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Developing A GIS-Based Approach for Enhancing Revenue Management of Fish Cold-Room Businesses in Oyo East Territory, Oyo State, Nigeria

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ABSTRACT

Cold-room or Refrigerating Chamber is a post-harvest warehouse in which a specific temperature is artificially generated, maintained and purposely designed for storing products in an environment below the outside temperature. An ideal fish cold-room is a category of cold storage system usually design for frozen fish or kinds of seafood since the spoilage of post-harvest fish due to protein denaturation, fat changes and dehydration are experimentally slowed down by reducing the storage temperature. Fish is one of easily perishable protein foods that need careful handling but most traditional fish farmer in the study area always prefer to sell their fish in bulk at either profitable or unprofitable price during harvest time due to lack of adequate post-harvest fish preservative and processing techniques. Hence, the study aimed at developing GIS based approach for the available post-harvest fish cold-rooms in the study area to ensure effective control and management of revenue from this informal business. The objectives include: to determine the available number of fish storage cold-rooms and identify likely problems associated with cold-rooms storage businesses in the study area, to identify necessary practical measures for solving the so identified problems. Also, the methodology adopted includes database design, data acquisition using GPS and Scanner respectively and as well as creation of spatial and attribute database for the acquired Cold-rooms Storage Facilities using ArcGIS 10.2.2. Various results were generated that pointed in the direction of uneven distribution of the fish storage facilities. It is therefore recommended that it is necessary for various concerned Local Government Authorities to align with "Sustainable Development Goal's Fourteen (SDGs14th) [1] on Food Security from Life below Water" by encouraging the establishment of adequate Modern Post-Harvest Cold-rooms Storage Facilities within their territory and equally ensure that

they are always in good condition for public use.

Keywords : Cold-room, Management, Warehouse, Seafood, Storage-temperature, database.

I. INTRODUCTION

Low temperature is one of the keys in the transportation of live fish. At these conditions metabolic and respiration rates are so low that fish or crustaceans can be transported for a long time with high survival rates [2]. Temperature is one of the physical parameters that affects the life process of fish, because fish are poikilothermal animals whose body temperature is influenced by the temperature of their habitat so that metabolism is highly dependent on the surrounding environment [3]. Arable farmers who could not afford to get their products to the market due to poor transport and storage facilities were forced to sell them at very low prices to middlemen, who eventually made more money than arable farmers [4].

Creating of artificial spawning nests is the unique and inexpensive way to improve the environmental conditions of water bodies for fish spawning. Exploitation of spawning nests construction is based on the use of the biological characteristics of fish spawning and implemented in several stages, with considering climatic, hydrological and water temperature factors. Construction of nests protects fish eggs from destruction; they are advanced for specific species of fish and can be characterized by high efficiency of substrate development and increased output of viable young fish [5].

Cold Chain Management [6] emphasized that cold storage is one of the most important parts of the frozen food supply chain that is always linking the manufacturing process with transportation to the retailer. The supply chain is becoming more complex and increasing in lengths, it is more important than ever for cold storage provider to ensure that perishable products that are stored in their warehouses are kept within the strict temperature (normally -20°C and -28°C). Hence, the design of cold-room should analyze and always compare before choosing the best match for each business.

Code of Practice by Food and Agriculture Organization of United Nations [7] stated that frozen products should be stored at temperatures approximate for the species, type of products and intended time of storage. The code also expressed that the International Institute of Refrigeration (IIR) recommends the storage temperatures of -18°C for lean fish, -24°C for fatty species and -30°C for lean fish intended to be kept in cold storage for over a year. According to [8], [9] and [10], once fish is frozen, it must be stored at a constant temperature of -23°C (-10°F) or below to maintain a long shelf life and ensure quality. Problems posed by the conservation of perishable food items in the rural areas of Nigeria justify the interests shown on the application of solar energy for refrigeration; through solar energy has the limitation of intermittency and weather dependence but can be aided by back-up or auxiliary solar thermal energy storage device for continuous application during the period when solar power system is not available [11].

According to [12], many challenges of increasing fish supply to meet growing demand for food, reducing the food loss and waste will contribute to the

objectives of at least five out of targets of United Nations Sustainable Development Goals:

- ✓ No Poverty.
- ✓ Zero Hunger.
- ✓ Responsible Consumption and Production.
- ✓ Life below Water
- ✓ Partnerships for the Goals.

The long distance of distribution necessitates some processing and storage, as preservation through refrigeration is not readily available in Nigeria [13], Also, the insect infestation is the cause of most prominent losses in quality and quantity of stored, dried fish in Nigerian [14]. The need for the development of fish preservation and processing machinery and techniques for effective fish handling, harvesting, processing and storage can never be over-emphasized especially now that aquaculture production is on the increase in Nigeria [15].

1.1 THE STUDY AREA

The study area (Oyo East local government) is in Oyo town (see fig. 1) and was among additional ten local government area councils created in Oyo State during military governance in December 1996 having divided the then Oyo Divisional Council into three (Oyo east, Oyo west and Atiba). It is currently classified among the local government councils forming zone four (Oyo areas) based on the distribution of geographical zones and classification in Oyo State.

Oyo East local government Area is geographically bounded in northern part by Atiba L.G.A, in the southern part by Afijio L.G.A and in the eastern part by Ogo-Oluwa L.G.A. The land mass of the study area spread approximately between latitude of 7^0 45' 34" N and 7^0 58' 56" N and longitude 3^0 53' 31" E and 4^0 07' 06" E respectively (See figure 1 representing the geographical location of Oyo East L.G.A.).

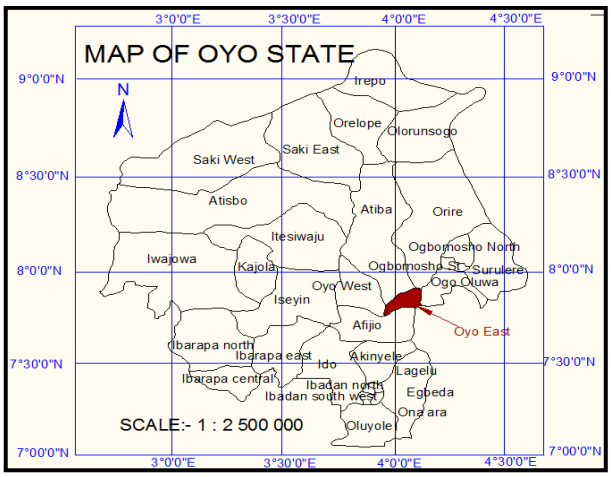

Figure 1. Map of Oyo State indicating Oyo East L.G.A. in Shaded Portion

1.2 CONCEPTUAL FRAMEWORK:

i. Data Representation: The real world objects of interest acquired in this study are represented as either raster or vector data.

ii. Database: Is the process adopted in this study to ensure that collected data for a particular area or subject for specific purpose are organized so that information can be easily accessed, managed and updated.

iii. Networking: the entire road connectivity within the study area (major road and streets) were digitized to form road network in order to ensure network analysis.

II. MATERIALS AND METHODS

The methodology section of this study involve:

- ➢ Database Design.
- ➢ Data Acquisition.
- ➢ Database Creation.
- ➢ Information Presentation.

2.1 DATABASE DESIGN

Database Design phase is made of three main stages, namely: Conceptual, Logical and Physical At the conceptual stage, basic entities were determined, the spatial relationships among the entities and attributes of each entity which supports the process and the

application for which the database is designed were considered and interested entities were represented as points, line and polygon which formed the basic data sets. Also, the logical phase translated the conceptual design to reflect the recording of data in computer system. Meanwhile, the relational data structure was adopted out of the existing hierarchical, network or relational approach. A sample of the records is shown in Tables 1,2 and 3.

Table 1. Point Table (Entities and Attributes)

Attribute Name	Description of Attributes
PE & PN	Easting and Northing of Available Fish Cold-room Storage Facility
C_CDT	Cold-room Condition
C_ADR	Cold-room Address
C_TR	Cold-room Tax-Rate
C_TYPE	Cold-room Type
C_OVIEW	Cold-room Overview

Table 2. Road Table

Attribute Name	Description Of Attributes
R_ID	Road Identifier Number
R_Status	Road Status
R _Length	Road Length

Table 3. Polygon Table

Attribute Name	Description Of Attributes
BDR	Boundary
ZN_1 and ZN_2	Zone 1 and Zone 2
ZN_3	Zone 3

2.2 DATA ACQUISITION

The datasets required were sourced from both primary and secondary data sources. The primary data were directly collected from the field with the aid of GPS and these include the following:

a) The location data of identified Cold-room Storage facilities that were not captured or precisely identified on the downloaded imagery were determined using Hand Held GPS.
b) Geometric coordinates of roads or streets that were not captured by the imagery as at time downloaded were also fixed by using GPS.
c) Other information (like road names through oral interview) that were taught useful in this study were adequately sourced through social survey.

The secondary datasets were also sourced from various sources:

a) Scanning and Digitizing of Administrative maps of the study area collected from Local Government Secretariat.
b) Downloading of Satellite Imagery of Oyo East LGA Administrative maps).

The georeferenced imagery, the GPS acquired data and digitized administrative boundary of Oyo East LGA were overplayed respectively using ArcGIS 10.2.2. and the shape file of the boundary of Oyo East LGA was traced out. The boundary was then partitioned into three zones 1, 2 and 3 respectively.

2.3 DATABASE CREATION

Geodatabase was created for acquired fish cold-rooms within the study area, they were captured into the database and the imported data for each of the entities were converted to shapefiles. The attribute data of each storage facility were populated into the database. Also, the shapefiles of the digitized entities from the

satellite imagery were integrated into the geodatabase in the Arc Catalog.

The geodatabase created for the identified cold-rooms within the study area contains the following:

(i) **(P_E) & (P_N)** represent the coordinates of each informal economic source.

(ii) **'Z_N'** that stands for zone in which each cold-room belongs to.

(iii) **'C_TR'** represents cold-room tax rate.

(iv) **'C_ADR'** is the address of the location of each cold-room facilities.

(v) **'C_TYPE'** represents the actual type of cold-room (is it water private or public own)?

(vi) **'C_CDT'** represents the condition of each cold-room (active or non-active)?

(vii) **'C_OVIEW'** is a brief summary or comments based on the gathered information.

III. IMFORMATION PRESENTATION

Composite map showing the spatial distribution of fish cold-rooms within the study area was produced (see figure 2). Also, various analyses were performed from the composite map as further presented and discussed as thus:

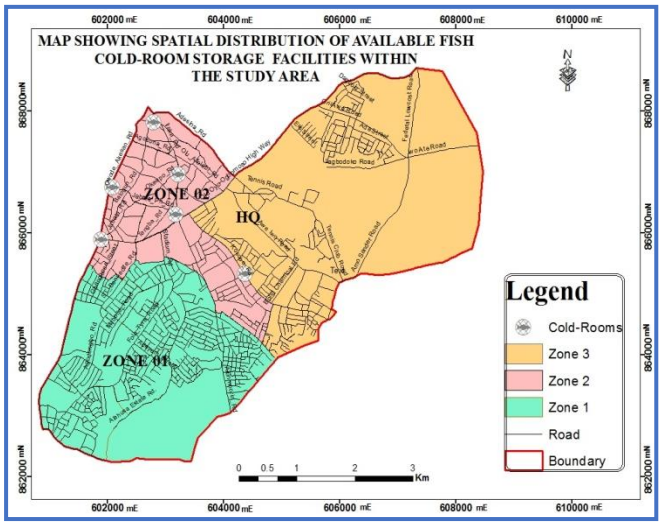

Figure 2. Map of Available Cold- rooms Storage Facilities within the Study Area.

Discussion:

Figure 2 is a map displaying spatial distribution of available six (6) cold-rooms within the study area. Based on the data acquired, the findings revealed that zero (0), Five (5) and One (1) cold-rooms are available in Zone 1, Zone 2 and Zone 3 respectively as at the time of capturing the data used for this study. As shown in Figure 2, the spatial locations of the existing cold-rooms were not evenly distributed within the study area. Meanwhile, fish is one of the easily perishable protein foods that need careful handling but most of indigenous or traditional fish farmers in the study area always prefer to supply and sell all their fish in bulk at profitable or non-profitable price during the harvest time as a result of lack of adequate post-harvest fish preservative, processing and storage facilities within the vicinity of the study area. Sad enough, the findings of this study also confirmed that majorly the imported/foreign species of fish are commonly available at the so identified cold-rooms. This is not encouraging enough in the part of those having the mind of venturing into the practice of aquacultures.

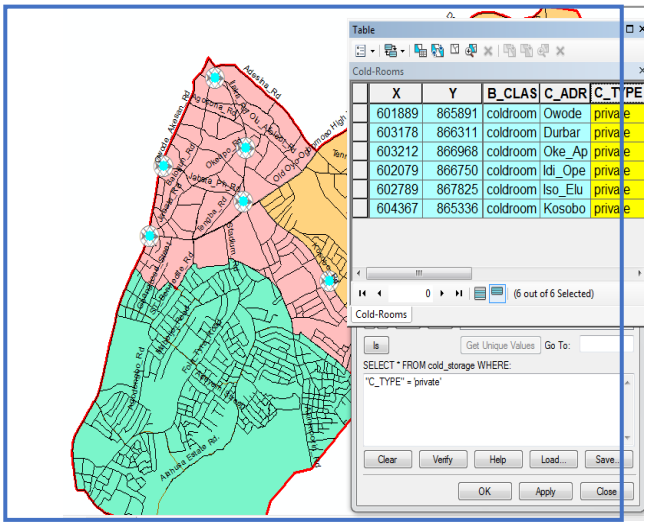

Figure 3. Result of Query Displaying All Private Owned Cold-rooms within the Study Area.

Discussion:

All the available Six (6) cold-rooms storage facilities were all private owned and no single one out of the

existing six (6) was owned by the concern state or local government authority. Graphically, the locations of the existing private cold-rooms are not evenly distributed within Oyo East Local Government Territory. This map could serve as a basic tool to provide vital information for the Local Government Authority in understanding what is where, planning and making rightful decision for the establishment of modern storage facilities for fish production and other agricultural products at will.

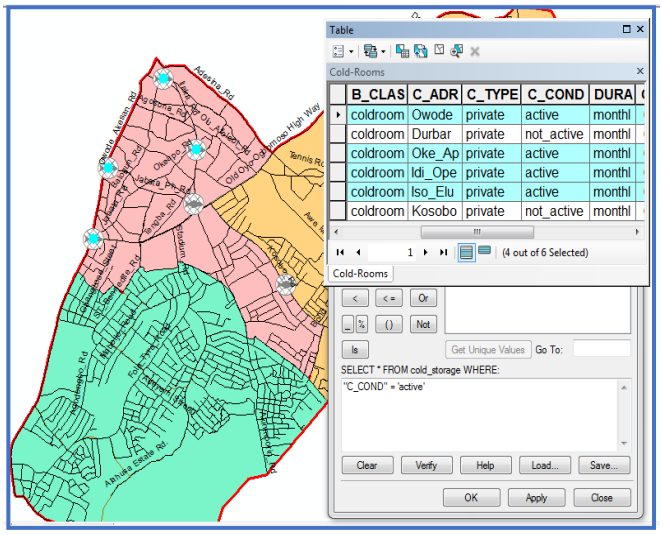

Figure 4. Result of Query Displaying All Active Cold-rooms within the Study Area

Discussion:

The Figure 4 shows the highlighted positions of the Four (4) active cold-rooms out of the Six (6) available within the study area. This is an indication that Two (2) were not in use and were tagged as "not-active" as at time of acquiring the data. Form the finding of this study, the two storage facilities were fold up as a result of high cost of running, fueling and maintaining the business due to inadequate supply of electricity.

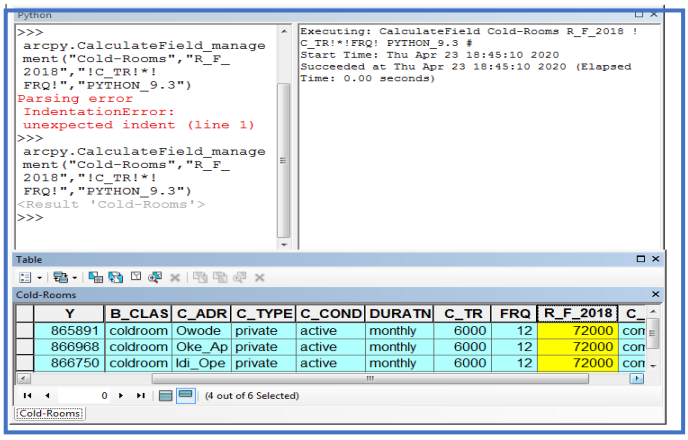

Figure 5. Python Interface Displaying the sample of likely Generated Annual Revenue from the Available Active Cold-rooms.

Discussion:

The figure 5 showcased in yellow column the annual revenue generation from each available active cold-room within the study area using Python written program in Arcpy. environment of ArcGIS 10.2 Software Version.

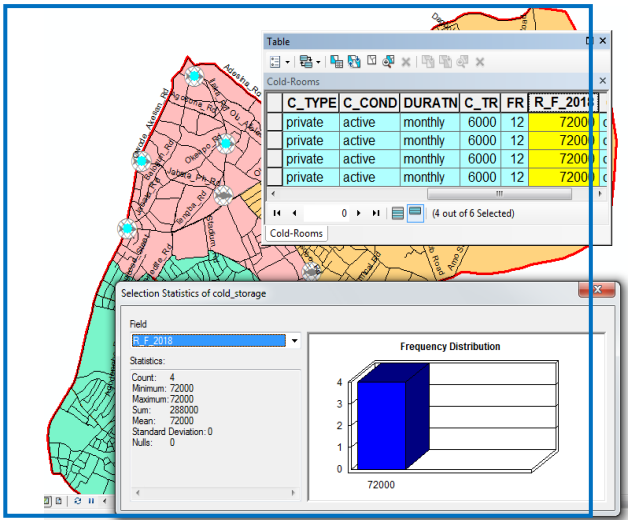

Figure 6. Result showing Annual Revenue that could be generated from all the Active Cold-rooms based on Monthly Tax Rate.

Discussion:

Based on the tax rate, the total amount of Seventy-Two Thousand Naira (72,000.00) could be generated annually from each private owned cold-room as shown in figure 6. If Government at Local levels now venture into construction and establishment of

modern cold storage facilities, then reasonable amount of revenue can be realized from this informal sector as well as process of empowering the youths.

Figure 6. Sample of Private Cold-room at Durbar Area, Oyo East L.G.A.

IV. CONCLUSION AND RECOMMENDATIONS

4.1 CONCLUSION

The acquired data were used to develop a geo-database for available fish cold-rooms storage facilities that were identified within Oyo East Local Government Territory. This could serve as a vital tool to understand the spatial distribution of cold storage facilities within the study area by the concerned authority and investigate the factors militating against this informal business in order to develop effective strategies to minimize these factors at will. The created geo-database was tested and has capabilities to search, retrieve, delete and update the information about each and every available cold-room. Cost of cold-room construction, maintenance cost, inadequate electricity supply among others are identified as the problems facing the private individual venturing into this kind of informal business. Having carried out these analyses, it was concluded that the aim and objectives of this study were achieved.

4.2 RECOMMENDATIONS

On the basis of the findings of this study, the following recommendations are put forward:

i) As part of Sustainable Development Goals (SDGs) especially target fourteen (14) on food security from life below water, every local government should take the establishment of modern and strategic storage facilities at subsidized rate as a serious and matter of necessity. This will in no exaggeration contribute indirectly to the SDGs objectives and at the same time serve as source of revenue from informal sector within their territory.

ii) Government should not only focus on the collection of tax from private storage operators but also ensure provision of adequate electricity supply to encourage more private investors in the business.

iii) Adequate training and seminar on modern techniques on fish nourishing, aquaculture should also be regularly organized at Local Government Authority levels in order to empower the interested and lazy youths as a means of poverty alleviation and job creation toward reducing the rate of unemployment in the country.

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