# EFFECT OF COVID-19 PANDEMIC ON CROP CULTIVATION: NEED FOR ARTIFICIAL INTELLIGENCE AND ROBOTIC SYSTEMS IN NIGERIAN AGRICULTURE

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#### ABSTRACT

The effect of COVID-19 lockdown on crop planting mechanization and the need to use artificial intelligence and robotic systems as better alternatives in the early planting season in Nigeria was examined during the lockdown (April to July, 2020). The study areas include Oyo and Bayelsa states. The data generated were gathered through oral interview, discussions, e-questionnaires, live questionnaires and routine sources. Purposive and online sampling techniques were adopted and data were analyzed using Kobo Toolbox (KT), Statistical Package for Social Sciences (SPSS) version 21, R-programming version 3.2.2 and word excel version 2013. About ninety-one (91) respondents' opinions were sampled. The crops planted during the lockdown include maize (35.16%), cassava (24.18%), tomatoes (15.38%), vegetables (9.89%), pepper (6.6%), yam (5.49%) and undecided (3.30%) as indicated by the respondents. About 52.7% respondents observed that planting time was affected by COVID-19 lockdown while 40.7% said that planting time was not affected because of their system of farming and closeness to farm locations and 6.6% of the respondents were undecided. This gap created in planting time can be bridged with robotic systems while the farmers are observing lockdown and planting their crops using Artificial Intelligence (AI) at home. Farm implements (Traditional & mechanized) were discovered to be in deplorable conditions by 76% of our respondents that can be curbed with maintenance robots using AI while 16% of the respondents agreed that implements and tools were in good shape during the period. The use of mechanization for crop planting stands at 32% while the use of traditional implements (Hoes, cutlasses, hand sprayers) stands at 68% during the lockdown due to non-availability of skilled labour. Hiring of mechanized implements (Tractors, planters, seeders) and tools became difficult during the lockdown as agreed upon by 87% of the respondents and 9% of the respondents indicated that implements and tools hiring was not difficult and 4% of the respondents are undecided. The problems encountered by farmers are capital (60%), credit facility (63%), loan (61.54%), agricultural insurance (69.2%), high cost of labour (85%) and high cost of transportation (86.8%). The possible solutions suggested by the respondents are access to credit facility, free movement, special incentives, availability of loans at low interest rate, subsidized farm implements, agricultural schemes creation, provision of fertilizers and herbicides. Farmers observed COVID-19 protocols; Social distancing (54.9%), hand washing (26.4%), hand sanitizing (6.6%), Coughing into arm (4.4%) combined (4.4%) and undecided (3.3%). None of the farmers interviewed use robotic system for their farming operations. Government is therefore advised, to look into farmers' plight by encouraging artificial intelligence and robotics systems to overcome challenges associated with crop cultivation during lockdown and human movement restrictions.

**KEYWORDS:** COVID-19, Mechanization, Robotics, Agricultural insurance, KT, R-Language, AI

#### **1. INTRODUCTION**

COVID-19 pandemic has caused a lot of harm in every sector of the economy in many countries of the world especially in Agricultural sector. In Nigeria, more than sixty percent of the population engages in Agriculture, and more than 75% of the food production in Nigeria comes from subsistence system of farming in rural areas (Bidemi, 2020). And some of these farmers came from neighbouring cities, towns to farm around the village where land is available in abundant. But lockdown restriction order has posed a great danger on the planting period of some certain crops (Cassava, yam, maize, vegetables, tomatoes, etc.). The history of COVID-19 first human cases was reported by officials of World Health Organization (WHO) in Wuhan City, China, in December 2019 (WHO, 2020). And some of the earliest known cases had been linked to food market in Wuhan, where some agricultural products and produces are sold. Some of the initial patients were from shop owners, market employees, and regular visitors to this market and the market was closed on 1st January, 2020 (WHO, 2020).

In Nigeria, however, the first case was recorded in February, 2020 in Lagos state, Nigeria, where an Italian man who worked in Lagos, brought the disease from Italy. Nigeria recorded a lot of imported cases in the earlier outbreak of the pandemic before the community transmission. And some of the measures put in place are, hand washing, hand sanitizing, social distancing and disinfectant of public places. More so, partial lockdown and restrictions of vehicles from certain hours of the night was introduced before a total lockdown in Lagos, Ogun and the Federal Capital Territory (FCT) so as to curb the spread of pandemic. Report of 11th May, 2020 showed that Nigeria has recorded a total number of 4641 confirmed cases, 902 cases have been discharged and death toll of 150 recorded in 34 states and the Federal Capital Territory (NCDC, 11<sup>th</sup> May, 2020). Furthermore, one of the measures mentioned earlier in curbing the spread of COVID-19 is movement restriction. Does that mean farmers are not allowed to go to farm to sow their seeds? The answer is "NO" but they were restricted due to the stringent policy of the government on movement and lockdown, and low turnout of public vehicles to convey farmers to their farms. This can be solved through remote farming using Artificial Intelligence (AI) and Robotic Systems (RS) on the farm. Robotics farming involves the use of robots for cultivation and planting of crops and to carry out other farm operations. However, the aftermath of the lockdown, makes farmers to sow their seeds sparingly leading to food insufficiency or food insecurity which will be followed by hunger and starvation. Because according to the Food and Agriculture Organization (FAO), there are currently 820 million people around the world suffering from chronic hunger in which 113 million are coping with acute severe hunger (starvation) that poses an immediate threat to their livelihood. Two third of the people in this category lives in eight countries of the world in which Nigeria is included. Bulk of the people in this category depend on food support from benefactors for survival and further cut from this source will aggravate their condition and endanger their survival. Likewise, about seventy percent (70%) of Nigeria population stems their livelihood from agriculture, majority of whom are subsistence cultivating less than two hectares (2ha) of land per year. The measures to fight the spread of COVID-19 might hinder these farmers from having easy access to both their farmlands and markets to sell their products or buy seeds and other essential farm inputs, or struggle due to higher food prices or limited purchasing power. Aside the producers (that is farmers), food supply chain also include agro-input dealers, transporters, agro-processors among others will be affected in the months ahead.

The Food and Agriculture Organization (FAO) of the United Nations discovered that COVID-19 lockdown has resulted into the inability of farmers, farm service providers, farm labourers, input suppliers, extension officers, processors and other various actors (including Transporters) in the food system to perform their tasks (FAO, 2020). FAO further proposed that COVID-19 lockdown constraints may manifest themselves in the failure to plant crops at the right time by farmers, or to use the best value and measures of inputs needed (such as seedlings, herbicides, pesticides, seeds, fertilizers), to carry out varied cultural practices (hoeing, thinning, pruning, mulching), and harvest and post-harvest activities. The effect of this is that the expected crop produce are not available to those (society) who need them, where and when they are needed. More so, some farmers may not be able to afford the cost of farm implements (such as tractor purchase, tractor hiring, plough, harrow, planter, boom sprayer) due to the Banks poor and partial services. While other farmers may experience temporary setbacks due to their inability to access credit/loan facilities in due time resulting into late planting and poor growth of crops. FAO (2020) recommended that yam and cassava may be planted in Nigeria between February-March and March-September respectively. However, this planting time has been distorted with the advent of COVID-19 in Nigeria hence the need for robots to work on the farms and stepping up of our farm mechanization through Artificial Intelligence (AI). More so, Momtaz Isaak et al. (2020) carried out an evaluation on the mechanization status of the respective field operations in sweet corn cultivation. However, they did not evaluate the effect of COVID-19 lockdown on crop planting mechanization. Although they considered planting as one of the field operations among others (such as tillage, fertilizing, spraying, harvesting, and plants cutting). Hiroyuki et al. (2020) studied the effect of mechanization on economies-of-scope (EOS) in cropping. However, they did not examine the effect of COVID-19 lockdown on crop planting. Therefore, the objective of this study was to look at the effect of COVID-19 lockdown on crop planting mechanization and the need to use robotic systems in the early planting season in Nigeria.

# 2. METHODOLOGY

# **2.1 Population of the Study**

The target populations were farmers, researchers/lecturers, students on farms/students of Agriculture, farm labourers, sellers and buyers of farm inputs etc. Proportionality of the population was not considered due to the effect of COVID.

# 2.2 Study areas

The survey was carried out with the target population in Oyo and Bayelsa states (Figure 1) of Nigeria from April to July, 2020.

# 2.3 Method of data collection (primary sources)

Data were collected using oral interview, discussion, questionnaires (e-questionnaires and hard copy paper questionnaires) and routine sources. One hundred (100) questionnaires were administered from the two states to examine the view of farmers, farm labourers, researchers and farmers' associates on key issues of planting of crops at this critical lockdown due to COVID-19 pandemic such as implements used, labour, transportation and agricultural insurance. Oral discussion with social distancing observation was used to collect data on whether the cost of labour, transportation and hiring implements increase or not.



Figure 1: Map of Nigeria showing the studied areas (Oyo and Bayelsa states)

# 2.4 Method of data collection (secondary sources)

Data were also gathered from routine sources such as radio programme, social media, internet, publications and reports from FAO, WHO and National Centre for Disease Control (NCDC).

# 2.5 Sampling technique and size

Purposive sampling technique was adopted coupled with online response survey due to COVID-19 lockdown limitations. A sample size of ninety one (91) was retrieved from the field. However, only 88 samples were viable and well filled with a response rate of 88 %.

# 2.6 Data Management and Analysis

Data management and analysis was done using Kobo Toolbox (KT) and Statistical Package for Social Sciences (SPSS), R-Language and word Excel.

# 3. **RESULTS AND DISCUSSIONS**

# 3.1 Socio-economic demography of the respondents

The respondents cut across all stakeholders and professionals in crop planting mechanization and 37.36% are farmers, 3.30% are labourers, 13.19% are researchers, 7.69% are farm traders, 21.98% are students on the farm, 13.19% are others and 3.30% are undecided as showed in Table 1. The gender consists of 69% males, 28% females and 3% undecided respondents as showed in Figure 2 and this shows that able men are more involved in crop plant mechanization than able women in the research area. The marital status shows a thin line difference between the single and the married respondents who participated in the research at 46.2 and 47.3% respectively as showed in Figure 3. Furthermore, the age distribution of the respondents point to the fact that energetic youths are more in the system of crop planting mechanization as showed in Figure 4 by various ages between 15-40 years.

Variables	Number of respondents	Percentage (%)
Farmers	34	37.36
Labourers	3	3.30
Researchers	12	13.19
Farm traders	7	7.69
Students on the farm	20	21.98
Others	12	13.19
Undecided	3	3.30
Total	91	100.00

**Table 1: Respondents professional status** 



Figure 2: Gender distribution of respondents



Figure 3: Marital status distribution of respondents



Figure 4: Age distribution of respondents

#### 3.2 Effect of COVID-19 on Early Planting Season of Crops

#### 3.2.1 Crops planted by farmers during the heat of COVID-19 scourge

Some of the crops examined during COVID-19 lockdown in the study areas include maize (35.16%), cassava (24.18%), tomatoes (15.38%), vegetables (9.89%), pepper (6.6%), yam (5.49%) and undecided (3.30%) as showed in Figure 5. However, the planting time of these crops were affected by COVID-19 lockdown as showed in Table 2 and this argument was supported by 52.7% of the respondents while 40.7% said that planting time of crops was not affected by COVID-19 and 6.6% were undecided (Table 2). Although, the 40.7% of the respondents who disagreed with the effect of COVID-19 on the planting time may be living in areas close to their farms and they may not need transport fares and vehicles to get to their farms because movement was restricted during the lockdown in major cities. More so, the farmers that were affected mostly were those who depend on labourers from the middle belt (North central of Nigeria) to get their work done who need to travel kilometers away from the farms and cross several states in Nigeria.



Table 2: Effect of COVID-19 on the planting time of crops				
S/N	Scale	Number of respondents	Percentage	
1	No effect of COVID-19	37	40.7	
2	Effect of COVID-19	48	52.7*	
3	Undecided	6	6.6	
4	Total	91	100	

Table 2: Effect of COVID-19 on the planting time of crops

\*Strong effect of COVID-19 on the planting time of crops (% response is > 50%)

# **3.3 Effect of COVID-19 lockdown on the number of labour and labourers on the farm during early planting season**

The effect of COVID-19 on labour was enormous at 64.8% of our respondents as shown in Figure 6. The figure shows that COVID-19 has negative effect on labour for crop planting and this was due to the impediment or restriction on movement and flow of people by the government and this in turn hinders the flow of labour from north central Nigeria where bulk of the labour in the southern and western parts of Nigeria were from. This was in line with the findings of Bidemi (2020) who reported that restrictions in movements and social distancing, led to the shortage of labour during COVID-19 lockdown. Most of these labourers relocate during the planting season to make money in cash and possessions. However, this relocation was not possible during the COVID-19 pandemic lockdown and the few labourers available during the pandemic were majorly within the immediate farm locations. Table 3 showed that labourers were scarce during COVID-19 lockdown at 62% while 24% of the labourers were available for crop planting and these labourers are from the immediate environment. This scarcity of labourers led to high cost of labour (85%, Figure 7) because demand for labour was more than the supply. However, cost of labour did not change for some farmers but remain normal at 10% as showed in Figure 7. This may be due to household labour and cooperative labour practices adopted by such farmers who have many children and wives and mostly live in rural areas.



Figure 6: Effect of covid-19 on labour

Table 5. Labourers so	carcity during COVID	-19
Scale	Frequency	Percentage (%)
No scarcity	24.0	26.4
Scarcity	62.0	68.1
Undecided	5.0	5.5
Total	91	100



**Figure 7: Cost of labour** 

# 3.4 Effect of COVID-19 lockdown on farmers' transportation

One of the challenges COVID-19 lockdown brought to farmers is the problem of transportation and means of getting vehicle to carry farm inputs and labourers to their farms and this was also reported by Timilsina et al. (2020) that farmers have to face logistics difficulty to get inputs such as; seeds, fertilizers, and insecticides. About 75.8% farmers had trouble in getting vehicle to their farms while 18.7% did not experience such since their farms are close to their house and have personal vehicle (Table 4). The lockdown also affects cost of transportation of farm inputs at 86.8% while 8.8% was not affected who have gotten their inputs long before the lockdown and have such inputs at their disposal (Table 5).

Table 4: Effect of COVID-19 lockdown on transportation of farmers		
Scale	Number of respondents	Percentage (%)
Not Hard to get vehicle	17	18.7
Hard to get vehicle	69	75.8*
Undecided	5	5.5
Total	91	100

\*Availability of vehicle is strongly affected by COVID-19 (% response is > 50)

Table 5: Effect of COVID-19 lockdown on farm input conveyance		
Scale	Number of respondents	Percentage (%)
Normal cost	8	8.8
High cost	79	86.8*
Undecided	4	4.4
Total	91	100

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\*Cost is strongly affected by COVID-19 (% response is > 50)

#### 3.5 Conditions of farm implements and tools during COVID-19 lockdown

Implements (plough, harrow, planter etc.) and farm tools (hand trowel, knapsack sprayers, hoes, cutlasses etc.) during the lockdown were in deplorable conditions at 76%, while only 16% of the implements and tools were in good shape (Figure 8). This shows that some of the implements and farm tools were abandon during the lockdown and devoid of routine maintenance. Furthermore, hiring of implements and farm tools became difficult during the lockdown as showed by 87% of the respondents and 9% of the respondents indicated that implements and farm tools hiring was not difficult and did not affect routine maintenance of farm implement and farm tools while 4% of the respondents were undecided as showed in Figure 9.



Figure 8: State of farm implements and tools during COVID



Figure 9: State of Hiring of farm implements and tools during COVID

# 3.6 The level of crop planting mechanization during COVID-19 lockdown

Table 8 showed that mechanized (tractor, plough, harrow etc.) and traditional (Hoe, cutlass etc.) implements are preferably used together by the respondents at 45.1% for crop planting than traditional and mechanized implements separately at 35.2 and 16.5% respectively. However, traditional implements were used more at 68% by the farmers in crop planting than mechanized implements at 32% as showed in Figure 10. This shows that farmers used crude implements to carry out most of their activities during the lockdown than mechanized implement. This finding is in line with Yinusa and Bamgboye (2015) who reported that traditional implement takes 72.2% and mechanized implements have 27.8%. This may be due to cost of purchasing mechanized implements, inadequate credit facility, inadequate support from the government and farm size.

Implements used	No. of respondents	Percentage (%)
Mechanize and Crude	41	45.1*
Crude/hand	32	35.2
Mechanize	15	16.5
Undecided	3	3.3
Total	91	100

Table 8: Types of implement u	sed during COVID-19 lockdown
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\*Leading variable (45.1 %)



# Figure 10: Crop planting using mechanized and traditional (crude/hand) implements

# 3.7 Financial problems faced by farmers during the COVID-19 lockdown

# 1. Problem of capital

Most of the respondents (65.9%, Table 6) showed that funding was not available during the COVID-19 lockdown and this invariably affects the level of crop planting mechanization during the early planting in Nigeria. This was also discovered by Timilsina et al (2020) who opined that financial crisis leads to acute hunger, and has brought agricultural activities to standstill, where society admire those who can produce food for them. However, 26% of the respondents hard enough capital to work but this percentage of farmers cannot produce enough to cater for the needs of their immediate environment. Therefore, this may lead to food insecurity and high cost of foodstuffs in the coming months after COVID-19 pandemic.

Capital	Number of respondents	Percentage
Not available	60	65.9
Available	26	28.6
Undecided	5	5.5
Total	91	100

Table 6: Problem of capital during COVID-19 lockdown

#### 2. Problem of credit facility and access to credit facility

Credit facility accessibility was affected by the lockdown as 63% (Figure 11) of the respondents were not able to access credit facility while 22% (Figure 11) did have access to credit facility and this was done through resilience and doggedness because banks were noted with long queues and covid-19 protocols of washing of hands, social distancing and others. However, 15% did not respond to the questions correctly.



Figure 11: Credit facility

# 3. Problem of loan

One of the major problems encountered by farmers during the COVID-19 lockdown was problem of loan accessibility. Because 61.54% of the respondents claimed inaccessibility of loan while 25.27% claimed accessibility as showed in Figure 12. The uncertainty of the future during the lockdown by banks and the downward trend of the economy of Nigeria and the entire world created fears and agitations in the minds of bankers to release loans. However, some farmers and other respondents have access to loan.



# 3.8 Farmers' agricultural insurance scheme

There are several institutions that have been put in place to cushion the effect of adversity at any point in time on agricultural production such as agricultural banks, agricultural insurance and subsidies on some farm inputs such as fertilizer. However, the system put in place by Nigerian government to access these agricultural schemes made it difficult for ordinary farmers to use or access such schemes. This research discovered that only 13.2% respondents have access to or know about agricultural insurance while 69.2% of the respondents do not which is not too good for agricultural sector as showed in Figure 13.



# 3.9 Farmer's Responses and Attitudes During COVID-19

This research discovered that COVID-19 lockdown got 87.9% (Table 9) farmers worried while 7.7% (Table 9) were not worried about the lockdown and this may be due to their farm location, residence, transportation cost, cost of labour and source of labour.

Farmers used some Personal Protective Equipment (PPE) to carry out their planting operation as showed in Table 10 and they include hand gloves, Nose mask, hand gloves, overall and protective shoes. Farmers used these PPE during COVID-19 to protect themselves from unforeseen happenings that may infringe on their health during the pandemic. However, nose mask was mostly used by farmers at 38.5% among other PPE and 11% of the respondents did not use any PPE which is dangerous and can lead to serious health challenges as showed in Table 10.

Furthermore, the farmers were not left behind in observing COVID-19 protocols and some of the protocols observed were social distancing (54.9%), hand washing (26.4%), hand sanitizing (6.6%) and Coughing into arm (4.%) as showed in Table 11 and some farmers combined two or more protocols as showed in Table 11.

# 3.10 Farmers' beliefs and supposed treatments of COVID-19

About 17.6 % (Table 12) of farmers have the confidence to say that they cannot contact Coronavirus and this confidence came from the fact that some farmers have herbal cures or treatment (25.3%, Table 13). More so, 73.6% of the respondents agreed that farmers can catch COVID-19 because they felt that their immunities are weak and this makes them susceptible to COVID-19 and about 62.6% respondents said that farmers do not have treatments or cures for COVID-19 (Table 13).

Table 9. Farmers Fsychology		
Worry about COID-19	Frequency	Percent
Not worried	7	7.7
Undecided	4	4.4
Very worried	80	87.9
Total	91	100.0

# **Table 9: Farmers' Psychology**

Tuble 1011 ersonar i rotecutte Equipment used by furmers during 00 (12-1)			
S/N	PPE used by farmers	No. of respondents	Percentage (%)
1	Hand gloves	5	5.5
2	None	10	11.0
3	Nose mask	35	38.5
4	Nose mask, hand gloves & overall	1	1.1
5	Nose mask & protective shoe	2	2.2
6	Overall	17	18.7
7	Protective shoe	18	19.8
8	Undecided	3	3.3
	Total	91	100.0

Table 10: Personal Protective Equipment used by farmers during COVID-19

#### Table 11: COVID-19 protocols observed by farmers

Protocols	No. of respondents	Percentage (%)
1. Coughing in arm	4	4.4
2. Hand sanitizing only	6	6.6
3. Hand washing only	24	26.4
4. Hand washing & coughing in arm	1	1.1
5. Hand washing, hand sanitizing & social dist.	1	1.1
6. Hand washing, hand sanitizing, social dist. &	2	2.2
Coughing into arm		
7. Social distancing only	50	54.9
8. Undecided	3	3.3
Total	91	100.0

# Table 12: Farmers' thoughts about Coronavirus

Farmers reaction to COVID	No. of respondents	Percentage (%)
1. I can catch COVID	67	73.6
2. Undecided	8	8.8
3. I cannot catch COVID	16	17.6
Total	91	100.0

#### Table 13: Treatment of COVID-19

Farmers have treatment	Frequency	Percentage (%)
No	57	62.6
Undecided	11	12.1
Yes	23	25.3
Total	91	100.0

# 3.11 Crop planting mechanization and factors affecting it.

The respondents scored crop planting mechanization during COVID-19 lockdown as 0, 1-20, 21-40, 41-60 and 61-80 at 7.7, 23.1, 34.1, 22.0, 9.9 and 3.3% of the respondents respectively (Table 14). The highest percentage of crop planting mechanization ranges from 21-40% as agreed upon by 34% of the respondents. This indicates that most farmers are yet to adopt modern ways of crop planting mechanization of artificial intelligence and robotics due to capital, famers' education, access to credit facility, land tenure system, inadequate government support and policies,

inadequate skilled labour, problem of transportation and bad roads as showed in Table 15. Table 16 showed the responses of our respondents on the fact that government help is at 14.3 while about 75.8% said that government has not helped during the lockdown.

Tuble 14. Scale of crop planting meenamzation		
Level of mechanization	Frequency	Percentage
0%	7	7.7
1-20%	21	23.1
21-40%	31	34.1
41-60%	20	22.0
61-80%	9	9.9
Undecided	3	3.3
Total	91	100.0

#### Table 14: Scale of crop planting mechanization

#### Table 15: Factors affecting crop planting mechanization

Factors	No. of respondents	Percentage (%)
Capital	53	58.2
Farmers' education	5	5.5
Credit facility	4	4.4
Land	4	4.4
No government support	10	11
Skilled labour	4	4.4
Transportation	8	8.8
Undecided	3	3.3
Total	91	100

#### **Table 16: Government help**

Items	Frequency	Percent
Government Help	13	14.3
Undecided	9	9.9
Govt. did not help	69	75.8
Total	91	100.0

#### 3.12 Possible solutions factors affecting crop planting mechanization

Some of the possible solutions suggested by the respondents include access to credit facility, free movement, special incentives, availability of loans at lower interest rates, giving farmers farm implements at highly subsidized costs, agricultural scheme creation, provision of fertilizer and herbicides, financial empowerment and farmer special intervention.

#### 3.13 Need for artificial intelligence and robotic systems in Nigerian agriculture.

The research data gathered from the field and discussed in the earlier sections is an evidence that Nigeria is long due for smart farming using robotic systems and Artificial Intelligence (AI). None of the farmers in this study used robots during the lockdown to cultivate their crops but most of the farmers waited for the relaxation of the lockdown before planting their crops. This affected the planting time of most of the crops discussed in section 3.2. Crop cultivation cannot be slowed

down by human movement restrictions where AI is functional on the farm and is controlled remotely at assigned location. The application of AI in Nigeria's agriculture with the incorporation of robotic solutions will enhance sustainable crop production. This starts from data gathering from farmers, cultivated fields and crop parameters to build reasonable applications that can be applied to crop cultivation by farmers as better alternatives during lockdown and curfew rather than the conventional methods of crop cultivation. The process starts with numerical computation (stage 1), data analysis and visualization, algorithm development (stage 2) and design and deployment of robot (stage 3). This has been divided into stages as follow;

**Stage one:** Stage one begins with data gathering (numerical computation) from farmers, fields and crops. The data gathered are stored in files, software and hardware (Figure 14).

**Stage two**: Stage two starts with data analysis and modeling, algorithm development and application development (Figure 15).

**Stage three**: Stage three starts with reporting and documentation of outputs for design of robots and deployment of robots on the farm (Figure 16).



Figure 14: Stage one (Data gathering and storage).



Figure 15: Stage 2 (Data analysis, Algorithm and App development)



**Figure 16: Stage three** 

# 4. CONCLUSIONS

This research has revealed that the level of farmers' crop planting mechanization during COVID-19 lockdown is below 50% and farmers have been plagued with several challenges ranging from capital to high increase in cost of labour, transportation and poor use of farm implements and tools. More so, farmers have kept to all the non-pharmaceutical protocols put in place by World Health Organization (WHO) and the Presidential Task Force (PTF) of Nigeria. Government is hereby advise to look into farmers' plight during and after the period of pandemic as crop planting mechanization using artificial intelligence and robotics systems will help to diversify farmers effort in food production. However, the development of robotic systems outlined in this publication as better alternative for crop planting during lockdown continues.

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# 6. COMPETING INTERESTS

Authors have declared that no competing interests exist.

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