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A study of poultry farms in Enugu State Nigeria and mapping of their mechanization needs using Global Positioning System (GPS) and Geographical Information System (GIS)

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Poultry has been identified by the World Bank funded Commercial Agricultural Development Program (CADP) as a value chain in the agricultural sector of Enugu State and thus has the potential for commercial agriculture. This work has investigated poultry farms in three production cluster areas in Enugu State namely: Emene (in Enugu East) located on 6.523815°N, 7.4151535°E and 1236 ft; Ngwo (in Enugu North/Udi) located on 6.523815°N, 7.57528°E and 572 ft and Nsukka located on 6.234754°N, 7.326473°E and 3422 ft. The study identified the position of each farm using Global Positioning System (GPS) hand held device; their specific mechanization needs and challenges limiting the performances of the farms using structured questionnaire, oral interviews and on-the-spot assessments. Position and mechanization data were represented in a map using ArcGIS version 10.3. The farms visited produce eggs, broilers or layers or combinations of them, and the sizes of the farms range from unit of thousands to tens of thousands of birds; these generally are commercial poultry farms but of low or medium scale levels. The survey reveals that most of the poultry farms are having the following mechanization needs: Power supply, egg handling, road network, waste handling, feed mill, pelleting machine, battery cage, automatic drinker, water pump, and automatic feeder; however the need depends on the level of production. Other problems or challenges facing the farms visited as observed during the survey are classified as management problems quantified as 60%, technical problems 30% and the problem of cost 10%. Result of this work is a step further in developing and building up the much talked about commodity-specific data base system for agribusiness decision support and development in the local area.

Key words: Mapping, poultry farms, mechanization needs, Global Positioning System (GPS), Geographical Information System (GIS).

INTRODUCTION

Poultry production is one of the major agricultural production activities going on in Enugu State of Nigeria. Poultry alongside with fruit trees (citrus, mango, guava, pineapple and cashew) and maize has been identified by the World Bank funded Commercial Agricultural Development Program as a value chain in the agricultural sector of Enugu State and thus has the potential for commercial agriculture (CADP-AB3498, 2009). Both rural

and urban dwellers are involved at varying levels. In urban or semi-urban areas, people operate poultry production systems at either subsistent, usually as a part time job or at commercial level. The level of production determines the land space, scale, technological application and other input resources. According to Adene (2010), commercial poultry production system is industrial in nature, large scale, dense and involves uniform stocks of modern poultry hybrids. It is capital and labour intensive as well as inputs and technology demanding. On the other hand, the rural poultry is by convention a subsistence system which comprises stocks of non-standard breeds or mixed strain, types and ages. It is generally of small scale, associated with household or grass root tenure and little or no veterinary inputs. The rural poultry sector is therefore in its original sense, a village-based, household or individual holding, an occupation which has however been extended to non-village settings in semi-urban localities, mainly by the middle class dwellers. However, between these two distinct systems, intermediate grades have evolved over time, in response to the national agro economy and consumer demands. This constitute what is now globally regarded as "family poultry" comprised of the rural or indigenous poultry types in some cases or a mixture of both indigenous and exotic hybrids or even totally exotic breeds. Available information shows that the scale of operation can range from stocks of a few units or a few dozens of a variety of poultry birds in the household poultry to tens or hundreds of thousands of chickens in the grades of commercial poultry (Adene, 2009).

Considering the contribution of poultry business to the economy of the state and the country at large, it is important to develop a good information network and data base system for decision support for poultry and allied business ventures. Also it is necessary to pursue full mechanization of the system in order to serve the growing population for both food and raw material for industries. Agricultural mechanization is the application of mechanical technology and increased power to agriculture, largely as a means to enhance the productivity of human labour and often to achieve results well beyond the capacity of human labour (UNIDO-FAO 2008). In Africa and specifically in Nigeria, record keeping and information management and retrieval systems are still generally unsatisfactory. Researchers, investors, government and farmers usually find it difficult to find or have access to needed information or data which may be necessary in different aspects of their specific interests. This research therefore seeks to contribute to solving this problem; and precisely in the aspect of poultry business in Enugu State by providing a map showing location of farms and their mechanization needs. The specific objectives include to identify the existing locations of some selected poultry farms in Enugu State using GPS, determine the mechanization needs and other challenges of these poultry farms through on-sight investigation, oral interviews and structured questionnaire and to represent the farms and their mechanization needs in a map using GIS software.

GIS and GPS as powerful information and management tools

Geographical Information System (GIS) is a high technological mapping system that integrates hardware, software and data for capturing, managing, analyzing and displaying all forms of geographically referenced information. GIS makes it possible to view, understand, question, interpret and visualize data in many ways that reveal relationships, patterns and trends in the form of maps, globes, reports and charts (ESRI, 2010). By using GIS, scientists can research changes in the environment; engineers can design road systems; electrical companies can manage their complex networks of power lines; government can track the uses of land; fire and police departments can plan emergency routes. Many private businesses have begun to use a GIS to plan and improve their services.

For agricultural purposes, GIS can be used to produce and read maps. Its major advantage is that it permits identifying spatial relationships between specific different map features. It can create maps in different scales, projections and colors. But it is not just a map making tool. It is primarily an analytical tool that provides new ways of looking at, linking and analyzing data by projecting tabular data into maps and integrating data from different, diverse sources. It accomplishes these by allowing creation of a set of maps, each with different theme such as soils, rainfall, temperature, relief, water sources, etc. From its early beginnings, GIS has been an integrating technology both from the point of view of its development as well as its use. This is because, once geographic information of any kind is translated into the digital form in a GIS, it becomes easy to copy, edit, analyze, manipulate and transmit (Maguire et. al., 1990). Some potential agricultural applications where GIS can lead to better management decision are: Precision farming, land use planning, watershed management, pest and disease management, irrigation management, resources inventory and mapping, crop area assessment and yield forecasting, biodiversity assessment, genetic resources management, etc. (Aronoff, 2010). Information

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Figure 1. Map of Enugu state showing the local governments.

and data on poultry business can be collated and/or accessed on the internet and used to create intelligent maps for better farm business practices (Xie and Wang, 2007). Khaleda and Murayama (2013) employed GIS in the delineation of the suitability of poultry sites in Gazipur, Bangladesh. Hassanein et al. (2012) applied GIS as a decision support system in planning the expansion of poultry farms in Egypt. Omodele et al. (2014) employed GIS in analysing the spatial distribution of poultry farms in Delta State.

On the other hand, GPS is applied in agriculture for guidance of equipment such as sprayers, fertilizer applicators and tillage implements to reduce excess overlap and skips. They can also be used to precisely locate soil sampling site, map weed, disease and insect infestations in fields and apply variable rate crop inputs, and in conjunction with yield monitors, record crop yields in fields (Liaghat and Balasundram, 2010; Dull, 2008). Possible agriculture related questions a GIS can answer the following questions: What is it (identification); Where is it (location); What has changed since (trends); What spatial patterns exist (patterns); What if (modeling) (ESRI, 2010). According to Stafford (2011), the advent of

information technology has accelerated our ability to acquire large volumes of spatial data. It is widely acknowledged that the key technologies facilitating the modern precision agriculture are yield monitor, remote and proximal sensing, GPS and GIS.

MATERIALS AND METHODS

Description of the study area

Enugu State (Figure 1) was created on August 27, 1991 with the city of Enugu as its capital. The State derived its name from the capital city which was established in 1912 as a small coal mining town, but later grew to be capital of the former Eastern Region of Nigeria in 1967 when the Gowon administration created twelve states in Nigeria. Enugu State is located in a tropical rain forest zone with a derived savanna. The city has a humid tropical savanna climate with its humidity at its highest between March and November. The mean daily temperature of Enugu State is 26°C (80.1°F) as in the rest of West Africa; the rainy season and the dry season are the only weather periods that occurs in Enugu. The average annual rainfall in Enugu is around 200 mm which arrives intermittently and becomes very heavy in rainy season. Other weather condition affecting the city is Harmattan; a dry and dusty

northeast trade wind lasting a few weeks from end of November to January or February. Like the rest of Nigeria, Enugu is hot all year round. Enugu State occupies much of the highland of Udi, Awgu and Nsukka. The hills are flanked by the rolling lowlands of Orji-River, Adada and Anambra. The area contains about nine geological information and is made up of shale, sandstones and siltstone (Ofomata, 2002a). Enugu State is located at height of 200 to 500 meters above sea land (Ofomata 2002b).

In the west and south west of the escarpment, the Udi-Nsukka plateau, all fall gently towards the lowland along the Niger and Imo River. The Anambra main River drains extensively to the area of Uzo-Uwani local government area in North West and Awgu in South West. Ekjlu and Inyaba River is linked to Ebonyi and Cross-River basin (Wigwe, 1975). The vegetation of Enugu falls within the rain forest savanna acetone. Its floristic composition is consequence of its location in the transition zone between the tropical grassland. About 60 to 70% of the vegetation in the area is grasses and is predominantly *Hyparrhenum* species, androgen species, and *Penisetum prupereum* (Ajaero, 2008; Anyadike, 2002).

Agriculture is one of the major economic activities in Enugu. The major crops produced include yam, cassava, cocoa yam and vegetable. However, it is practiced on a subsistence level with continuous cropping. Other economic activities in Enugu State include palm-base works and designs, clay works and blacksmithing (Mbagwu and Obi, 2003). Enugu city serves as a host of various government institutions (Ajaero, 2008). According to 2006 Nigerian census, the Enugu metropolitan area has an estimated population of 722,664 persons. This is made up of 312,332 males and 410,332 females.

Research methodology

The research methodology is basically survey, involving on-site investigation, oral interviews and the use of structured questionnaire. Poultry farms investigated in this study were selected randomnly based on the zones where many clusters are located. Three of such zones were selected, namely: Emene (in Enugu East), Ngwo (in Enugu North/Udi) and Nsukka; which include rural and semi-urban settlements where there are clusters of poultry farmers. A total of eighteen poultry farms were visited during the survey. Primary and secondary data collected were used to analyze the mechanization needs of poultry farms in Enugu State. The primary data was generated through on-sight investigation, oral interviews and the use of structured questionnaire administered to the farmers, to find out their mechanization needs and other challenges facing poultry production in the area. Global Positioning System (GPS) hand held device was used to collect position data of the poultry farms. The secondary data were obtained from literature. Finally Geographical Information System (GIS) software (ArcGIS version 10.3) was used for data capturing, analysis, and mapping to show the different locations of the poultry farms on the study area and their mechanization needs indicated by different colour codes on the map.

RESULTS AND DISCUSSION

Poultry farms, locations and mechanization needs

The names of the poultry farms visited, their locations and mechanization needs are presented in Table 1. For easy mapping, the various farms have been coded as Pf 1 to 18, where Pf refers to poultry farm. It was found that the farms visited produce eggs, broilers or layers or combinations of them; and the sizes of the farms range

from units of thousands to tens of thousands of birds. The poultry farms operate either battery cage or deep litter system or both. Usually, those just starting the business at commercial level prefer to start with deep litter because it is relatively cheaper compared to battery cage; unfortunately quality and durable battery cages are both scarce and expensive. ArcGIS version 10.3 was used to capture and represent the data shown in Table 1, and different maps were produced showing poultry farm locations and their mechanization needs (Figures 2 to 5).

Summary of other problems, needs and challenges faced by poultry farms visited

From on-sight investigations and interviews conducted at the various poultry farms visited, the following are the summary of challenges or problems faced by most poultry farms that either resulted in bankruptcy, total closing down of the farm or operating below profit margin which eventually would lead to gradual folding up. They include: (i). Poor record keeping and accountability; (ii) Lack of business honesty; (iii) Poor management; (iv) Pilfering and inadequate security (v) Inability to separate business from family affairs; (vi) Lack of sustained interest and commitment after the original owner is no more; (vii) Inadequate skills and experience in managing diseases especially at preventive level; (viii) Low level or complete absence of mechanization; (ix) Poor odour control and management; (x) Relatively unstable and high cost of input materials like feed, drugs, etc. Items one to six are classified as management problems which make up 60%, items seven to nine are technical problems representing 30% while item ten is the problem of cost representing only 10%.

DISCUSSION

Table 2 shows the identified mechanization needs and number of the poultry farms involved. The needs in descending order include: Power supply, egg handling, road network, waste handling, feed mill, pelleting machine, battery cage, automatic drinker, water pump, and automatic feeder. The observations as represented in Figure 6 show that about 56% of the poultry farms in the surveyed areas in Enugu State needed power supply. This result implies that the remaining 44% either depend on personal electricity generators or do not use electricity at all for any activity in the poultry pen. Due to the frequent power outage and erratic nature of electricity supply from the national grid, many of the farmers who can afford it depend more on electricity generating gasoline or diesel plants which come in different sizes. For most poultry farms electricity is used mainly for lighting and heating; only very few farms have equipment that require electric power for operating them. The cost of

Table 1. GPS reading and the address of poultry farms in Enugu State.

Notation	Name and address of poultry farms	Latitude (°N)	Longitude (°E)	Altitude (Ft)	Mechanization needs
Pf1	Bora poultry farm: km.5 old Enugu road, Enugu Ngwo	6.44602	7.451535	1236	Power supply, and egg handling machine
Pf2	Bora poultry farm: km.5 old road, Enugu Ngwo	6.44124	7.457445	1307	Power supply, egg handling machine, and fund
Pf3	Ozokwor poultry farm: Ugwuagbara in enugu north local government area near st Theresa	6.420118	7.456462	1323	Power supply, bad access road
Pf4	Nagnald poultry farm: km.5 Agu-Eke layout, hilltop Ngwo	6.442925	7.451552	1235	Battery cages and poor access road
Pf5	Engr Nwaeze poultry farm: km.8 Agu-Amabor Ngwo, Enugu Ngwo	6.413743	7441105	1293	Water pumping machine
Pf6	Parthy poultry farm: km.8 Agu Amabor Enugu Ngwo	6.41281	7.440473	1349	Feed mixer and automatic drinker
PF7	Educhi poultry farm: Onuagu Etiti village Enugu Ngwo	6.415112	7.45467	1310	Power supply and automatic feeder
Pf8	Beny's poultry farm: Ugwuomu Nike Emene, Emmanuel town	6.523815	7.577528	572	Power supply, egg handling machine and waste packing machine
Pf9	MIC poultry farm: Onuagu Etiti village Enugu Ngwo	6.527792	7.578562	1221	Power supply/ egg and waste packing machine
Pf10	Goodwill poultry farm: Phinomar Nig. LTD Enugu Ngwo. Box, 655 Enugu	6.425763	7.463465	1272	Waste packing device and egg handling equipment
Pf11	CADP Ministry of Agricultural Resources, World Bank assisted poultry, Ugwuomu Emene, Enugu East LGA	6.52607	7.577168	570	Power supply, truck for moving the waste and road network
Pf12	Nebo poultry farm: Ugwomu Nike Enugu state	6.523492	7.579607	557	Egg handling machine and pelleting machine
Pf13	Nebo poultry farm: Ugwuomu Nike, Emene, Enugu East LGA	6.523492	7.586053	525	Power supply, egg handling machine and bad road
Pf14	Odalije poultry farm: km.5 Agu-Eke layout Odalije street Enugu Ngwo	6.444258	7.45606	1285	Feed mill, power supply and battery cage
Pf15	Uncle's poultry farm: km.20 Ugwuomu Emene	6.527792	7.578562	562	Automatic drinker, road network
Pf16	Ibigbo poultry farm: opposite hill view sec. sch. Uwani Edem Nru Nsukka	6.844	7.377	1345	Power supply, feed mill, tractor for waste handling and egg handling machine
Pf17	Department of animal science, poultry farm: UNN	6.854	7.388	3422	Bad road, feed mill
Pf18	Department of Veterinary Medicine poultry farm: Old Vet, UNN	6.854	7.396	3756	Pelleting machine

fuel and maintenance of the plants invariably affect the total cost of production and hence places the farmer often at lower profit margins. About 44% indicated need for egg handling equipment or devices; most poultry farmers pick up eggs either from battery cage or deep litter systems by hand to a collection point where they are moved with
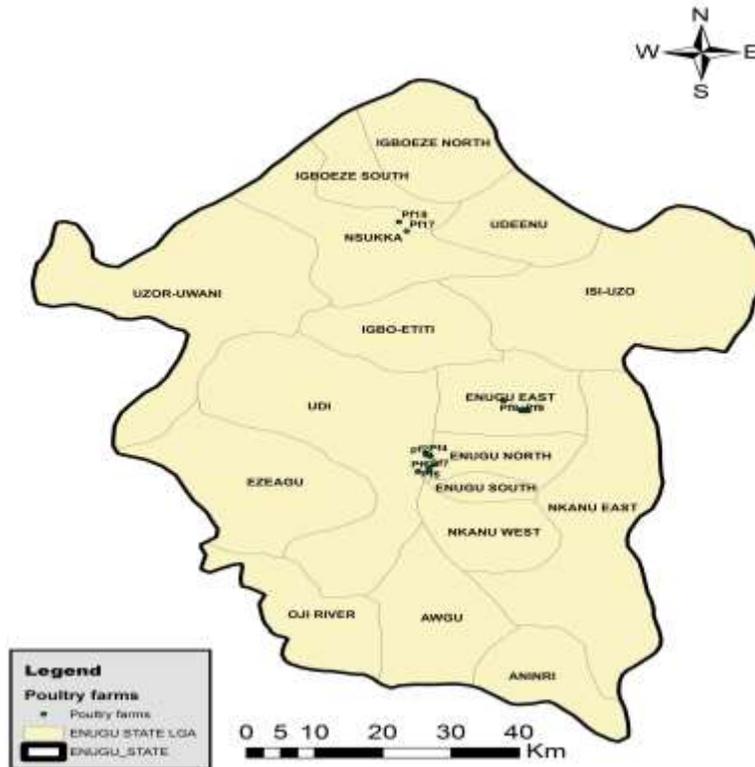
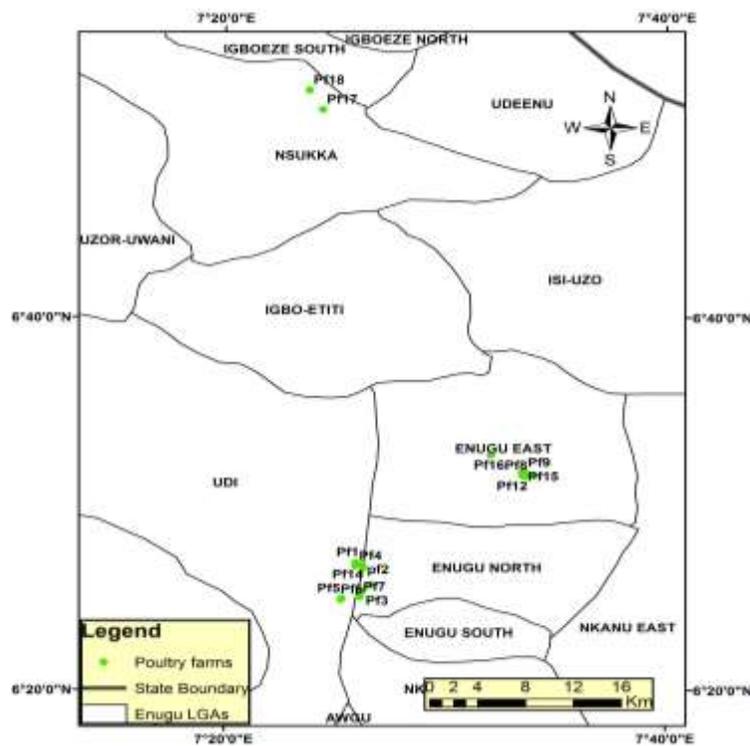**Figure 2.** Map showing locations of surveyed poultry farms in Emene, Ngwo and Nsukka.

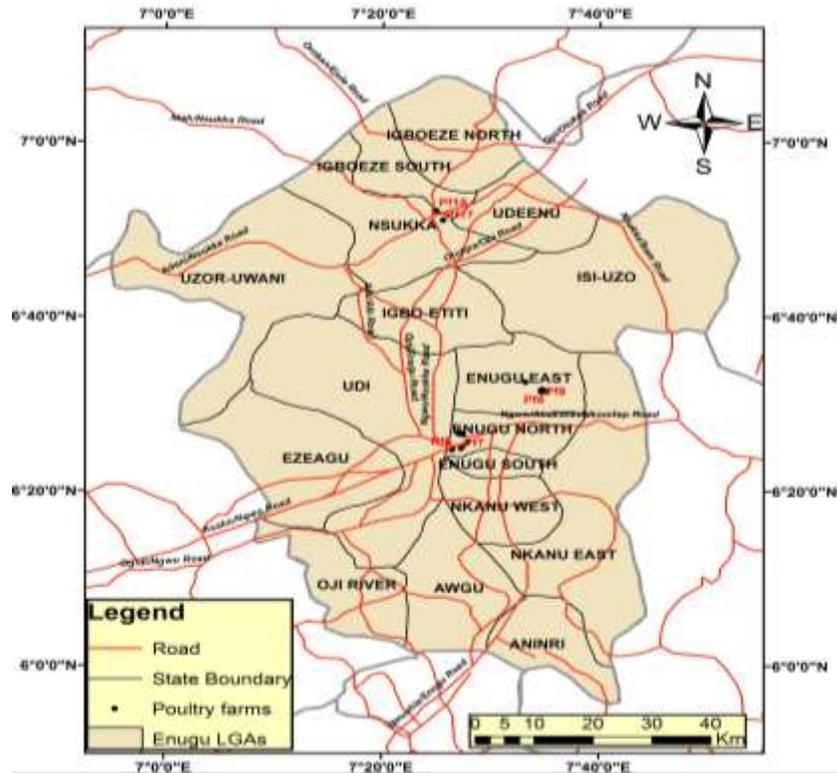**Figure 3.** Enlarged map showing locations of surveyed poultry farms in Emene, Ngwo and Nsukka.

Figure 4. Map showing locations of surveyed poultry farms in Emene, Ngwo and Nsukka indicating the road network.
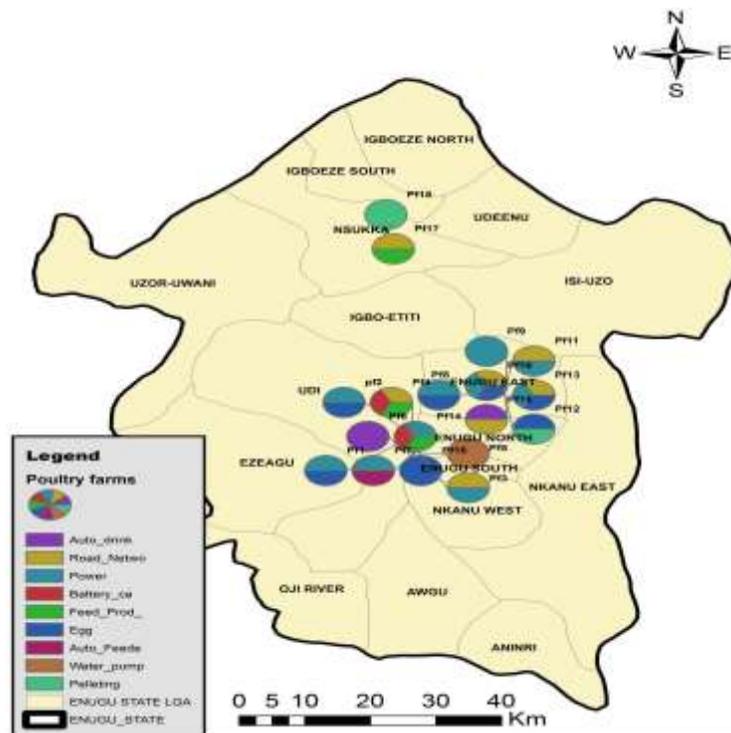

Figure 5. Map showing the location and mechanization needs of poultry farms at Emene, Ngwo and Nsukka.

Table 2. Identified mechanization needs and number of poultry farms involved.

S/N	Mechanization needs	Number of poultry farms
1	Automatic drinker	2
2	Road network	6
3	Power supply	10
4	Battery cage	2
5	Feed mill	4
6	Egg handling	8
7	Automatic feeder	1
8	Water pump	1
9	Pelleting machine	2
10	Waste handling	5
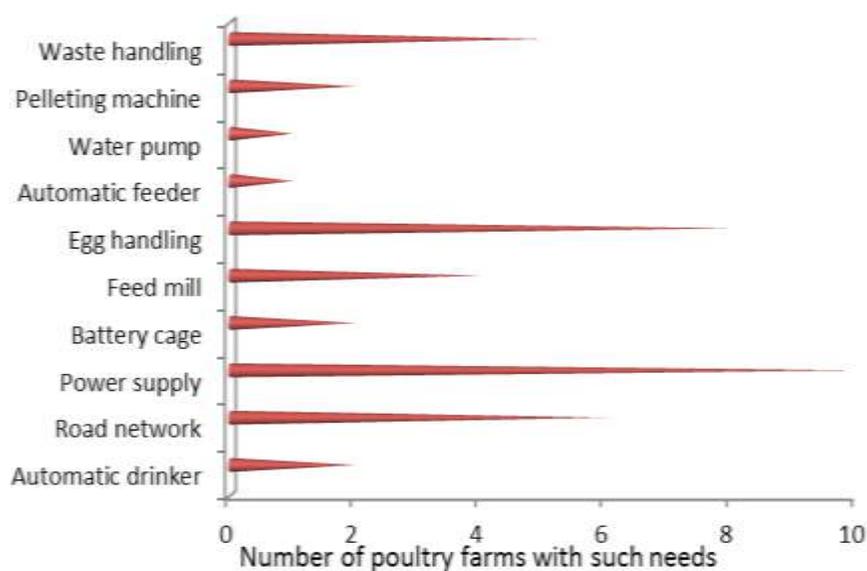
Figure 6. Mechanization needs of poultry farms in Enugu State.

either wheel barrows, hand trolleys or simply with plastic or metal containers/crates carried by hand to temporary storage rooms before they are moved to market. Significant damages are usually incurred depending on how careful the individual operators are, and this explains why up to 44% of farmers are requesting for better methods, tools or equipment for egg handling. 33% of the poultry farms indicated need for good road network; incidentally good roads are one of the major challenges facing the State as a whole. Responses from individuals interviewed during the survey revealed that many of the damages incurred on eggs usually occurred during transportation due to bad roads. This is so because majority of the poultry pens are usually situated in undeveloped areas of either semi urban or rural areas where the only access roads available are those initiated by the farmers themselves by just clearing the access lands with or without grading. Such roads are usually

susceptible to erosion and quickly develop pot holes; and without any form of maintenance, which is usually expensive, become very bad and almost unusable. About 28% indicated need for better waste handling equipment. It was observed that most farms use mostly hand tools for waste removal from the poultry pens and then move them with either hand push machines or tractors to designated dumping sites. At the site, they may be bagged and stored for sale to crop farmers as organic fertilizers. Some use water to flush out the waste to certain channels and away to either open lands or prepared ponds. About 22% indicated need for feed mills. Interacting with the farmers revealed that most of them buy their poultry feeds from dealers representing animal feed companies; therefore only very few venture into personal feed formulation and milling. Furthermore, only very few of the farmers are aware or even think of the need for specialized equipment such as: Battery cage,

automatic drinker, pelleting machine, automatic feeder, water pumps. This result is in line with what was earlier stated by Adene (2010), that the level of production determines the land space, scale, technological application and other input resources. That there were no poultry farms among those visited that indicated hatchery equipment, incubators and other related technologies as their mechanization needs suggests the level and type of poultry production going on in Enugu State. It is actually commonly reported that producers of day-old chicks are either scarce or nonexistent in Enugu and the whole South Eastern Nigeria, unlike the South West where it is more common to find many producers of day-old chicks. The reason for this is not very clear; some elite poultry farmers suggest that it is more about attitude than capital; since hatchery and production of day-old chicks require huge capital investment on equipment, waiting time to patiently develop the skill and practice, and involves certain level of risk, especially at the beginning. Notwithstanding, the fact remains that day-old chicks are constantly in high demand by poultry farmers in the South East and other parts of the country, which is an indication of a potential market.

Conclusion

Poultry has been identified by the World Bank funded Commercial Agricultural Development Program (CADP) as a value chain in the agricultural sector of Enugu State and thus has the potential for commercial agriculture. This work has investigated poultry farms in three production cluster areas in Enugu State namely: Emene (in Enugu East), Ngwo (in Enugu North/Udi) and Nsukka. The study identified the position of each farm, their specific mechanization needs and challenges limiting the performances of these farms. Position and mechanization data were represented in a map for easy and quick information, understanding and decision support which are useful to the government, non-governmental organizations, investors, researchers, consumers, etc. for improving and enhancing poultry production business in Enugu State. The farms visited produce eggs, broilers or layers or combinations of them; and the sizes of the farms range from units of thousands to tens of thousands of birds; these generally are commercial poultry farms but of a low or medium scale levels. The survey reveals that most of the poultry farms are having the following mechanization needs: Power supply, egg handling, road network, waste handling, feed mill, pelleting machine, battery cage, automatic drinker, water pump, and automatic feeder; however this depends on the level of production. Other problems or challenges facing the farms visited as observed during the survey are classified as management problems quantified as 60%, technical problems 30% and the problem of cost 10%. It is therefore concluded that if these needs and challenges

will become adequately tackled, poultry production in Enugu State will be greatly enhanced, thereby improving supply of egg, chicken meat, and layers for producers. Also more jobs will be created and this will positively impact on the economy of the State and the Country at large.

Recommendations

From the findings earlier stated, the following recommendations are made:

(i) There is need for continual workshops, training, enlightenment campaign and continuing education for poultry farmers; and this can be achieved through improved extension services by the various government and non-government agencies. This will help to address the management and technical problems/challenges encountered by the farmers.
(ii) The government should encourage the engineers and researchers through grants, incentives and favourable policies to develop indigenous technologies which will be affordable while adequately addressing the mechanization needs of the poultry farmers at their various levels of production, especially for egg and waste handling.
(iii) Necessary infrastructure such as good road network should be planned and implemented by the government to minimize all losses associated with bad roads and increase networking, marketing and associated business opportunities.
(iv) Considering that many of the machines used by high level commercial farmers are electrically powered, and the general need of electricity for lighting and simple heating; concerted efforts should be made by government and non-governmental organizations to provide steady electric power supply.

CONFLICTS OF INTERESTS

The authors have not declared any conflict of interests.

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