

Opportunities and Challenges for Local Agricultural Machinery Manufacturers

Insights from Mali

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Introduction

Agricultural mechanization refers to the use of animal or mechanical power along the value chain, comprising crops such as grain, legumes, fruits, and vegetables as well as livestock and fish. African value chains are among the least mechanized of all continents (Daum & Birner, 2020). This is problematic since low levels of mechanization are associated with limited labor productivity (Fuglie & Rada, 2013) and a high labor burden, affecting in particular also women (Daum et al, 2020). According to the Malabo Montpellier Panel, the low levels of mechanization are the “main constraints to increasing domestic food supplies in Africa” (Malabo Montpellier Panel, 2018b, p. 8). However, with the re-emergence of agriculture on Africa’s development agenda, there is now a renewed interest in agricultural mechanization by governments across Africa (Daum & Birner, 2020).

Historical research, as well as contemporary research from Asia and Latin America, has shown that the local manufacture of machinery can play a key role during agricultural mechanization (Binswanger, 1986; Diao et al, 2020). In particular, as compared to the import of machinery, private-market-led local manufacturers may be better able to design and produce local-specific technologies as well as create meaningful jobs in rural areas. However, despite these opportunities, previous research has shown that local manufacturers often face various challenges related to the production and marketing of their machinery. This includes, among others, unreliable electricity supply, a lack of standards, and testing undermining the trust in local machinery and tariff policies favoring the import of machinery from other countries (as described by Daum & Birner, 2017 for Ghana).

This report identifies factors and actors influencing the success of local manufacturers and explores the opportunities and challenges for the local agricultural machinery industry. The analysis is based on a mixed-methods approach. The approach is comprised of a quantitative survey among local manufacturers; a qualitative mapping exercise called net-maps (Schiffer & Hauck, 2010) among

local manufacturers and other stakeholders, which allows for identifying key actors and bottlenecks; and key informant interviews with stakeholders that are important for the success of local manufacturers such as representatives from farmers and industry associations, regulatory bodies, financial institutions, training institutions, among others. The report provides policy recommendations on how to make local manufacturers thrive and increase their competitiveness vis-à-vis machinery imports. The report identifies opportunities for mechanization policy and investments to increase productivity, incomes, and employment opportunities and add value to African produce. The work is part of the Program of Accompanying Research for Agricultural

Innovation (PARI), which has identified “mechanization and skill development for productivity growth, employment and value addition” as one of its top priorities. PARI is led by the Center of Development Research (ZEF) and funded by the German Federal Ministry for Economic Cooperation and Development as part of the One World, No Hunger Initiative (SEWOH). PARI’s research cluster on mechanization is led by the University of Hohenheim, the Forum for Agricultural Research in Africa (FARA), and ZEF and jointly implemented with the Institut National des Recherches Agricoles du Bénin (INRAB), Kenya Agricultural and Livestock Research Organization (KALRO), Agricultural Research Council of Nigeria (ARCN), Institut d’Economie Rurale (IER).

General information on the status of local manufacturing

Local manufacturing of agricultural equipment began around the 1980 years in Mali with the settlement of some units of agricultural equipment production in the main production zones such as the office du Niger and CMDT (Malian Company of Textile Development) through collaborative projects with the Netherlands (Sanogo et al., 2007). Since then, a network of local manufacturers has been set up to supply quality tools to farmers at lower prices, adapted to their needs, and offered them proximity to maintenance and repair services. In Mali, there are four categories of local manufacturers which are specialized workshops, blacksmith networks, tractors assembly factories, and the informal sector (not structured).

The specialized workshops are mainly those which have been set up through the

collaboration between Mali and Netherlands in the Office du Niger and CMDT zones. With the Malian cotton crisis in 2002, these workshops closed and the employees with high qualified skills, set up their own in the cotton production zone of Koutiala, while those from the Office du Niger zone specialized in tillers and threshers assemblies, through the adaptation of some prototypes based on the imported machines from Thailand, Philippine, China, etc. The blacksmith network initially began in the cotton and rice production zones to manufacture spare parts for different animal traction machines. The network brings together 31,130 agricultural equipment units spread over different agricultural production areas mainly Office du Niger, CMDT, ORS, OHVN, etc. The main network of blacksmiths is SOCAFON, which is an association of blacksmiths cooperative from the Office du Niger. It manufactures

local agricultural equipment and offers after-sales service insurance, training, and technical assistance for machine operators, welders, mechanics, etc. The tractor assembly factories are only composed by the company Mali Tracteurs SA located 25 km from Bamako. The factory assembles and produces tractors and accessories for an Indian company Mahindra brand (Kergna et al., 2020).

Among the policies that promote the local agricultural equipment manufacturing, there is the Agricultural Orientation Law (Loi d'Orientation Agricole), which promotes sustainable, modern, and competitive agriculture. There is therefore a recognition in the law in article 135, which stipulates agricultural family farmers be supplied with agricultural equipment, through the promotion of traditional and industrial units of agricultural equipment manufacturing. In addition, there is the Agricultural Sector Investment Plan (Plan National de

l'Investissement dans le Secteur Agricole), that has five programs including an investment program that constitutes one of the key factors in the agricultural sector, production systems intensification, processing, and agricultural products valuation. In this investment program, agricultural mechanization is among the priority actions with the promotion of animal traction and motorized machines including tractors, threshers, tillers and others. Among other policies, there is the national program of vocational training (Programme Nationale de la Formation Professionnelle), and the creation law of the Malian chambers of métiers and handicrafts (including tailors, shopkeeping, blacksmith, etc.) codes of Mali. Local manufacturing of agricultural equipment is regulated by the two latter laws. According to the national artisan's federation (Fédération Nationale des Artisans du Mali) in 2001, there is 663 artisan associations with 28, 609 members from different regions of Mali.

Methods

Survey

A multistage sampling technique was used to get the required sample size of local agricultural equipment manufacturers. The target population was all local manufacturers involved in agricultural equipment manufacturing. The first stage was the purpose selection of the three regions Koulikoro, Sikasso and Segou in the southern part of Mali, where many efforts have been done by the government and its partners in terms of investment in the agricultural sector. //

The choice of these three regions is also based on the importance of their contribution to national agricultural production and the number of agricultural equipment manufacturers. The second stage was the selection of three production zones in each region (whether 6 production zones) according to the diversity of the agricultural production system and the number of agricultural equipment manufacturers. In each region, there is a federation of handicrafts associations with a list of all the members including tailors, carpenters, jewelers, dressmakers, shopkeepers, etc. for which we had no access due to professional reasons, as stated by the federation's president. Lastly, a snowball sampling method was utilized in the selection of respondents based on the 4 categories of local agricultural equipment manufacturers as described above.

The study was carried out in three regions, Koulikoro, Sikasso and Segou based on their share in the country's agricultural production. Sikasso region is the cotton-growing zone which lies at latitudes 13°S, drained by the rivers Niger and Bani with its tributaries such as Baoulé, Bagoé and Banifing (Dufumier, 2005). The cotton-growing area of Sikasso is about 181 000 Km² shared out in 6,345 villages and is one of the regions with which the project of agricultural equipment development with the Netherlands partners began. In the Sikasso region, cotton is grown with cereals crops and an extensive livestock system dominated by cattle breeding. The estimated population in Sikasso is estimated at 4.5 million, with an average annual growth rate between 3.2 to 4.3 % (Camara, 2015). The climate varies from the Sudano-Sahelian type in the north to Sudano-Guinean in the south with one rainy

season recording a mean rainfall of 550 to 1200 mm/year (Soumaré et al., 2006).

The Segou region is located in the central part of Mali between the north latitude of 12°30 to 15°30 and the west longitude 4° to 7°. It covers around 62, 504 Km² and 2/3 of that area are occupied by the Sahelian zone almost 43,298 Km². Its climate is distinguished by the Sudano north, the Sahelian south, and the Sahelian north and is characterized by one rainy season with an average annual rainfall of 200 to 800 from the northern to the southern part of the region (Sourisseau et al, 2016). The region is also drained by the river Niger at 292 km and the river Bani which facilitates agricultural irrigation. Its main irrigated agricultural area is estimated at 2,750 000 hectares. The estimated population of the Segou region is about 2.3 million, according to the last demographic census in 2009. Agriculture evolution in that region is linked with public investment in the zone of Office du Niger, which permitted the increase in rice production in terms of irrigable lands and yield improvement. In 2011, the number of handicrafts, including metal processing, textiles, metallic and building construction clothing, and textiles in the Segou region was estimated to be 5,411 members (BERD, 2011).

The region of Koulikoro is located in the Midwest part of Mali and it covers 90,210 Km² and 1,924 villages. There are four types of climatic zones in the Koulikoro region. The Guinean-North, the Sudanian South, the Sudanian North, and the Sahelian South with one rainy season from May to October (BIRA, 2014; PNUD, 2015). The average annual rainfall varies from 150 to 1150 mm depending on the agro-climatic zones. According to the last general demographic census, the estimated human population is about 2.4 million with the region's economy

essentially depending on the agricultural sector which employs 90% of the active population. The handicrafts sub-sector is very important to the socio-economic development of the region through youth and women employment and increased public resources, with payment of local development taxes by selling handicrafts

products. According to the region handicrafts federation, there are 140 associations with 4,616 members including 2 034 women. The handicrafts sub-sector actors are the local public institutions, NGOs, handicrafts federation, the private sector, the professional training centers, and the projects and programs for development through other partners.

Net-Maps

The team was able to conduct two net maps due to the unavailability of stakeholders (it's the rainy season all of them are busy with farm activities). One net map was to determine which actors are involved in the manufacturing of agricultural equipment in the rice region (stakeholders were available but the area was not secure); and one net map on the relationship between manufacturers and end-users of equipment.

Stakeholders net-map

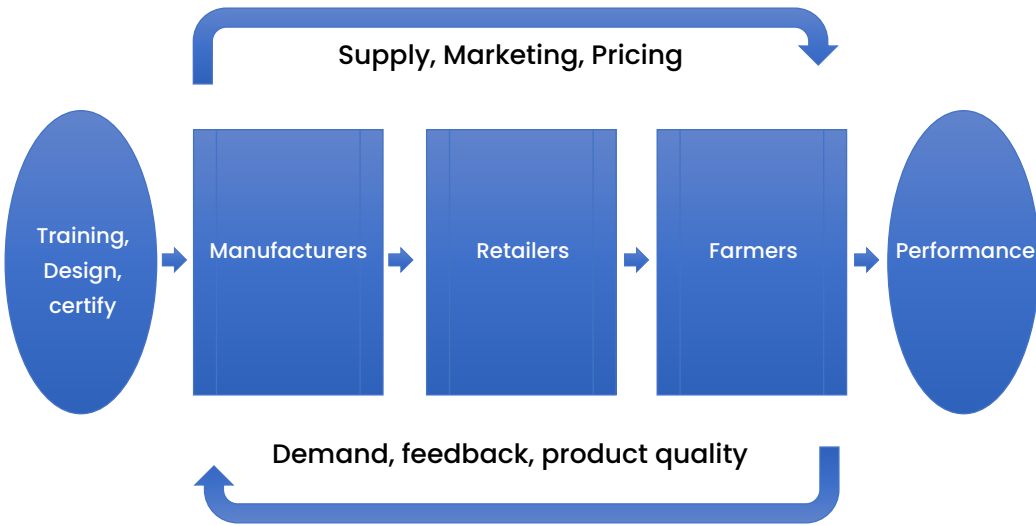
The objective is to determine how they are linked, how influential they are, and what their goals are. We brought together manufacturers who are members of the chamber of arts, carpenters, mechanics, weavers, blacksmiths, jewelers, shoemakers, extension agents, NGO workers, vocational school agents, etc. The chamber of arts aims to register, organize, build capacity, protect and coordinate member activities. First, the research team explored the understanding of stakeholders on the role of the chamber of arts. The responses were oriented on registration and capacity building and the net map was oriented to consider these aspects.

The net-map was conducted to bring together representatives from the chamber of arts, public sector agencies, private enterprises, non-governmental organizations (NGOs), and traditional authorities to form a consultative group. The chamber of arts aims to identify and coordinate all stakeholders toward an improved capacity of making preferment agricultural equipment, especially for manufacturers and establishing a relation between manufacturers and development projects operating in the region.

The research questions started with qualitative interviews of stakeholders to understand the goals that members would like to achieve. Next, the capacity-building process with the chamber of arts was described with the research results briefly discussed. By drawing the relationships between stakeholders, much focus was placed on some actors of importance (providers of raw material, energy, transport, etc.). During the interviews, some actors were not on the map but were equally important in the capacity-building process. The interpretation of the map engaged discussions about the possible involvement of a collaboration with actors on the map and others not mentioned.

Manufacturers and En-Users Relationship net-map

The farmers and manufacturers present at the meeting conducted the team to build a net map for determining their relationships regarding agricultural equipment. The objective was to collect information on how end-users feedback on equipment usage could help improve performance and sustainability. The research team was interested in how manufacturers can benefit from the feedback of farmers who use or are supposed to use their fabricated equipment to improve the performance and efficiency of the equipment. This is done sometimes through retailers that are of relevance to manufacturers. Continuous demand for the equipment and feedback on functionality and performance would help improve the design and fabrication processes. The team believes that understanding the relationship based on knowledge and information shared between manufacturers and farmers would address issues farmers face, as critical for sustainable quality improvement of agricultural equipment. The following conceptual framework provides the flow of relationships between manufacturers and farmers.



The team uses social, economic and environmental indicators to measure the difference in effects associated with equipment between manufacturers and farmers. The indicators measure the change in output (improved functionality and improved performance) of the equipment.

| Key Informants

The key informants were purposively selected according to their availability. At least four key informants were chosen including institutions involved in mechanization issues in each study zone. There were farmer's organizations, agricultural extension services, a federation of artisan associations, and the rural engineering service. In each institution, we interviewed the agent in charge of mechanization issues but for farmer's organizations and artisan's associations, the interview was done with the president.

Results from the survey

Business background of local manufacturers

Globally, most of the manufacturers' businesses (about 90%) have been created after the 1990 years due to probably the Structural Adjusted Programs (SAPs) effects with the disengagement of Office du Niger and CMDT companies from productive commercialization activities plus the networking of organized local manufacturers through some projects funded by the Netherland Cooperation, while the rest of the manufacturers' businesses (almost 10%) have been created before the 1990 years. 95% of the respondents were business owners with 77% of the interviewed manufacturers formally recorded in the regions of Segou and Sikasso having the highest number of recorded agricultural equipment manufacturers business. Also, 130 of 153 respondents belong to manufacturers' associations or organizations. Most of these businesses are members of the chambers of crafts that exist in each region in Mali and members of the craftsmen's federation in each region. However, some do not belong to any association or organization and represent almost 15% of our sample size. Generally, the manufacturers who do not belong to any association are not far from towns with most of them having no literacy.

Table 1 below presents the property types of manufacturers' businesses by region. In general, most of the manufacturers' businesses are private or domestic properties around 146 of 153 businesses. In Koulikoro region 94% of the respondent are the promoter of their business while 4% are not the promoter which should be the government and cooperative business owners. In Segou and Sikasso regions, 97 and 98 % of the manufacturers are respectively promoters of their business while 6 and 2 % of them are not.

Table 1: Number and frequency of business property types by region

	Koulikoro		Segou		Sikasso		Total	
Regions	Number	%	Number	%	Number	%	Number	%
Private sector/ domestic properties	50	94.34	49	92.45	47	100	146	95.42
Private sector/ foreign properties	-	-	1	1.89	-	-	1	0.65
Government properties	1	1.89	-	-	-	-	1	0.65
Cooperatives (members properties)	2	3.77	2	3.77	-	-	4	2.61

Companies of public-private partnership	-	-	-	-	-	-	-	-
Companies of co-properties	-	-	1	1.89	-	-	1	0.65

Source: local manufacturer surveys, 2021

Overall, Table 2 shows that manufacturers’ age varied from 25 to 76 years old according to the region with an average age of 45 years old. In giving the details by region, Segou has an average age of 43 years old which varies from 27 to 76 years old and more than 50% of the manufacturers are less than 40 years old. In Koulikoro, the manufacturers’ average age varies from 26 to 66 years old and only 21% of them have less than 40 years old but in Sikasso, the average age of the manufacturers is between 25 to 70 years old. Among the 153 respondents, 43% of them have an engineering background training as shown in table 3 below which indicates they received training in conceptualizing and developing some prototype machines through NGOs and research and development projects. This background training in engineering does not necessarily imply the local manufacturers have an engineering diploma or degree. Be that as it may, it is important to mention that some of the local manufacturers have engineering degrees.

Table 2: Average age of manufacturer respondents

Regions	Average Age
Koulikoro	46
Segou	43
Sikasso	48
Total Average Age	45

Source: local manufacturer surveys, 2021

Most of the local manufacturers who have received training in engineering in the Segou and Koulikoro regions amount to 50% and 45% respectively. Only 4% of the respondents have received training in business administration, economics, or marketing while 27% of them are involved in agriculture mainly in Sikasso and 26% of the local manufacturers recorded no background training. As shown in table 4, most of the manufacturers (almost 50%) have only reached the primary school level followed by 30% of them who have not gone to school. About 7% of the respondents said they had other levels of education which include rural literacy and Koranic School. This situation reflects the rural reality of Mali, where many of the active population have not gone so far as informal.



Table 3: Local manufacturer's Background training

	Agriculture		Business administration/ economic/ marketing		engineer		Not Applicable	
Regions	Number	%	Number	%	Number	%	Number	%
Koulikoro	13	31.0	0	0.0	30	45.5	10	25.6
Segou	9	21.4	2	33.3	33	50.0	9	23.1
Sikasso	20	47.6	4	66.7	3	4.5	20	51.3
Total	42	100.0	6	100.0	66	100.0	39	100.0

Source: local manufacturer surveys, 2021

education. Some manufacturers have professional certificates or diplomas. But among the respondents, we recorded one Ph.D. and one degree from the research center, which is also involved in agricultural equipment manufacturing, and one master's degree. Among the 153 respondents, 74% of them have cultivated agricultural land mostly in Segou and Sikasso regions. But only 28% of them have received training in business administration, management, or accounting and those are mainly in Koulikoro and Sikasso regions.

Table 4: Local Manufacturer's Education Level

	Koulikoro		Segou		Sikasso		Total	
Level of Education	Number	%	Number	%	Number	%	Number	%
Primary School	28	52.8	28	52.8	21	44.7	77	50.3
High school	2	3.8	1	1.9	0	0.0	3	2.0
University	0	0.0	1	1.9	0	0.0	1	0.7
Certificate/ diploma	3	5.7	2	3.8	0	0.0	5	3.3
Professional Training	3	5.7	2	3.8	2	4.3	7	4.6
License	1	1.9	0	0.0	0	0.0	1	0.7
Master	0	0.0	0	0.0	1	2.1	1	0.7
Ph.D.	1	1.9	0	0.0	0	0.0	1	0.7
None	11	20.8	14	26.4	21	44.7	46	30.1
Others	4	7.5	5	9.4	2	4.3	11	7.2

Source: local manufacturer surveys, 2021

Table 5 below shows that the majority of the respondents (61%) became manufacturers by heritage while a good number of them realized their dream or vision to become manufacturers. In Mali, some ethnic groups can inherit the agricultural equipment manufacturer's activities. Table 6 below presents the barriers that the manufacturers are facing in their activities. For the respondents, the main barriers were lack of machines and capital which represent 45% to 29% respectively.

Table 5: How respondents have become manufacturers

	Koulikoro		Segou		Sikasso		Total	
Becoming Manufacturers	Number	%	Number	%	Number	%	Number	%
Dream/Vision	23	43.4	20	37.7	13	27.7	56	36.6
Family/Parents	29	54.7	32	60.4	33	70.2	94	61.4
No alternative/choice	0	0.0	0	0.0	1	2.1	1	0.7
Others	1	1.9	1	1.9	0	0.0	2	1.3

Source: local manufacturer surveys, 2021

Among other barriers, we have a lack of land, conducive environment, lack of electricity, low price and selling. This lack of machines was mostly reported in the Koulikoro region than in the other two regions while lack of capital was mainly reported in Segou and Sikasso regions. This is essentially due to the nature of the activity of local agricultural equipment production itself which is not structured with many of the local manufacturers working in informal sectors.

Table 6: Barriers in the manufacturer business

	Koulikoro		Segou		Sikasso		Total	
Barriers	Number	%	Number	%	Number	%	Number	%
Lack of land	7	13.2	3	5.7	4	8.5	14	9.2
Lack of machine	32	60.4	20	37.7	17	36.2	69	45.1
Lack of capital	8	15.1	20	37.7	16	34.0	44	28.8
Lack of knowledge/qualification	1	1.9	0	0.0	0	0.0	1	0.7
Conducive environment	3	5.7	6	11.3	3	6.4	12	7.8
Others	2	3.8	4	7.5	7	14.9	13	8.5

Source: local manufacturer surveys, 2021

Design and Production

Overall, as shown in table 7, about 60% of the interviewed local manufacturers are developing their products with 113 of 153 who declared to conduct their research in designing the agricultural equipment products. There is a difference between the three study areas with lower numbers in the Sikasso region, even if many of the local manufacturers interviewed declared to personally develop their products. However, a good number (55 respondents) of them have also responded to copies from other local manufacturers or imported products. Only a few (6 respondents) of the local manufacturers are designing and considering the idea or demand of customers.

Table 7: sources of product design

	Koulikoro		Segou		Sikasso		Total	
Product design sources	Number	%	Number	%	Number	%	Number	%
Personal development	36	67.9	32	60.4	23	48.9	91	59.5
Copy from other manufacturers	15	28.3	18	34.0	22	46.8	55	35.9
Government Organisms	0	0.0	0	0.0	1	2.1	1	0.7
Ideas/demands of customers	2	3.8	3	5.7	1	2.1	6	3.9
Conducive environment	3	5.7	6	11.3	3	6.4	12	7.8
Others	2	3.8	4	7.5	7	14.9	13	8.5

Source: local manufacturer surveys, 2021

Table 8, are presented the local production of agricultural equipment per field area. It shows that most of the local manufacturer's units are specialized in crop production. About 71% of their machines produced are made for crop production purposes, with a higher % age of 78.21% in the Segou region. This crop's production machines are mainly plow and harrow in Koulikoro and Sikasso regions for maize, sorghum and millet production. In the Segou region, however, the main machine for crop production is a power tiller for rice production. The second specialized field for agricultural machines production is food processing for which, 8.33 % of the machines produced are intended. The food processing machines are mainly milling, threshing and shelling machines. Only a few machines are made for animal production or horticulture and forest. However, this does not mean that local manufacturers for animal production are not many in the three regions but compared to local manufacturers for crop production, they are inferior in terms of number. Sometimes, it is even difficult to differentiate between the local manufacturers for crops and animal production as they can do both. In addition to agricultural equipment designing, some local manufacturing units produce construction equipment. It was noted that 8.56 % of the equipment produced by the

respondents is for construction with a higher % age of 13.25 in the Koulikoro region.

Table 8: %age of machines production by specialized field per region

Field areas	Koulikoro	Segou	Sikasso	Total
	%	%	%	%
Crops production	69.53	78.21	63.51	70.69
Animal production	4.06	5.19	9.96	6.26
Horticulture	3.68	4.51	2.06	3.47
Food processing	6.04	3.45	16.43	8.33
Construction	13.25	5.09	7.19	8.56
Forest	1.91	1.28	1.17	1.46

Source: local manufacturer surveys, 2021

Table 9 below presents several different types of machines sold by the local manufacturers in each region. It is shown that the types of machines sold reflect the region's local manufacturers' realities. Like in Koulikoro and Sikasso where dry cereals are mainly grown, the main agricultural machine sold is the plow with 2,525 and 1,375 respectively in 2020. There is also the direct seeder machine, which is the second most agricultural equipment sold in these two regions while in Segou we have 230 power tillers sold which are used in irrigated rice cultivation. The machine most sold in the Segou region is the chart with 1,867 in 2020 and 1,798 in 2018.

Table 9: Number of different types of machines sold per region

Types of machines sold	Koulikoro		Segou		Sikasso	
	2020	2018	2020	2018	2020	2018
Power tiller	40	42	230	251	86	45
Plough	2,525	2,069	563	446	1,375	4,400
Ripper	124	96	221	166	81	90
Harrow	286	119	527	507	296	392
Direct seeder	1,084	1,879	169	188	684	882
Planting machine	90	230	0	0	10	30
Fertilizer dispenser	0	0	0	0	60	60
Boom sprayer	5	0	0	20	14	6
Combine harvesters	0	0	31	1	0	2
Chopping machine	15	5	50	26	25	58

Milling machine	36	29	56	99	578	727
Threshing machine	124	121	160	154	622	510
Shelling machine	71	64	130	127	659	679
Storage facility	0	0	14	40	46	13
Chart/trailer	740	947	1,867	1,798	343	423
Pump for irrigation	15	53	362	332	171	68
Generator	3	0	97	53	20	30
Packing machine	0	0	3	0	0	0

Source: local manufacturer surveys, 2021

Although we do have some agro-climatic zones in the Segou region where the agricultural production system is based on dry cereals such as sorghum and millet, Among other machines sold are milling, threshing, and shelling machines. These machines are more important in the Sikasso region as it is the first production zone of dry cereals in Mali and particularly maize which is threshed, shelled and ground for human food and poultry farming. As declared by the respondents (almost 54%), most of the machines produced are based on customers’ demand but there are also some (22%) that are produced regularly. The rest of the respondents (about 48) indicated that the machines are produced on customers’ demand.

Furthermore, we have some local manufacturers who produce and sell machines that consume renewable energies such as solar panels. Among the 153 samples, only 14 of them have declared to sell machines that consume solar panels as a source of energy. The machines functioning with solar panels as a source of power mainly pump for irrigation and water towers. The manufacturers do not have the required knowledge and skills to produce machines that use renewable energy due to a lack of knowledge and skills; 100 out of the 153 respondents indicated that they do not have qualified skills to produce machines that used renewable energy.

Figure 1 shows the trends in the number of certified machines sold in each region, the percentage of local manufacturers who do not certify their machines is the most important with more than half of the respondents in Sikasso and Koulikoro showing 68% and 62. 3% respectively. In Segou, the number is relatively lower compared to Sikasso and Koulikoro. Globally, 54% of the respondents have declared their machines are not officially tested but 79% of the respondents have declared their adhesion to respecting the certification norms.

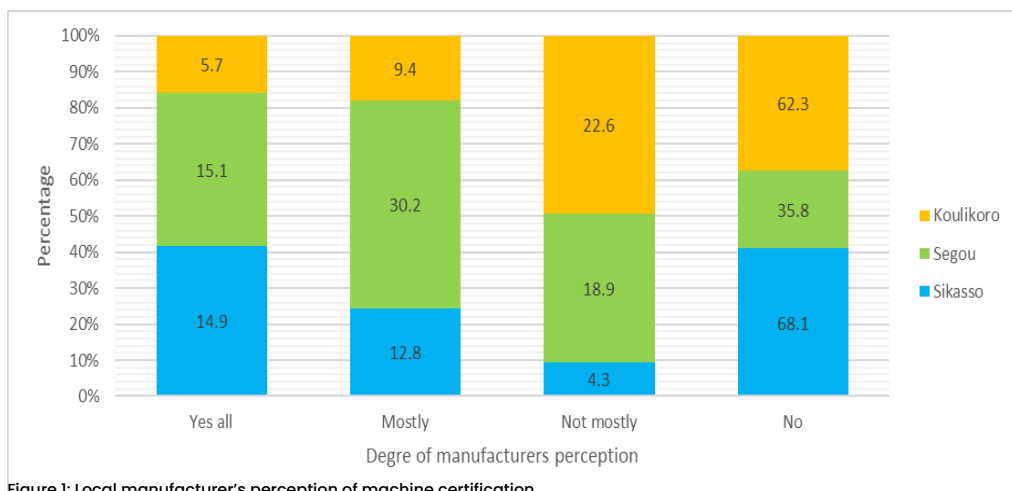


Figure 1: Local manufacturer's perception of machine certification

Source: local manufacturer surveys, 2021.

Nevertheless, nearly 40% of the respondents have said that they grant warranties to their products and 70% of them have declared to provide after-sales services while 30% of them do not. Also, many of the local manufacturers (about 46%) do not record their products sold. The rest are always (24%), mostly (10) and (20%) recording their sales.

Marketing and customers

The local agricultural equipment manufacturing business is not well structured and many of the business owners are still working in the informal sector. As most of their product advertising mode is done through the me-to-me channel about 62% of the respondents have said to promote their product in that way of communication. Besides the me-to-me channel, they use the local radio (about 15% of the respondents) and participate in some machinery exhibitions (only 9% of them) to promote their products. However, some local manufacturers use social media and agro-machine dealer's networks and represent 2% and 7 % of the respondents. None of them are using TV or newspapers channel in promoting their products but we found only one local manufacturing business in the Segou region which uses the competitive price.

Most of the customers for local manufacturers are farmers who live in rural areas. As shown in figure 2, the main customers in the three regions are farmers with 78 to 84% of customers being producers. The higher %age is in Segou and Koulikoro regions with 84% and 83 % of the small-scale farmers purchasing the local manufacturers' products and over 60% of them live in the villages.

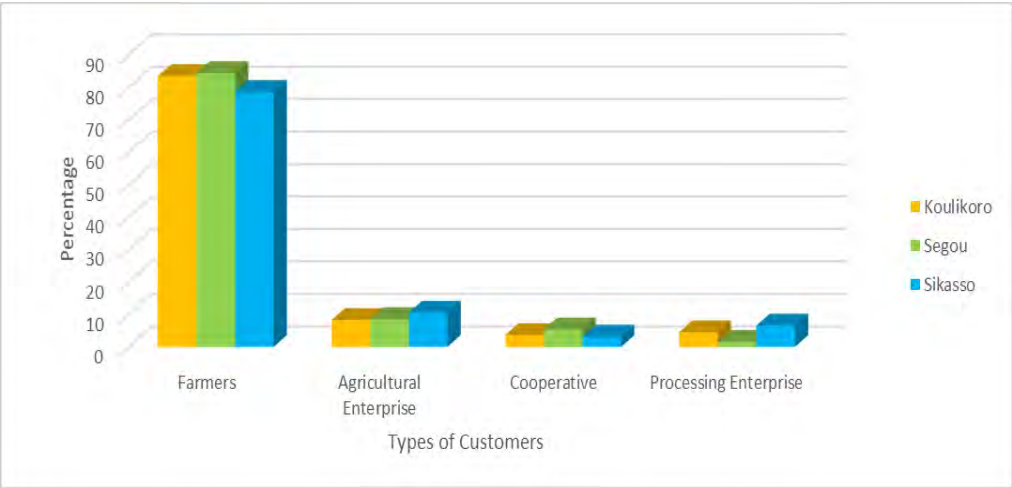


Figure 2: Types of Customers for local manufacturer products
Source: local manufacturer surveys, 2021

Almost, all the respondents use the cash payment method and only one business owner interviewed in the Sikasso region reported payment by nature of cereal like maize. This method of payment is very used in rural areas of Mali mostly for threshing and shelling operations. Before starting the agricultural equipment production, 99% of them the respondents declared to receive advances from their customers. At the same time, about 86% of them sell their product at credit to regulars such as farmers. It is also declared that most of the clients (almost 97%) of local manufacturers have been satisfied.

Figure 3 shows the importance of competition in the local agricultural equipment market where agricultural machines importers, government programs, manufacturers in other parts of the country and same zone manufacturers. The last type of competitor is the most important in each study region and represents 64 to 66 % of competitors. Among other competitors, we have importers of agricultural machines (24%) in Segou and manufacturers in other parts of Mali in Sikasso and Koulikoro amounting to 19% and 18 %. In comparing the advantages between importers and

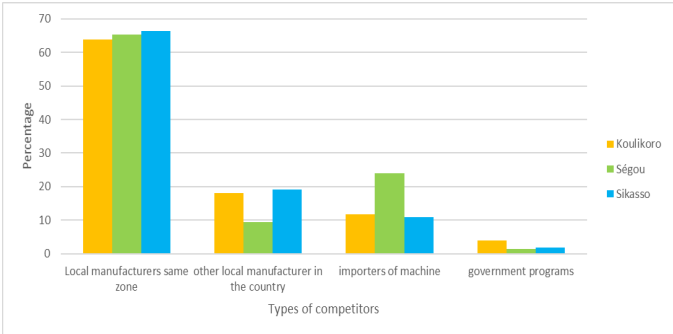


Figure 3: Types of Competitors
Source: local manufacturer surveys, 2021

local manufacturers in terms of price, quality, availability, local adaptation, brands or trust and others. Figure 4 shows that local manufacturers think that they are more competitive in price, quality and local adaptation compare to agricultural machine importers. In contrast, the importers are more competitive in agricultural machines availability, reputation, brands, trust and others like essential quality in design, strong financial capacity and access to calls for tenders.

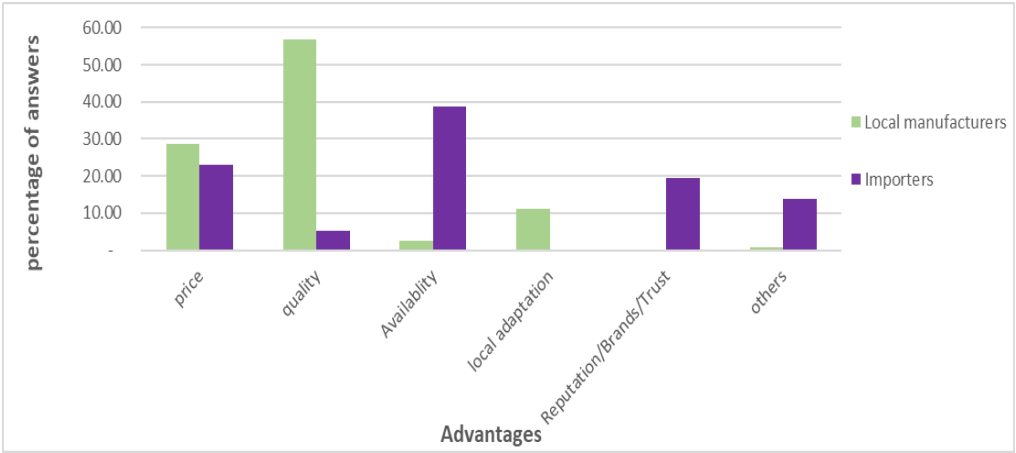


Figure 4: Advantages between importers and local manufacturers
Source: local manufacturer surveys, 2021

| Employees, knowledge and skills

In the local manufacturing units, the number of employees varies from 1 to 38 people for the 3 regions. As shown in table 10, the total average number of employees in 2020 is 7 people and it has not changed much from 3 years ago. But considering the average number of employees per region, it varies from 5.40 to 9.57 people with the higher average number of employees in the Sikasso region. In some parts of the Sikasso region, many of the employees (about 78%) in Koulikoro and Segou have received training in engineering. This should be explained by the mechanization programs implemented by research or other projects in the two regions which have benefited a lot of training in agricultural mechanization engineering.

Table 10: Number of different types of machines sold per region

Regions	The average number of employees in 2020	The average number of employees 3 years ago
Koulikoro	5.40	5.19
Ségou	6.32	5.91
Sikasso	9.57	9.26
Total	7.00	6.70

Source: local manufacturer surveys, 2021

The second basic training received by the local manufacturing units' employees is agriculture and the higher number is 77% of the employees in the Sikasso region. While it is 19 and 17% of the employees in Koulikoro and Segou. Among all the employees in the three regions, only 7 people have received training in the business of administration or economics and marketing. This is related to the fact that many of these local manufacturers have inherited this agricultural equipment manufacturing from their parents. As in Mali, we do have some ethnic groups who practice this profession from father to son and they are caste men. From childhood, they are withdrawn from school to assist their fathers in the forge workshop. This corroborates with the education level of the majority of employees who have not gone beyond the primary school as said by 71% of the respondents. According to local manufacturers, the knowledge or skills of the staff hired are mostly satisfying as shown in table 11. About 66 of 153 respondents are satisfied with the staff's knowledge or skills quality and 31 of them are very satisfied. However, 34 of the respondents are somewhat or not really and not at all satisfied with the staff directly hired after they completed their education. In contrast, local manufacturers' perception of the education system in table 12, is to increase the quality of the labor market with more practices. This situation of less-skilled workers is a general problem for the handicrafts sector and to meet the needs of the labor market, there is a need to do more practices in school. Moreover, some manufacturers in the three regions think that the education system should have better teachers, update the curricula or do more theory.

Table 7: sources of product design

	Koulikoro		Segou		Sikasso		Total	
Satisfaction level	Number	%	Number	%	Number	%	Number	%
Very much	9	18.8	11	23.9	11	23.4	31	22.0
Mostly	22	45.8	23	50.0	21	44.7	66	46.8
Somewhat	11	22.9	8	17.4	10	21.3	29	20.6
Not really	4	8.3	3	6.5	3	6.4	10	7.1
Not at all	2	4.2	1	2.2	2	4.3	5	3.5

Source: local manufacturer surveys, 2021

As many of them (62%) provide professional training and in the last three years (2018), they have trained a total average of 5 people and the trainee used to receive on average about 16,718 in local money Fcfa which is around 29 to 30 US dollars according to the exchange rate in 2018. This salary received is the highest in the Segou region with around 28, 000 in local money which is about 49 US dollars in 2018. In Sikasso region, trainees do not receive any salary because most of them have been sent by relatives to simply learn. Some trainees are being sent for practical learning by institutions for academic purposes. Once they get some knowledge and skills, they open their own agricultural equipment production business in the same or neighboring village. Only a few of them are being employed by some organizations. Among the respondents, only 40 of 153 are collaborating with some institution and project.

Table 7: sources of product design

	Koulikoro		Segou		Sikasso		Total	
Perception	Number	%	Number	%	Number	%	Number	%
More practice	14	26.4	11	20.8	16	34.0	41	26.8
More theory	2	3.8	3	5.7	0	0.0	5	3.3
Better teachers	3	5.7	0	0.0	0	0.0	3	2.0
Update curricula	0	0.0	2	3.8	3	6.4	5	3.3
Others	34	64.2	37	69.8	28	59.6	99	64.7

Source: local manufacturer surveys, 2021

Enabling business environment

As shown in table 13, in the last three years, about 31% of the local manufacturers interviewed have applied for a loan or credit to support their business. Most of them have used that credit in purchasing equipment or raw materials. However, 69% of them did not apply for credit because of high-interest rates, lack of collateral, and lack of information on the repayment mechanism of the credit. Some of them also prefer other sources of credit such as relatives or friends. There is not much difference between the three regions in terms of local manufacturers who did or did not apply for loan or credit.

Table 13: Loan or credit applying

Regions	Number of Local Manufacturers who applied for credit	
	Yes	No
Koulikoro	13	40
Segou	18	35
Sikasso	16	31
Total	47	106

Source: local manufacturer surveys, 2021

Table 14 below presents the number of local manufacturers who received or did not the loan. Among the 47 respondents who applied for credit, 39 of them declared receipt of a loan or credit with only 10 of them saying otherwise. The credit received by local manufacturers is from mainly Micro Finance Institutions (MFIs), friends and family, and commercial banks. In Koulikoro and Sikasso regions, the source of credit is mainly from MFIs while in the Segou region the credit's sources are essentially from friends and family. Among the respondents who have received credit, some local manufacturers received credit from traders. As indicated in table 15, the average interest rate of the loan received varied between 10.77 to 12.87% according to the regions, but the average total interest rate was 11.81%.

Table 14: number of respondents who received loan or credit

Regions	Number of Local Manufacturers who received credit	
	Yes	No
Koulikoro	11	2
Segou	14	4
Sikasso	12	4
Total average number	37	10

Source: local manufacturer surveys, 2021

The lowest interest rate is 5 and the greatest is 20 both are recorded in the Koulikoro regions. This interest rate changes depending on the type of financial institution whether a commercial bank or an MFI. Generally, the interest rate of an MFI is higher than that of a commercial bank. However, it is important to note that most of the lower interest rates cases are coming from subsidies either from a project or from the government. Thus, one of the biggest challenges for local manufacturers is access to finance as respondents' costs of credit are sometimes beyond the reach of a majority of local manufacturers in particular artisans who practice traditional tools fabricating. They typically lack collateral for bank and MFIs loans.

Table 15: Average interest rate per region

Regions	Interest Rate per year (%)
Koulikoro	12.45
Segou	12.87
Sikasso	10.77
Total average rate	11.84

Source: local manufacturer surveys, 2021

From the sample, the local manufacturers have received support from the government and donators. But the supports are focused on capacity building in terms of knowledge and skills development and free subsidized machinery and equipment. As 41% of the respondents have declared to receive government support and 43% of them have received the donators' support. In total, 76% of the respondents have access to the electricity grid and 24% of them did not have access to it. About 26% of the respondents reported policies and regulations which negatively affect local manufacturers' business.

| challenges and opportunities

Among additional aspects of opportunities shared by the local manufacturers interviewed, we have some government initiatives through agricultural motorization subsidies although not focused on local manufacturing actors. At the very least, these programs attempt to increase small-scale farmers' mechanization level plus the increasing demand for agricultural equipment, which can be seized as market opportunities for local manufacturers in repairing machines or selling spare parts. Another opportunity is the existence of the national artisan federation which can advocate for its members. Further, we recorded a few success stories with specialized workshops and blacksmith networks such as SOCAFON in Office du Niger through the support of some mechanization projects funded by partners.

However, local manufacturers interviewed reported facing challenges such as a lack in the factors of production like machinery equipment and the higher cost to succeed in their manufacturing business. The electricity's reliability and access were also cited as a major challenge depending on the location including the higher cost of electricity. Despite the support given by public and private sectors in training local manufacturers, there is still a lack of skilled artisans as most of them are still working with rudimentary equipment. Suddenly, a good number of local manufacturers do not worry much about the quality even less than the certification of their products.

Results from net maps sessions

| Stakeholders in manufacturing agricultural equipment

From the study results, it is clear that at the level of manufacturers, not much attention is given to capacity building to facilitate the creation and development of new designs, with quality attributes of good functionality and aesthetics to compete with imported equipment. The design of the equipment means using engineering drawings and specifications to meet quality requirements which are standard methods and approaches for making standard equipment (tractor assembly factory).



However, through the discussion, the team understood that most manufacturers design their equipment before production. Upon investigation for better comprehension, it was found that patterns and templates were the main design resources. Those patterns and templates are the tools the manufacturers used when undertaking their apprenticeship training. These templates and patterns are not modified from time to time to reflect the changing needs and requirements of farmers. Using old templates and patterns that are not consistently modified implies that the manufacturers produce the same equipment without innovation.

The outcome of the net-map revealed manufacturers face several problems during the fabrication of equipment. Problems such as energy, working material, skills and high cost of engineering equipment were reported as the major difficulties faced during the fabrication of agricultural equipment. It was also mentioned that manufacturers were exposed to effects on health as shops are of poor quality (not ventilated, dust and smoke).

Although locally made agricultural equipment plays a very significant role in the economy of Mali. Many farmers purchase them because of their affordable price and suitability for local conditions. Several manufacturers complain about the lack of engineering standards and safety. It is reported that the absence of mandatory standards results in poor design as well as wrong operating equipment. In the absence of formal training, few manufacturers reported that among the standards adopted include the use of quality materials and the use of templates and patterns as design tools.

The relevant actors are sellers (providers) of raw material (used iron); energy providers (electric, thermic, fuelwood or charcoal); manufacturers; project/NGO; extension services; retailers; cooperatives/organizations; training schools, the chamber of arts and end-users. These actors are related to each other: manufacturers need good quality iron (bars of leaf) to make equipment and energy is required to shape the equipment as desired. The two actors are very important to manufacturers even for making traditional tools (hoes, cutlass, etc.). Manufacturers can get the iron with sellers on credit or cash; there is no formal contract. For electricity, manufacturers pay a monthly bill to the electricity company based on their energy consumption. Should they not pay over two months, electricity is shut off. It is worth indicating that electricity is very expensive in Mali and not available all over the country. Once the manufacturers fabricate equipment, they are retailed or sold at a shop. For light equipment such as plows, arrows, and charts retailers order a number of them on a credit basis with payment being made after-sales. For heavier equipment such as dryers, threshers, or any motorized one, payment is made either through a down payment or full cost before equipment is manufactured. Projects or NGOs are the most important customers for manufacturers of dryers and motorized equipment usually because projects and NGOs buy equipment for cooperatives or organizations they coach; however, some cooperatives purchase equipment on their own through a direct arrangement with the manufacturer. It is not frequent to find schools sending their students for training in a manufacturer shop; but formal sectors such as tractor assembly factories, the cooperative of blacksmiths at Office du Niger (rice agency) zone, receive students from vocational schools and universities. Farmers purchase equipment

through direct payment or credit and their feedback is determinant of the number of particular equipment made by the manufacturers and how to better improve the equipment. The Chamber of Arts builds the relationship between manufacturers and projects/NGOs, helps to train registered manufacturers and helps them acquire working equipment through partners (EU; USAID, GIZ).

Actors with high levels of influence are farmers, projects/NGOs and the chamber of arts. The Chamber of Arts was described as an actor that could advise the majority of manufacturers and other actors but its influence was limited because of a lack of funding and a rather passive attitude toward its' coordinating role. The discussions reveal bottlenecks in acquiring funds, capacity building and competition with imported equipment. The imported equipment even more expensive is preferred by projects/NGOs which can order high quantities. Even if a manufacturer won a bid he doesn't have the funds to satisfy the market and the banking system is not in favor. Another source of bottleneck is the aesthetics, manufacturers don't often have the engineering design, they use templates and patterns.

| Manufacturers' and End-Users relationship

Table 16 shows the indicators and assumptions that were used to measure change. While the indicators are meant to provide information to describe the situation, the assumptions serve as expectations for the performance of activities. To analyze the information collected, it is necessary to outline the path in which the indicators of change and assumptions are linked and valid. In the context of this net-map, the indicators and assumptions presented in Table 1 provide information and expectations that are necessary for measuring challenges, performance and quality aspects of the equipment.

Table16: The manufacturer's and end-users indicators and assumptions

Manufacturers Level Indicators	Assumptions
1. Level of knowledge and skills in equipment design	1. Knowing the design process and principles contribute to a quality product.
2. Manufacturers report using standards in making equipment and certified by relevant institution	2. Rationale for policy and planning of standards and certification programs.
3. Manufacturers reporting of lack of training on standards and designing of equipment	3. Training of manufacturers enhances skills to bring about standard products and increased sales.
4. Quantity of equipment sold, pricing and means of reaching out to customers	4. Increased sales, affordable pricing and promotional means of reaching out to customers can improve business development.
End-users Level Indicators	Assumptions
1. Level of equipment degradation	1. Knowledge of equipment weaknesses can help modify equipment to meet end-users' choices and needs.

2. Years of equipment usage (durability)	2. Justification for the redesign of new equipment to meet end-user needs. Years of usage give an understanding of how consistent an equipment would perform.
3. Frequency of repair or spare part change	3. Reduced time and cost are indications of the use of efficient equipment.
4. Time saving and cost of access	4. Justification for performance equipment, particularly for female end-users.

The manufacturer side of the conceptual framework focuses on the equipment fabrication including design challenges, problems faced during fabrication, safety standards, certification and training, marketing and pricing. The end-user side of the conceptual framework focuses on the operational-related equipment including the number used, years of usage, repairs, spare parts, access cost and effect on gender. It is recognized that usability and performance of the equipment are essential as performance is dependent on several factors including user behavior, cultural acceptance and operating conditions.

Results from Key Informant Interviews

According to the key informants, some local manufacturers are technically well skilled through training partnerships abroad with projects from technical services such as the Malian company of textile development, the project FAFPA, HELVETAS and other NGOs. However, there is also a need for capacity building of many local manufacturers through training in upgrading, maintenance and servicing of manufactured equipment. In addition, there is insufficient monitoring of students in vocational training centers. To remedy this, more practice is needed, i.e. 80% of the time in the manufacturing workshops for practice and 20% in the training centers for theories courses. Among other difficulties, one of the biggest challenges for local manufacturers' businesses is access to finance to support their business.

For example, with the West African Development Bank (BOAD) fund to support artisans, the interest rate was very high. The administrative procedure to acquire funds was cumbersome coupled with the lack of collateral. Often, the amount granted was too small to meet the needs and the guarantee problem. Another challenge is the lack of structure in local manufacturers. There are other challenges such as the supply of raw materials (iron), the export of scrap metal which is used by local manufacturers and electricity infrastructures with higher prices of kilowatt units. Local manufacturers therefore turn generators which break down most of the time. Lastly, there is competition between local manufacturers' agricultural equipment and imported materials and machines.

Discussion and Policy Recommendations

The study focuses on the opportunities and challenges of local agricultural machinery manufacturers in three agro-ecological zones of Mali. The agro-ecological zones are chosen for their contribution to agricultural production and their importance to manufacturers. These are the rice zone, the cotton zone and the rain-fed cereals zones.

To address the opportunities and challenges of manufacturers the study developed a questionnaire for interviewing identified manufacturers and conducted net-maps for determining stakeholders and the relationships between manufacturers and end-users (farmers). Most of the manufacturers are domestic privates (nearly 95%) as the type of business they run is of small capital and the equipment they fabricate is not aesthetic. The customers they deal with are not very keen on aesthetic quality. The results show that the majority of manufacturers have an engineering background (66) while 42 of them have an agricultural background. About 39 of them have no background and 6 have a business administration background. The term engineer is used abusively in the answers of manufacturers because it is related to knowing or having the capacity to make/fabricate equipment.

Regarding education level, more than 50% of manufacturers have primary school level with about 30% having no formal education level. This could be partly explained by the heritage character of manufacturing (manufacturing is the job for casts traditionally). This is why many (61%) entered the job through family wills; only 36.6% do it because it is their dream. The main barriers to manufacturing are the lack of machines (working equipment) and lack of capital; these two reasons could be considered a lack of funds. Few manufacturers mentioned lack of knowledge as a barrier because they believe in their capacity to fabricate the equipment. They don't use real engineering design but they use templates and patterns.

About 71% of the equipment is for crop production as those are most demanded and manufacturers have their template or pattern. Most of the machines are not certified because customers who purchase them are not keen on quality; they want equipment that is doing the work. The informal sector dominates the manufacturing businesses therefore fabricants are not keen on the aesthetics of the material. Customers of equipment are individual or organized farmers. However, projects or NGOs purchase the equipment for many organizations.

Manufacturers compete among themselves whether in the same zone or different zones. Their equipment competes on the market with imported ones which are more expensive but are not rustic. The other problem with manufacturers' equipment is they can't be found in important

quantities therefore Projects and NGOs can't order high quantities from manufacturers. Manufacturers use on average 7 persons with different education levels (most don't have any level). They originate from the family or relatives; if hired usually they have high level of qualification. Manufacturers perceive quality as dependent of practice; the more practice the better quality of equipment fabricated.

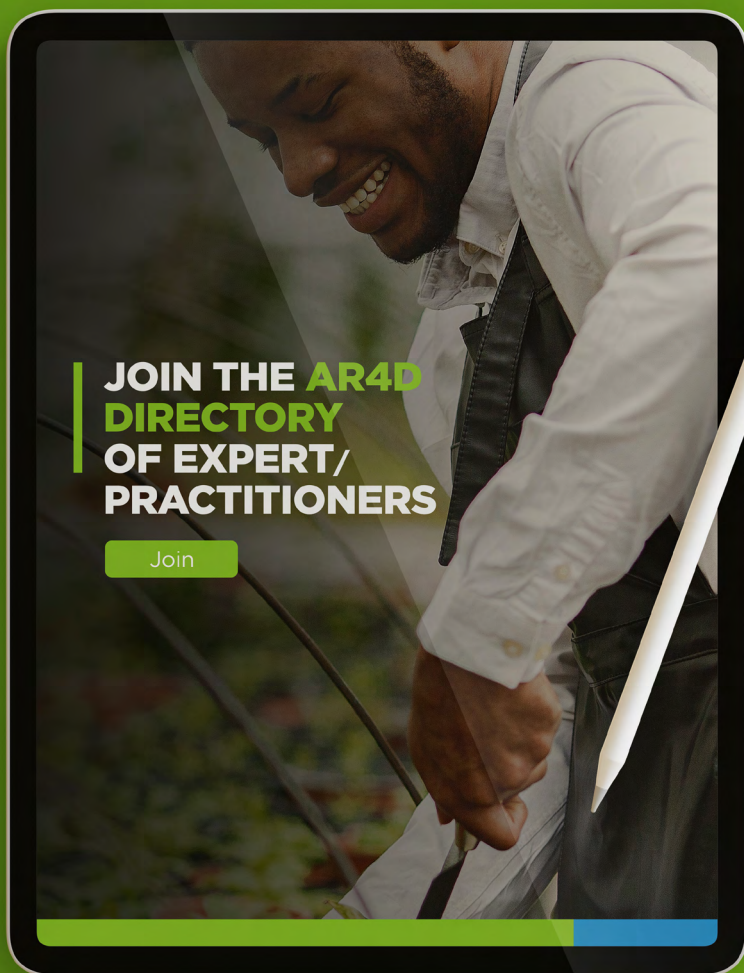
As most manufacturers don't have advanced education levels, very few of them apply for credit and fewer obtain it. The credit system in Mali has a high-interest rate and the conditions required are not affordable to manufacturers. Only formal manufacturers such as tractor assembly factories or the cooperative of blacksmiths in the Office du Niger zone obtain credit from the banks.

Since manufacturers are registered with the Chamber of Arts for capacity building and benefit from projects and subsidies from the government, the stakeholders in the business are farmers, retailers, projects/NGOs, training schools, extension agents, energy and raw material providers, cooperatives and organizations. The main stakeholders are however farmers, retailers, energy and raw material providers and the chamber of arts. Little importance is given to schools as many enter the business through family links.

Implication for more quality equipment, manufacturers should be sensitized and encouraged by projects and operating agencies in the agricultural development sector. Facilitate access to funds to purchase quality materials, organize training sessions for those in the business and develop curricula for schools.

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