SUSTAINABLE AGRICULTURAL INTENSIFICATION IN NORTHERN GHANA

Case for Conservation Farming

made MARKET DEVELOPMENT PROGRAMME FOR NORTHERN GHANA

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The Market Development Programme for Northern Ghana (MADE) is a six-year
UK aid-funded programme promoting growth and poverty reduction in the
60 districts covered by the Northern Savannah Ecological Zone (NSEZ).

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ACRONYMS

ADP	Animal Draft Power
BDA	Business Development Advisor
BDS	Business Development Services
CA	Conservation Agriculture
CF	Conservation Farming
CFU	Zambian Conservation Farming Unit
CSA	Climate-Smart Agriculture
CSAZ	DFID-supported, CFU-managed Climate Smart Agriculture Programme (Zambia)
DFID	UK AID Department for International Development
FC	Farmer Coordinator – CFU-supported Lead Farmer under CSAZ
FEA	Farm Enterprise Advisor
FGD	Focus Group Discussions
GAC	Global Affairs Canada
GAP	Good Agricultural Practices
GoG	Government of Ghana
GRBL	Great River Business Ltd
ICP	In Country Partner (CFU Kenyan and Ugandan Franchise Partners)
KII	Key Informant Interview
M4P	Making Markets Work for the Poor Approach
MADE	DFID-supported, NA-manged Market Development for Northern Ghana Programme
MAG	Modernising Agriculture in Ghana
MOFA	Ministry of Food and Agriculture
MT	Minimum Tillage
NA	Nathan Associates
NBSSI	National Board for Small Scale Industries
NCBA	US-Based National Cooperative Business Association
NDA	Northern Development Authority
NGO	Non-Governmental Organisation
NORAD	Norwegian Development Agency
NSEZ	Northern Savannah Ecological Zone
M&E	Monitoring & Evaluation
PAFID	Participatory Approaches for Integrated Development (CFU Kenyan Partner)
PROFIT	Production Finance and Technology (USAID-funded, Zambia 2004-2008
RCSA	NORAD Regional Climate Smart Agriculture Programme (CFU)
RM	Results Management
SADA	Savannah Accelerated Development Authority
SARI	Savannah Agricultural Research Institute
SHF	Smallholder Farmer
SNV	Stichting Nederlandse Vrijwillingers (Netherlands Development Organisation)
SSP	Spray Service Provider
TECAS	GIZ-supported Training and Extension for Conservation Agriculture in the Savannah
TSP	Mechanised or Animal Draft Tillage Service Provider

SECTION 1 CONTEXT AND INTRODUCTION

The issue

Funded by the UK Department for International Development (DFID), the MADE programme supports DFID Ghana's objective of promoting growth and reducing poverty in the 63 districts of Ghana's Northern Savannah Ecological Zone (NSEZ). More specifically, the MADE programme is designed to improve the incomes and resilience of poor smallholder farmers (SHFs) and small-scale rural entrepreneurs (SSEs) in the NSEZ by improving the way that markets work.

MADE has achieved considerable success not only in raising the capacity, turnover and competitiveness of agribusinesses, but also in encouraging commercial partnerships and driving the intensification of agricultural production in the region. Improved access to vital inputs and services has resulted in higher yields (40–100%) and encouraged smallholders to cultivate more land. Over the six years of the programme, average out-grower farm size has doubled, and as a result, the quantity of marketable produce has climbed steadily. Investment by the private sector has also risen sharply year-on-year. The basic market elements needed for the commercialisation of agricultural production are slowly falling into place, and the gender, FEA and commercial partnership assessment studies[1] undertaken to validate the programme's business case all show an increase in interest, capacity and confidence across the of interest, capacity and growing confidence across the sector.

MADE uses a market systems approach to achieve positive changes in the annual real incomes of smallholder farmers. It does this by facilitating partner agribusinesses to develop, adopt and use business models that centre on providing farmers with bundles of improved input products and support services. This is known as the "Advanced Model". These bundles include the services of farm enterprise advisors (FEAs), who are employed by the agribusinesses and who work directly with smallholder farmers to promote good agronomic practices and the growing of crops that can be sold for attractive returns.

This progress has been achieved in a region of the country where agricultural production has been historically disadvantaged due to the harsh climate and the limitations of a single, annual rain-fed growing season. Under the spectre of climate change, further intensification of agricultural production might place too great a strain on the already degraded natural resources, undermining what has been achieved and preventing further progress. The introduction into the advanced model (see box) of practices to mitigate some of the worst effects of climate change while at the same time protecting the environment and promoting further improvements in yields and productivity is ultimately what the MADE programme must seek to achieve.

The potential solution

One of the key issues for smallholder farmers in Ghana's Northern Region is effective land management. Traditionally, farmers replenished lost soil fertility by practicing shifting cultivation and land rotation. However, faced with increasing demand for agricultural products and constrained by lack of resources, farmers shortened or abandoned long fallow periods in favour of continuous cropping on the same piece of land. Addressing resource constraints and allowing farmers to bring more of their land into production has relieved some of these pressures, but cultivation practices associated with intensification inevitably lead to over-extraction of soil nutrients and deterioration of the resource base of the soil.[2] The next step in the commercialisation process is therefore to ensure that agricultural intensification is sustainable. **Conservation farming (CF)** – also known as conservation agriculture (CA) – is one of the main approaches to sustainable agricultural production being promoted across Africa to support smallholder development, ensure food security and build farmer resilience to climate change.

Conservation farming consists of regional and crop-specific farming, and land management practices that protect the soil from erosion and degradation, improve its quality and biodiversity and **optimise yields**. It facilitates good agronomy such as timely planting and improves overall land husbandry for rain-fed and irrigated production, by promoting maintenance of permanent

[1] Material available on the MADE website

[2] Conservation Agriculture in Northern Ghana – Greater Rural Opportunities for Women – Learning Series. The GROW project MEDA/Gov of Canada

soil cover, minimum soil disturbance and crop rotation. Complemented by other good agricultural practices already being employed under the advanced model, conservation farming is widely regarded as vital to supporting a strong agricultural base in Northern Ghana. It is also consistent with Ghana's National Climate Change Policy (NCCP) to ensure a climate-resilient and climate-compatible economy that addresses a low-carbon growth path for Ghana while achieving sustainable development.[3]

The three main objectives in making agriculture **climate-smart**[4] are: sustainable increases in agricultural productivity and incomes; the adaption and building of resilience to climate change; and the reduction of greenhouse gas emissions.

The conservation farming system advocated for use in Northern Ghana involves three key principles – disturb the soil as little as possible, keep the soil covered as much as possible and mix and rotate crops (see box). To gain the full benefit of conservation agriculture, all three have to be applied simultaneously.

Conservation farming was introduced into Ghana's Northern Region with strategies for its adoption built around a programme of hands-on farmer training, using demonstration plots to raise **understanding** and build **confidence**.

Similar training elements have been employed across large areas of southern and eastern Africa over the last 20 years, in almost all cases driven by government policy and development agency support. Considering the proven advantages of this approach and the scale of its promotion, the level of uptake in Ghana has been disappointing.[5] A study in 2012 showed that short-term economic constraints, limited availability of inputs and services, and the absence of suitable tillage equipment were more limiting to its adoption than farmer knowledge.[6]

The pathway by which innovation is delivered is often more important than the technology itself. The MADE programme offers an alternative, market- rather than technology-driven strategy for the adoption of conservation farming. By introducing it alongside other key elements of the advanced model that ensure smallholder farmers have access to essential input elements, mechanisation services and advisory services, the aim is to ensure agribusiness buy-in and investment in its introduction and uptake.

The assignment

To capture the extent to which conservation farming is being promoted and adopted in Northern Ghana, and to review and quantify its potential impact, MADE invited two senior managers from the Zambian Conservation Farming Unit (CFU) to carry out a series of field interviews with farmers, agribusinesses and government extension workers to verify the extent of CF uptake. A summary of key findings of these interviews are discussed in Section 2. The key advantages of conservation farming are described in Sections 3 and 4. Section 5 includes a review of the challenges and opportunities for conservation farming in Northern Ghana.

It is anticipated that the findings and recommendations from this study will aid future conservation farming efforts and interventions by donor-funded programmes with similar scope and will contribute to the development of a business case that will incentivise agribusinesses and farmers to adopt conservation farming practices.

Minimum soil disturbance
Instead of overall ploughing, a farmer instead disturbs the soil only where he needs to place the seeds and inputs. Minimum Tillage is the essential difference between conservation farming and conventional farming. By disturbing the soil less, the soil profile and health is protected for longer.

Maintenance of permanent soil cover
Conservation Farming advocates for leaving crop residues in situ after harvest and not burning or removing them. This plant matter adds to the organic carbon content of the soil, limits top-soil erosion and helps reduce water loss through evaporation.

Crop rotation
Rotating crops prevents pest and disease cycle build-up and when legumes are incorporated (as prioritised), helps fix valuable nitrogen in the soil for the next crop. Farmers who rotate and do not depend solely on crops such as maize manage to spread their risk and withstand market and environmental shocks better.

[3] Ghana's Climate Change Policy, Ministry of Environment, Science, Technology and Innovation, 2013
[4] FAO Climate Smart Agriculture Definition
[5] It is estimated that there are currently 2,983,835 CF minimum tillage adopters in Zambia, with an additional 1,220,175 adopters in Kenya, Tanzania, and Uganda since 2011, through CFU-supported in-country partners.
[6] GROW Ahead Ghana, Crowdfunding for Climate Resilience

SECTION 2 OBSERVATIONS AND FINDINGS

General observations

The market systems approach and models developed by MADE over the course of the programme have increased farmer access to input supplies, services and markets, and have boosted farm yields. The good agricultural practices (GAP) now employed by farmers under the guidance of Farm Enterprise Advisors (FEAs) have proved positive in increasing climate- and market-related resilience.

The uptake of conservation farming minimum tillage practices is being promoted, but to date has not been widely adopted. If established as an additional good agricultural practice and a component of the MADE models, conservation farming would help smallholder farmers build greater resilience to climate change, while further raising yields and profitability.

Few stakeholders interviewed, including front-line Ministry of Agriculture (MOFA) extension officers and FEAs, understand the negative effects of traditional ploughing and ridging on soil health and structure. Many of those interviewed did not appreciate the many environmental and commercial benefits that could be realised from the correct application of conservation farming minimal tillage practices.

Key findings

Market alignment mitigates vulnerability but does not build longer-term climate resilience

The FEA, commercial partnership and gender assessments undertaken to validate the business case for the market systems approach show that MADE has had a positive impact on the livelihoods of smallholder farmers who receive yield-enhancing inputs and services from agribusinesses supported by the programme. Improved market access and service supply linkages have enabled farmers to learn about and access products that can mitigate their vulnerability to short-term climate-related shocks, but not to build resilience against longer-term climate change.

Yields have improved but remain low

Although MADE interventions have significantly increased yields – in some cases by 100% – and in a relatively short period of time, field interviews with farmers, MOFA extension staff and agribusiness owners revealed that crop yields still remain low. In fact, the crop stands observed during the assignment appeared to show even lower yields than those claimed by farmers and agribusinesses in previous seasons. This might be the result of the unreliable rains during the early season, or possibly an over-estimation of yields resulting from a misunderstanding of field areas. It might equally reflect the loss of soil fertility due to land over-exploitation. Overall, the yields observed suggest that farming households are not fully insulated against climate change, erratic rainfall patterns or the occasional climatic events such as floods or prolonged dry spells that are occurring with increasing regularity in Northern Ghana. Low farm yields also negatively expose the agribusinesses, as they require high crop volumes to help fuel and expand their operations.

Remote, isolated communities continue to be disadvantaged

Isolated and remote communities unable to secure access to advisory services or credit report average yields of maize of one to three bags per acre. Average maize yields of MADE-beneficiary smallholder farmers have been estimated at between 7 and 11 bags. Some agribusiness owners confirmed this range, while others suggested the potential to realise 15–20 bags. Improved seed varieties, such as PANNAR 12, for example, which is popular in the

1–3 BAGS PER ACRE
Reported maize crop yield for SHFs in Northern Ghana not benefiting from Advanced Model

7–11 BAGS PER ACRE
Validated maize crop yield for SHFs benefiting from MADE

18–20 BAGS PER ACRE
Potential yield for MADE SHFs' beneficiaries adopting Conservation Farming

Upper West, have a potential yield of 20 bags per acre. Of the farmers visited during the assignment, only two were considered to have the potential to realise this figure.

One of them had adopted conservation farming mechanised minimum tillage (see snapshot 2) and was working with a MADE-supported agribusiness whose owner was promoting adoption of minimum tillage.

GAPs need upgrading to take into account climate change

The market systems approach and models developed by MADE over the course of the programme have increased on-farm resilience. Good Agricultural Practices, or GAPs, are an important step in increasing climate- and market-related resilience. However, the benefits of GAPs would increase further if they were transposed onto a conservation farming model,[7] rather than alongside the traditional land preparation practice of mechanised ploughing and ridging that is predominant across Northern Ghana.

Scientists and extension workers continue to promote the three principal good agronomic practices (GAPs) for improved production of cereal crops in Northern Ghana: use of certified seed varieties; planting in rows; and improved use of agrochemicals. To these can be added the use of crop rotations and inter-cropping. Despite the work of MADE to drive the adoption of these practices, and 30 years of agricultural-led development projects, the northern regions of Ghana have failed to significantly address the problem of low yields.[8] As already noted, there is still much room for improvement.

The commercial platforms established by MADE need to fully address conservation issues

At present they do not, although they do offer a foundation for their adoption. In year six of the programme, MADE entered into collaborative partnerships with 15 agribusinesses, three irrigation equipment suppliers and two mechanisation equipment manufacturers to set up demonstration plots and model farms to promote wider uptake of advanced climate smart practices. The yield changes resulting from these trials have still to be validated, but visual evidence suggests a significant improvement in crop performance, particularly on the CF/Inter-cropping test plots. Improved yields are being achieved despite a reduction in the volume and cost of agrochemicals applied.

Farm enterprise advisors are well placed to manage adoption of conservation farming

The main role of the FEAs is to ensure valuable inputs and services are optimally used. However, interviews conducted with these private sector agents highlighted huge differences in their knowledge and understanding of the wider science behind conservation farming. Although training in climate-smart practices has been provided through the Damongo College farm business management courses supported by MADE, the training modules are light in conservation farming content. GAP teaching at the Ministry of Agriculture training colleges still appears to promote the use of traditional land preparation practices. This is despite the Government of Ghana's commitment to a climate-resilient and climate-compatible economy, through its National Climate Change Policy (NCCP). The study team could find no evidence to suggest that the changes to the extension course syllabus currently under consideration, will move away from this traditional approach.

Conservation farming can bring about labour and cost savings

The crucial role of women in agriculture is well known and MADE has realised significant progress in improving the yields and livelihood options for women in Northern Ghana. In addition to food insecurity and inadequate nutrition, the labour inputs associated with conventional forms of land preparation and weeding are highly significant factors in relation to gender. The labour and cost savings associated with the correct application of conservation farming practices can provide more time for women to explore and engage in other income-earning opportunities.

Conservation farming is not well understood

Few stakeholders interviewed, including front-line MOFA extension officers, demonstrated an understanding of the negative effects that traditional ploughing and ridging technologies have on soil health and structure. Many of those interviewed did not appreciate the many environmental and commercial benefits that could be realised from the correct application of conservation farming practices. There were some exceptions. The USAID-funded ADVANCE programme and the GIZ-supported TECAS programme are both actively promoting conservation farming through their farmer networks and report significant improvements in crop yields.

[7] The CFU has worked with SHFs and partners in Kenya, Malawi, Mozambique, Senegal, Tanzania, Uganda and Zambia for twenty-three years. Our experience shows that farmers who convert from ploughing, harrowing, overall digging and/or hoe ridge-splitting (the tillage practices employed by the vast majority of Ghanaian smallholders) to minimum tillage are far better able to mitigate the negative effects of climate change and/or single-season, weather-related shocks.

[8] IFAD 2012, Morris et al. 1999

Table 1: Summary of key findings by stakeholder grouping

STAKEHOLDERS	KEY FINDINGS
MADE	Ready-made commercial platforms and business models are in place to continue creating important market and input supply links, as well as potentially to introduce the adoption of CF minimum tillage practices for future interventions.
	The introduction of GAPs has substantially increased yields, but there has been only limited promotion with partner firms of CF minimum tillage (apart from on demonstration plots). The MADE team has substantial practical knowledge and experience of modern agricultural practices but only limited experience of how properly designed CF can mitigate the effects of future adverse climate events. The negative impact of ploughing and ridging on soils and yields in very dry or wet seasons has not been appreciated or fully highlighted.
	The mechanisation training being offered to tractor operators at Damongo College as part of the MADE FEA training programme is demonstrating the use and value of rippers which are required for the adoption of CF. These courses are exposing the shortage of skilled operators and the lack of mechanisation equipment that would be needed to accompany the uptake of CF.
Agribusiness owners and staff	Agribusinesses have benefited from increased sales of products and services through adoption of the MADE business models and approaches. Improved access to input supplies and services has led to increased SHF yields, but there is still scope for significant further improvements.
	In most cases, herbicide training has been effective, and the use of herbicides has increased. Some agribusinesses and FEAs have limited technical knowledge of the chemicals they market. There is a limited understanding of the impact of early mechanised ploughing on medium- to long-term soil health and fertility or the commercial benefits resulting from the adoption of conservation farming.
Farmers	Yields remain below what could be achieved with correct tillage practices. Average maize yields are typically 7–11 bags per acre for conventional tillage (ploughing), as against 18-24 bags for adopters of CF minimum tillage. Farmers are not aware of the impact of soil disturbance on longer-term farm fertility and productivity.
	Farmer yields have increased under MADE, thanks to more reliable access to improved seed varieties, agrochemicals, fertiliser and mechanised tillage services, and to certain GAP practices. However, yields could be higher.
Public, private, and not-for-profit partners	The USAID-funded ADVANCE programme has introduced up to 1,000 farmers to the benefits of CF hoe and mechanised minimum tillage practices, but overall CF minimum tillage uptake is very limited in Northern Ghana. Others introducing farmers to CF minimum tillage are the GIZ-supported TECAS programme and the Vibrant Village Foundation, an NGO based in Wa.
	There is a lack of understanding of CF minimum tillage compared to other tillage practices and GAPs related to cropping, fertiliser and seeding regimens, which are common knowledge.

Snapshots

Evidence of GAPs outside the MADE programme was very limited. Field observations of maize and soya plots belonging to non-MADE farmers indicated that most would realise far lower yields than farmers working with MADE-supported agribusinesses. From visual assessments, five to eight bags of maize less per acre would be a safe average. It was also obvious during on-farm visits that there has been positive impact arising from getting these basic practices right.

SNAPSHOT 1: ALOKODONGO CO LTD

SUPPORT FIRM | UPPER EAST

Mr George Alokodongo, owner of Alokodongo Company Limited, was Ghana's farmer of the year in 1996. He is an experienced producer with a genuine concern for his fellow farmers. For the past eight seasons he has been engaging 550 farmers in an out-grower scheme. They produce foundation seed for one of the bigger seed suppliers, Simple Price, another MADE-supported firm. Unlike most out-grower businesses, Alokodongo growers have been trained to place their NPK fertiliser adjacent to the targeted crop and buried. A much better use of what is a grower's most costly input. The farmers interviewed stated that the training they received from Alokodongo's FEAs, namely more accurate spacing, improved fertiliser placement and the use of herbicides to control weeds, has increased their yields – in some cases doubling what they used to realise prior to joining the firm's out-grower scheme. Mr Alokodongo's farmers, such as Mrs Alice Abugum (see below), have increased their yields from 5–6 bags of maize per acre prior to joining Mr Alokodongo's out-grower scheme to 11–12 bags. Last season, when the rains were better, his growers informed us that they realised around 13–15 bags per acre. However, with less rainfall this season and a much more uneven distribution of that rain, some of his growers will struggle to reach six bags.

Alice Abugum, maize farmer

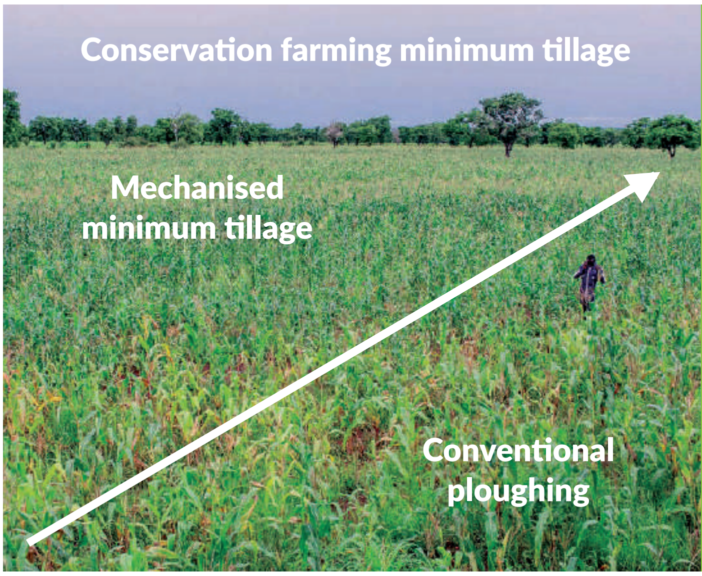
The benefits of GAP

With access to input and crop marketing services from a MADE-supported agribusiness, Alice Abugum has increased her yields from 5–6 bags of maize prior to 11–12 bags. A more efficient tillage practice that increases water capture and retention and that also enables her to optimise the accuracy of her input and seeding applications would increase her yields up to 20 bags in a single season.

SNAPSHOT 2: BATBAK SERVICES

LEAD FIRM | UPPER EAST

Mr Abrahim Alabani is a 55-year-old farmer from the Sung area of Karaga District in Northern Region. Mr Alabani, who is working with the MADE partner agribusiness BatBak Services, has a 30-acre farm subdivided into two holdings of 17 acres and 13 acres. When the partner firm asked for a volunteer to set up a climate-smart demo plot, Mr Alabani quickly offered up 17 acres of his farm for the pilot. The MADE-supported BatBak Services provided him with a loan for the inputs and provided technical support. Asked why he took such as risk, putting 17 acres out of the 30 acres to a new technology that he had never practiced before, he said, *"Farming in this area of the country is a matter of faith. I just trusted that these people knew something that I did not, and at any rate, the 17-acre land was already tired and giving me only 5 bags per acre."* To his pleasant surprise that season, he harvested 423 bags of maize from those 17 acres – around 25 bags per acre. An aerial view of Mr Alabani's two adjacent fields (see below) clearly shows the different plant growth and health characteristics of the two plots. Planted after the three-week dry spell that stalled growth and stressed crops planted earlier, the minimum tillage maize shows clear benefits, with higher stands and improved appearance. The yellowing of the maize in the traditionally ploughed field is typical of fertiliser that has been leached off the surface during heavy rainfall.



The additional benefits of conservation farming: minimum tillage

The 2017 FAO Climate Change Risk Profile for Ghana stated that poor land and water management in the north is already resulting in some degradation of the resource base on which the agricultural sector is anchored.

Adopting minimum tillage practices would help reduce soil erosion, loss of soil moisture, and loss of soil productivity, all of which are commonly associated with traditional land husbandry practices found in the Northern Savannah Ecological Zone.

The value of managed extension

If extension workers are not aware of systems or practices that are conservation-smart, they will not be able to disseminate any knowledge or know-how that farmers can then use and apply on their farms to build farmer resilience to climate change. Even with this awareness, it is doubtful that extension agents would be able to encourage widespread adoption of conservation farming.

Agribusinesses prepared to invest in the future of the industry must be convinced of its commercial advantages and be willing to support their out-growers in its adoption. Typically, farmers say they plough because of the soil types found in Northern Ghana. **The physical and chemical composition of soils in Northern Ghana make it one of the last regions on the continent where farmers should be ploughing**.

Conservation farming lone rangers
There are a number of what the TECAS project agronomist referred to as 'Conservation Farming Lone Rangers.'

The USAID-funded ADVANCE project has incorporated minimum tillage training into its activities and estimates that as many as 1,000 farmers have adopted it, with significant impact on yields.

Agro-dealers such as John Deere and FOFAANA Farms stock tractor-driven rippers, and the Vibrant Village Foundation has also started to roll out minimum tillage training and demo plots.

A number of MADE-supported agribusinesses, including Yuonu Co Ltd, are working directly with minimum tillage adopters, and have reported good results.

The Directorate of Agricultural Extension Services (DAES) is directly responsible for overseeing agricultural technology diffusion through the management of an extension delivery service in the country. Ministry of Food and Agriculture (MOFA) front-line extension staff are expected to provide up-to-date and timely extension services to farmers as part of their mission to promote sustainable agriculture.

The reality on the ground is different, of course, with ministry extension officers lacking time and resources to provide up-to-date and widespread extension support. Extension agents reported that they spend the first three months of the year exclusively engaged in registering farmers for the government-run fertiliser subsidy initiative as part of the Planting for Food and Jobs programme. According to the MOFA website, the Ministry is currently engaged with 17 separate donors and programmes, and whatever staff time is left after registration is allocated to those projects and partnerships.

The 21 MOFA extension staff in Yendi, for example, are expected to provide extension services to close to 60,000 smallholder farmers. In Upper West Region, the regional extension officer informed the team that he needs at least 200 front-line extension staff to provide the kind of extension and monitoring activities he would like, to service the estimated 100,000 rural farming households in his region. The plan is to have 160 front-line officers – a vast increase from the 45 currently in post. In Techiman, the MOFA regional extension officer has eight extension officers to provide support to 26,000 farming households across the district. Two of those are vets, and do not provide crop-related extension advice.

Development programmes such as the USAID-funded ADVANCE programme and the GIZ-supported TECAS programme can introduce ideas and support change, but only to the extent that they are aligned with market interests and supported by private sector service providers. Ultimately it is the industry itself that must decide that change is required; and for longer-term sustainability, it is the industry that must invest in its adoption. Government and development programmes can and should support and promote those efforts but lack the capacity on the ground to make it happen.

FEAs working directly with farmers are the most obvious agents of change. There are far more FEAs than MOFA extension staff[9] and although heavily committed to farmer selection and registration activities, they are well placed to support farmers with land preparation during the pre-season, and to provide GAP advice during the growing season and at harvest. However, interviews with business owners and operations managers suggest that many of their FEA staff require further training to be able to provide the type and level of support to farmers that would encourage the necessary changes to traditional land preparation practices by smallholder farmers. Significant progress has been achieved in establishing a private-sector led farm advisory service that is "fit-for-purpose", but it will take time and effort to bring it up to a level to oversee the widespread adoption of conservation farming.

[9] MADE currently offers shared operational support to 357 FEAs with its 62 partner firms, with an FEA to farmer ratio of 1:260

SECTION 3
HOW CONSERVATION FARMING PRACTICES IMPROVE YIELDS AND PROFITABILITY

Minimum tillage raises the efficiency and potential of GAPs to increase on-farm yields and build climate resilience

Enhanced and ready access to fertilisers, improved drought-resistant seed varieties, agrochemicals and farm advisory services has driven up yields from smallholder farmers benefitting from the MADE programme – in some cases by as much as 100%. Yield dividends, combined with access to wider markets, increases farm income and provides a degree of on-farm insulation against both climate and commercial risks. Yet current yields are still well below what is possible under the improved agricultural practices introduced. Susceptibility to climatic shocks – as witnessed in the 2019 early season – is still high.

When introduced alongside good agricultural practices and effective farm advisory services, conservation farming can lead to further substantial improvements in yields and can offset many of the difficulties and frustrations associated with the narrow planting window.

Minimum tillage refers to the practice of land management that allows seeds to be placed at the proper depth to ensure a good seedbed, to promote rapid germination resulting in satisfactory stands and favourable growing conditions while minimising the disturbance of the soil.

This helps to improve the fertility and physical condition of the soil, facilitating higher water infiltration, less resistance to root growth, less surface water run-off, less soil compaction and less erosion compared to traditional ploughing and land preparation practices.

Table 2: Operational losses resulting from a conventional ploughing tillage operation

PLOUGHING TILLAGE BASED PRODUCTION LOSSES – ONE ACRE MAIZE CROP

Causes	Losses (%)	Expected yield	1.6 tons
Late planting – two weeks late after 1st viable rainfall	14		
Inaccurate surface fertiliser application and measurement	9		
Inaccurate seeding. Poor plant populations	9		
Sub-optimal emergence due to uneven depth of seeding in ploughed field	9		
Loss of rainwater – intermittent moisture stress	7		
Excessive weed competition	5		
Total losses (%)	**53**		
Net yield			896 KG

Capturing the "nitrogen flush"

In climates with a long dry season such as Northern Ghana, there is a 'nitrogen flush' at the start of the rains. Farmers who have cereal seeds in the ground when the first planting rains begin, realises improved yields – attributed to the nitrogen flush. If seed planting is delayed until the onset of the first planting rains, much of the nitrogen is lost by immediate leaching. A farmer can expect to lose 1.5% of his/her maize yield for every day of delay and these losses are not normally recoverable irrespective of what inputs or GAPs are subsequently employed.

While some farmers are able to secure access to mechanised ploughing service prior to the first planting rains, many are not – and these are therefore unable to establish their crop in time. The full extent of yield loss suffered as a result of missing that planting window can be up to 14%. Fewer than 30% of the farmers interviewed were able to access a ploughing service on time in 2019.

The two photographs here of farmers working with Rhino Seeds outside Yendi show the contrast in two soya crops, one planted early (bottom) and one planted late (top). Their fertiliser and seeding regimens were identical, and both growers established their crop using a mechanised ploughing service. Neither farmer used inoculant on the soya crop. Of course, farmers who planted late blamed the weather and the rain, but their tardiness had nothing to do with the weather. If they had been on time, their crop would have performed better. They were late in either organising or receiving a ploughing service, an occurrence which is common across much of Northern Ghana.

Ploughing is tougher after the post-harvest period up to the first planting rains. The ground is firm and baked and it is much more difficult to pull through the whole surface area of a field once the soils have hardened. It is time consuming and fuel consumption increases, as does the wear and tear on machines and animals. CF MT which involves turning over (ripping) only 21% of a field's surface area is viable even after the soils have hardened – thus eliminating the need to wait for the first planting rains to trigger land preparation

Soya crop planted late

Soya crop planted early

Improving the accuracy of fertiliser application

Because it is difficult for farmers to determine where the crop is going to emerge in a ploughed field, farmers tend to place the fertiliser adjacent to the crop after the crop has emerged, when the impact of the fertiliser treatment is significantly reduced. Surface placement of NPK substantially reduces its effect and wash out can also be significant. This results in some NPK fertiliser being available for adjacent weed species, compounding losses, as well as becoming a polluting agent.

Fertiliser is one of the most expensive inputs in Ghana, but for the most part farmers do not apply it accurately. None of the farmers interviewed use any sort of applicator (such as a bottle cap or a plastic water cap). Instead they estimate quantities by hand, which leads to waste, and again lowers its efficacy.

Amounts vary one place to the next and from farmer-to-farmer. They stop when they run out of fertiliser and seldom know how much they have applied per acre. One farmer interviewed did not know the size of his holdings, and thought he was applying inputs on 1.25 acres; measuring his field revealed it was actually just over three acres. A second farmer thought he was cultivating three acres, whereas the actual size was closer to 1.5 acres.

By restricting the seeding and the application of fertiliser to rip lines, more accurate seedling rates and depths can be realised in CF MT practices. The farmer who planted later (opposite, top) is experiencing poor crop emergence and will suffer low yields.

Conventional surface placement of NPK fertiliser

NPK fertiliser is widely used in agriculture

Emerging tap roots

Improved crop emergence: accurate seeding and even planting depths

Using improved and drought resistant seeds irrespective of their inherent qualities and characteristics tends to increase yields. Firms working with MADE have been instrumental in driving up the adoption and use of these improved varieties. However, farmers could achieve much more with these hybrids, or even with traditional types favoured for home consumption, if they adopted conservation farming minimum tillage.

Conservation farming minimum tillage practices enable a farmer to place the fertiliser under the soil and directly into the rip line, prior to planting, enabling the emerging tap root from the seed to quickly access the NPK fertiliser and thereby optimising the nitrogen flush. The farmer of the maize in the photograph below will see the minimal benefit from his application.

The standard planting depth in ridge holes established on ploughed fields is often uneven with some seeds planted too shallow and some too deep. This results in poor plant emergence. When seeds are planted **too shallow**, they will emerge after very light rain and wilt or die if more rains do not soon follow (this was seen in parts of Northern Ghana during the 2019 season). When they are planted **too deep**, they may fail to emerge at all. The gapping (see the photograph below) will lead to low yields.

Gapping from inaccurate planting depth

Increased water capture and infiltration on CF MT

High yielding maize from a mechanised CF-minimum tillage farm plot

The NSEZ is particularly vulnerable to the anticipated changes in climate, as it depends heavily on rain-fed agriculture. Changes in the onset of rains, increases in the frequency and intensity of heavy rainfall events, higher incidence of low rainfall years, higher-intensity rainfall events and increased frequency and intensity of mid-season dry spells are likely to seriously threaten crop yields and agricultural productivity. This will be compounded if run-off and erosion is not checked, and if the soil moisture content is lost because of lack of cover. Trials elsewhere in Africa, have shown that water infiltration and capture on fields managed using conservation farming minimum tillage is 12–32% higher than on conventionally ploughed fields. Increased water capture and retention are two of the major benefits of conversion to conservation farming minimum tillage.

The photograph above shows Mr Ibrahim Jaluu (Upper West Region) in front of his CSA CF mechanised MT plot. Despite planting this maize crop nearly one month (29 days) after the first optimum planting rains he had an excellent crop, and better than any conventional tilled crop observed and or visited during the study.

Table 3: The extent of the benefits that can be achieved by adopting CF-minimum tillage

MECHANISED PLOUGHING + GAP	
Potential yield if GAP applied	2 000 kg
Total % losses from tillage practice	44%
Final net yield	1 120 kg
Income	1 120 GHȻ
On-farm production costs	525 GHȻ
Gross income	**595 GHȻ**

CSA CF MECHANISED MIN TILLAGE + GAP	
Potential yield (conservative)	2 800 kg
Total % losses from tillage practice	14%
Final net yield	2 400 kg
Income	2 400 GHȻ
On-farm production costs	455 GHȻ
Gross income	**1 945 GHȻ**

The gross income differentials highlighted in the table above showcase the positive impact that can be achieved when a farmer converts from a mechanised ploughing service to a conservation farming mechanised minimum tillage service.

SECTION 4
HOW CONSERVATION FARMING PRACTICES HELP PROTECT THE ENVIRONMENT

When applied correctly, conservation farming minimum tillage practices can mitigate some of the worst environmental effects associated with small scale traditional ploughing and ridging practices.

Reduced soil erosion

Since tillage fractures the soil, it leads to the destruction of soil structures, accelerating surface run-off and soil erosion. When ploughing is carried out over a period of years, hardpans and compacted layers can develop, cutting off root elongation, inhibiting crop development and seriously affecting yields. It can also lead to higher erosion rates and the removal of topsoil, where most of the soil's organic matter, flora and fauna, essential to maintain a healthy and thriving eco-system, are found.

Sediment from soil erosion is a major water quality pollutant. It transports nitrogen and phosphorous nutrients from fields into waterways, leading to eutrophication. Agrochemicals can also be washed into these waterways, posing serious threats to aquatic species and water quality. Most of the fields visited in Northern Ghana showed varying degrees of top-soil erosion, acute water loss and soil drying, in some cases within 4–5 hours after heavy rain showers.

If unchecked, widespread ploughing could eventually destroy the agricultural base that underpins current and future generations of farmers in Northern Ghana – irrespective of what climate is doing or might do.

Increased crop residues

Increased yields from the adoption of conservation farming minimum tillage means more post-harvest biomass is left on the surface of the field. These crop residues serve to decrease water run-off and soil erosion during high intensity rainfalls and strong winds. Crop residues also increase water infiltration rates into the soil, further reducing surface water run-off, and prevent water loss due to evaporation while providing a conducive environment for soil organisms to break down toxic chemicals.

Ploughing tends to mix crop residues back into the soil, eliminating these benefits and yields from poorly managed fields are often so low, that there ae few, if any crop residues left after harvest, leaving the soil bare during the dry season.

Reduced greenhouse gas emissions

Rapid loss of soil carbon as CO_2 from the soil during tillage contributes to the global warming of the planet. While fossils fuels remain the main producer of CO_2, widespread adoption of conservation farming minimum tillage could offset 13–16% of global fossil fuel emissions. In contrast, conventional tillage practices act as a source rather than a sink for greenhouse gasses.

The reduction in diesel consumption for every 20,000 hectares converted from ploughing to CF MT would be around 150,000 litres with a highly significant reduction in costs and carbon emissions.

SECTION 5
CHALLENGES AND OPPORTUNITIES

Mechanised ploughing is a traditional practice in Northern Ghana

Significant progress continues to be made in establishing sound commercial input supply, bulk crop aggregation and third-party service provision platforms and networks where previously none existed. These changes, and the adoption of digital technology allowing the greater diffusion of new ideas, are helping to address the traditional mind-set that 'what has been, must be right'. Traditional practices in Northern Ghana are being overturned, and industry is leading the change by adopting and adapting models that are shown to result in growth, improved profitability and competitiveness. The appetite and willingness to introduce conservation farming minimum tillage as a practice of choice will only happen once industry is convinced of its value and is shown the high return that can be achieved through investment.

Agribusinesses are actively promoting conservation farming minimum tillage through their farmer networks. MADE has entered into collaborative partnerships with equipment suppliers and partner firms to promote innovative technologies using demonstration plots and model farms that can be applied to increase wider adoption of advanced conservation farming practices. MADE is also delivering mechanisation training to agribusiness machine operatives at Damongo College, including the use and maintenance of rippers used for minimum tillage. Much has been achieved but much more needs to be done to drive the message home.

Abrahim Alabani (seated) and pictured with the MADE supported BatBak Ltd CEO, Mr Samuel Bakawere, a skilled CF MT adopter. Mr Alabani is also a CF MT adopter and has seen his yields jump up from 5 maize bags per acre to 25 under CF MT

Shortage of skilled tillage service providers

The quality of land preparation in the NSEZ is generally poor, with tractor operators completing a ploughing operation as quickly as possible to be able to move on to the next client. For the farmer, poor and unreliable mechanisation services compound the already negative water capture and retention issues associated with ploughing.

A database of operators trained at Damongo College could act as a starting point for rolling out conservation farming mechanised minimum tillage. A ripping service platform could also be used to bundle other mechanised services such as shelling, haulage, spray and planting services – increasing farmer access to these services as well as increasing product and equipment sales for agribusinesses, and income streams and revenues for tillage services providers (TSPs). There is a strong business case for a TSP to convert from providing mechanised ploughing and harrowing services to offering conservation farming mechanised minimum tillage.

Technical, maintenance and overall business skills and acumen would have to improve across the tillage service provider (TSP) sector since they are an important cog in the delivery of essential services to the farmers contracted with MADE supported agribusinesses.

Table 4: One acre tillage operation differentials

MECHANISED PLOUGHING/HARROWING	CSA CF MECHANISED MT
Soil disturbance – 100%	Soil disturbance – 21%
Ploughing depth – 8–12 cm	Ripping depth – 20–30 cm
Time to plough – 90 minutes	Time to rip – 30 minutes
Fuel consumption – 5–7 liters	Fuel consumption – 2–4 liters
Ploughing window for TSP – 1–3 months	Ripping window for TSP – 5–7 months
Costs to farmer – 140 GH₵	Cost to farmer – 70 GH₵
Farmer yields 7–11 bags of maize	**Farmer yields 20–30 bags of maize**

ANNEX 1
CLIMATE CHANGE IMPACT ON GHANA'S AGRICULTURAL INDUSTRY

Ghana has a tropical climate aligned with the country's varied topography. Annual rainfall ranges from 1,100 mm in the north to about 2,100 mm in the southwest. The Northern Savannah Ecological Zone (NSEZ) has one rainy season that extends from May to September, while the south has two rainy seasons, from April to July and from September to November. The dry season (December to March) brings the arid and dusty Harmattan wind that blows from the Sahara, and is characterised by low humidity, hot days and cool nights. Average annual temperatures are around 26°C, with higher temperatures in the north and during the dry season. The area between the forest in the southwest and the savanna in the north is vital for domestic food production, due to having more reliable rains and an extended growing season.[10]

Farming methods and systems specifically introduced to prevent losses of arable acreage while regenerating degraded lands are referred to as conservation farming (CF). Conservation farming endorses the maintenance of a permanent soil cover, minimum soil disturbance and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency, leading to an improvement in sustainable crop production.[11]

Current poor land-use practices in the north of the country, ranging from unsustainable soil and water management, compromised biodiversity and unsuitable choice of crops, are already resulting in some degradation of the resource base upon which the sector is anchored. Future climate change threatens major disruption to rainfall patterns,[12] leading to accelerated food insecurity.

The NSEZ is particularly vulnerable to these shifts in climate as it depends heavily on rain-fed agriculture. Shifts in the onset of rains, increases in the frequency and intensity of heavy rainfall events, higher incidence of low rainfall years, higher-intensity rainfall events and increased frequency and intensity of mid-season dry spells are likely to seriously threaten crop yields and agricultural productivity. Climate variability also threatens natural processes that sustain fodder for livestock and moisture for crops and promote sustainable development in general. It is predicted that increased temperatures will result in more frequent occurrences of heat stress and increased infestations of pests and outbreaks of diseases, thus eroding the productivity of crops and livestock, as well as increasing expenditure on pesticides, herbicides and veterinary drugs.

Table 5: Projected climate trends

HISTORIC CLIMATE	FUTURE PREDICTED CLIMATE
Climate trends since the 1960s include: ■ Increase in average annual temperatures of approximately 1°C (an average increase of 0.21°C per decade). ■ Increase in the average number of "hot" nights per year (73), with the rate of increase most pronounced from September to November. ■ Reduction in overall rainfall levels of 2.4% per decade. ■ Increase in sea surface temperatures (precise data are not available). ■ Rise in sea level of 63 mm over the past 30 years of 1.13 mm per year.	**Projected climate changes include:** ■ Increase in average annual temperatures between 1.4 and 5.8°C by 2080, with the greatest increases in the north. ■ Increase in the frequency of hot days and nights of 18–59% by 2060. ■ Decrease in overall rainfall of 4.4% by 2040, with more erratic and intense rainfall during the wet season and lower precipitation levels during the dry season. ■ Rise in sea surface temperatures by approximately 2–4°C. ■ Sea level rise of 75–190 mm by 2100. ■ Average coastal erosion and shoreline loss of 0.38 m per year.

[10] FAO. 2016. Fishery and Aquaculture Country Profiles: The Republic of Ghana.
[11] FAO
[12] FAO Ghana Climate Change Risk, 2017

ANNEX 2
THE NEGATIVE EFFECTS OF CONTINUOUS CROPPING AND EXCESSIVE SOIL DISTURBANCE

In order to filter what aspects of GAP applied through the MADE programme could be regarded as climate-smart agriculture-conservation farming and what could not, the team applied the following sequence to what is happening on the ground with MADE and its partners: To begin with, could the following overarching questions be answered in the positive?

1. Is rainfall, one of the more important inputs required by a smallholder farmer to produce a crop, used and maintained in a more efficient manner?
2. Do the technologies enhance food security?
3. Can most farmers big and small apply them? Both men and women?
4. Do they reduce labour inputs and costs?
5. Are they more productive, enabling farmers to increase their income, even during wetter or drier seasons?
6. Are they less damaging to soils and the environment, even if moderately so?

The starting point is the tillage practices – the physical manipulation of the soils that farmers are using to establish their crops. It is the first farming operation that rainfall encounters as it descends from the sky and strikes the ground.

Experience has demonstrated that any tillage practice that involves overall or excessive soil disturbance such as ridge splitting or ploughing (either with animals or mechanised), irrespective of any subsequent interventions or inputs (such as the use of improved seed varieties, for example) cannot for good reason qualify as conservation farming, due to the inability of those practices to effectively capture and retain rainfall during dry years and/or enable rainfall to infiltrate soils during heavy rainfall seasons.

Practices involving excessive soil disturbance (overall tillage) lead to a number of land management issues, starting with excessive soil erosion that occurs as a result of the total inversion of the surface area to be used to sow crops. On-farm soil erosion from these practices also increases negative downstream environmental effects, such as increased river sedimentation.

'On the ground' tillage practices must be separated from 'above the ground' practices, the various practices such as the use of crop rotations, use of fertiliser, improved seed varieties, relay cropping, agro-forestry etc. that are interposed on and across the tillage practice. Ploughing, harrowing, overall digging and ridge-splitting are the tillage conventions that the vast majority of smallholders employ to establish their crops across the continent and have been used by farmers for the past 4,000 years.

Minimum tillage and zero-tillage are the 'non-negotiables' on which conservation farming is built, as they provide a foundation that can accommodate a wide range of GAP-related agronomic practices, planting configurations, crops and cropping systems suited to local conditions, including rotations, inter-crops, relays, and agro-forestry trees. Minimum tillage practices also capture and maintain more moisture than overall tillage practices.

To a large extent, declining productivity arises from the manner in which farmers prepare their land for growing crops. The maintenance of good soil quality is vital for the environmental and economic sustainability of annual cropping. A decline in soil quality has a marked impact on plant growth and yield, grain quality, production costs and the increased risk of soil erosion. The 2017 FAO Climate Change Risk Profile for Ghana stated that poor land and water use management in the north is already resulting in some degradation of the resource base upon which the agricultural sector is anchored.

There are a number of negative consequences that arise from the continuous and overall soil disturbance associated with conventional hoe and ploughing tillage practices that are prevalent in the areas we visited. The arrival of early showers in Northern Ghana triggers land preparation, and hoes, ploughs, harrows – all the tools we associate with 'farming' – are used to churn up thousands of tons of soil per hectare to prepare seedbeds for planting.

The medium-term consequences of unnecessary soil disturbance associated with conventional tillage practices are well known. They include, to name a few, erosion, oxidation of organic matter, collapse of structure, compaction, restricted infiltration of rainwater, acidification and ultimately land degradation when responses to fertiliser, manure and improved seed varieties (including drought resistant varieties) decline and even weeds struggle to survive.

The groundwater laterite and savannah ochrosols soils we observed in part during the assignment are generally fragile and tend to be humus-deficient due to the low organic matter content of those soils The combination of ploughing (or any form of overall soil disturbance, such as ridging) will inevitably lead to soil depletion and land degradation. When these soils are continuously disturbed by conventional tillage practices, compacted layers can also be created, leading to root stunting, which leads to excessive crop stress during dry periods.

We did not test for root stunting in any of the fields we visited, since it is a live crop and we did not want to start pulling up crop that has a food and cash value; however, our experience has demonstrated that we would have most likely found the same stunting in fields that have been under the plough. One farmer we visited was suffering from water logging across his field, despite the lower rainfall experienced this season. It is highly probable that water logging is a result of that field being ploughed every season for the past forty years.

Global warming and tillage
Intensive soil tillage accelerates organic matter mineralization and converts plant residues in carbon dioxide which is liberated into the atmosphere contributing to the greenhouse effect and to global warming. Recent research performed in the USA by USAID/ARS shows that soil carbon is lost very fast – as carbon dioxide – within minutes after the ground is intensively tilled, and the amount is directly related to the intensity of tillage. After 19 days, total losses of carbon from ploughed wheat fields were up to five times higher than for unploughed fields. While fossil fuels are the main producer of carbon dioxide, estimates are that the widespread adoption of conservation tillage could offset as much as 16% of world-wide fossil fuel emissions (CTIC, 1996).

From overall ploughing (top) to conservation farming animal draft power minimum tillage (below)

Overall soil movement: ridging with a hoe

Minimum tillage: CF allows permanent planting

Mechanized ploughing

CF mechanized minimum tillage

Excessive soil disturbance to establish crop ridges

Ridges tend to increase the negative impact of dry spells and/or heavy downpours. Heavy rainfall collects between ridge lines, whereas the crop is growing on top of the ridge. The top of the ridge where the crop roots lie tend to dry up faster. The photograph (on the right) was taken at around 13h00, following a rain shower earlier that morning that lasted roughly from 07h30 to 08h30. In just five hours, the tops of these ridges had already started to dry off. This field was relatively level, but even so, one can observe the water run-off that has occurred as the rainwater was channelled into and down the spaces between the ridges. On fields that are located on slopes, the water run-off and consequent soil erosion would have increased.

Row spacing is too wide in the field in the photograph – wasting space that could be used to establish crops on. This is a common problem with many fields where the tillage practice is based on the construction of planting ridges.

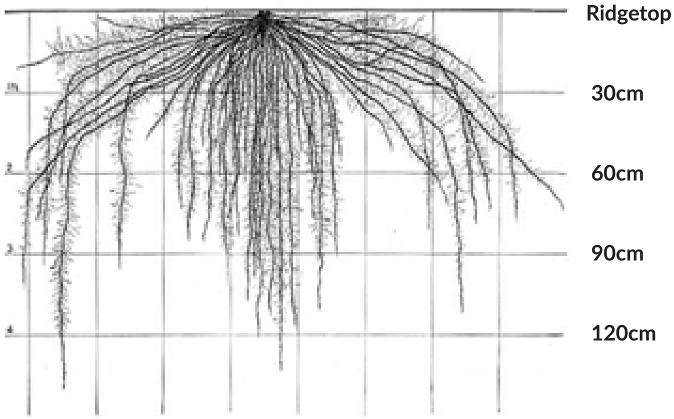
Though this was not a farmer working with a MADE-supported agribusiness, the same issues that affect this field were also evident with farmers that ridge and do work with a MADE-supported firm we interviewed. Erosion, for example on ridged fields in a farming block under the Alokodongo Ltd out-grower scheme, was extensive in places. Drying out on the tops of those ridges under the same out-grower was also prevalent, as in the field in the photograph above.

Fertiliser application on ridges is also wasteful – most of the farmers interviewed during the assignment wait for the maize to emerge, plant more seeds in any gaps, complete the first weeding then apply basal NPK. Some farmers we interviewed mix the NPK D with Urea top dressing.

The problem with this application method is that heavy rain will wash the fertiliser into the furrows so much will be wasted. Also, NPK contains phosphate, which dissolves slowly and should be applied under the soils at planting for better results.

A field that has been ridged, with clear water runoff effects and drying out on ridge tops

Maize roots



The picture above shows the natural rooting habit of maize which is shallow and spreading. Plants are very flexible when maize is grown in ridges the roots adjust. The shallower roots will cluster in the ridge and then grow downwards and sideways.

This does not matter if the rains are regular but when dry spells occur as they have done this season in Northern Ghana the maize will wilt faster than the maize grown on the flat land, because the shallow roots in the ridge provides most of the water and the ridges drive the rain into the furrows.

ANNEX 3
RAINFALL DATA

From the rainfall data we were able to acquire, it appears that mid- to late May was an optimum time to get the crop into the ground in some areas. Distribution of that rainfall was for the most part normal.

Average April showers measured from the four stations in Upper West Region was 33.72 mm across 3–4 rain days – just enough for farmers to get their land preparation completed prior to the May rains, but not sow their crop.

Though there were only four rain days recorded at the Navrongo station in Upper East Region, a total of 82mm fell on the last three days of the month – this would have still represented the first optimum planting period for that area. Even though June would have been a difficult month for crop, crop planted at the end of May would have benefited from the nitrogen flush that occurs with those first heavy rains. If the crop had been established in a CF minimum tillage practice, moisture capture and retention would have increased the effective rainfall volume by around 15–25%, ensuring the crop would have survived in decent shape until July, when the rainfall significantly increased. Farmers who did not plant their crop in late May would have not planted in June (blaming the weather at that juncture) and would have established their crop in July – completely missing the nitrogen flush that happened in May and perhaps running out of rain at the end of the season in October to fill their crop out. Of course, on ploughed fields where daily evaporation rates are substantial, as well as water run-off, this might have been the most prudent course, but it would lead to a poor yield result as well. This was observed a number of times during on-farm visit.

Table 6: 2019 rainfall data for Northern Ghana regions[13]

REGION	MONTH	RAINFALL VOLUME – mm				RAIN DAYS*			
Upper West	May	158	115	132	160	8	9	7	8
Four stations –	June	160	145	86	50	10	7	5	9
up to 24/09	July	186	205	187	219	11	10	9	14
	August	346	177	307	205	17	12	11	14
	September*	93	247	144	238	13	9	12	15
Bono East	May	141				9			
One station	June	155				8			
up to 30/09	July	120				11			
	August	115				5			
	September	142				12			
Northern	May	144	149	114		12	10	7	
Three stations –	June	105	40	121		10	8	11	
up to 28/09	July	251	179	263		11	13	15	
	August	93	47	96		10	5	9	
	September	227	242	212		19	14	15	
Upper East	May	114				4			
One station –	June	80				6			
up to 27/09	July	192				12			
	August	297				11			
	September	209				11			

[13] *Rainfall distribution is considered normal across an 8–14 rain day range

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