural resources to the extent that there are irreversible environmental effects and, eventually, a negative impact on food production, food security and food self-sufficiency. In general, the status of mechanization is very poor. Farmers and drivers have received little or no training, resulting in malpractice that further increases soil erosion and brake down rates of the machinery. A lack of trained mechanics and spare parts or the purchasing power of farmers to obtain these, further adds to the underutilization of the equipment. Additionally, motorization is often inadequate for the West African farming systems of many smallholder farms with scattered fields, bad access roads and not fully cleared fields.

More attention to mechanization

The problems stated above stress the need for a careful and well-considered guidance of the mechanization process in West Africa. Mechanization has received less attention than it deserves on basis of the consequences it has. There is a lack of statistics and information on mechanization issues due to many years of neglect, and research on the subject has been minimal. As opposed to animal traction and soil and water conservation, which receive considerable attention, motorization is not being studied at this time in West Africa. Additionally, extension services and research institutions are often understaffed and in need of capacity building. Most extension workers have had little or no training to deal with motorization issues. The underlying problem may be the lack of long-term national policies and strategies on agricultural mechanization in many countries. This has resulted in a discontinuous mechanization climate, dependent on the whims and fashions that have reigned the donor organisations and local governments over the past decades. Generally, research institutions, extension systems and government bodies should be strengthened and include mechanization issues in their mandate. Currently, several West African governments have elaborated mechanization strategies in collaboration with FAO, but in many cases implementation of the document is lacking. Even in cases where governments have explicitly shifted from motorization towards the promotion of animal traction in light of the adverse environmental effects, one may find that offers by donors for large scale motorization inputs will not be declined.

Information exchange

There is a lack of exchange of information on mechanization in relation to soil conservation issues both between and within countries. Networks that were in existence before (Kaul, 1991) are hardly functioning now, due to financial constraints, lack of commitment, changing fashions in the international donor systems, etc. The same goes for attempts to improve communication through newsletters, directories, etc. There is a need to put in place a platform that co-ordinates all activities in the domain of mechanization issues in West Africa. It should also serve as an information exchange. All stake holders that have a role to play in mechanization as well as in soil and water

conservation should be represented in this platform; governments, commercial sector, national and international research institutions, NGO's and donor institutions.

Gender issues

Gender issues were not dealt with in the questionnaire but certainly should be considered. The most important issue is that women hardly ever have access to mechanized inputs on the farm. Even in cases where mechanization increases their workload considerably they have no say in how mechanical inputs are managed and used. If, for instance, a farmer increases his acreage when using a tractor for land preparation but not for weeding, the workload for weeding, which is a women's task in most communities, will increase tremendously. Some other tasks traditionally done by women may be taken over by men when these tasks are mechanized. This could mean an alleviation of the workload but also a loss of income. In general, mechanization has an effect on the roles and task patterns of men and women on the farm. Gender issues therefore have to be taken into account when discussing mechanization issues, and formulating new policies.