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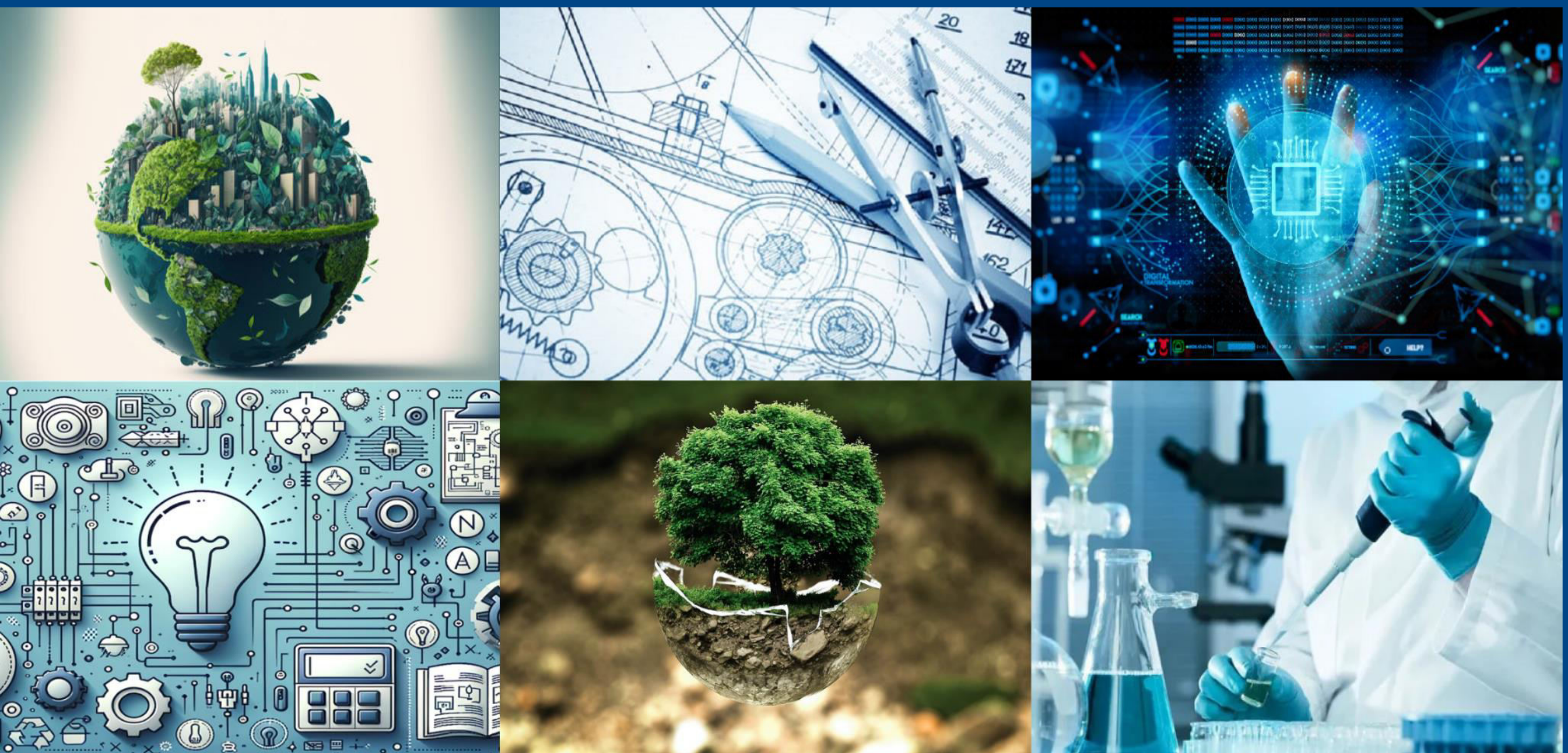

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Application of Unified Modelling Language Class Diagram for Flood Risk Management

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ABSTRACT: Flooding is a common occurrence in the Etsako Central Local Government Area of Edo State, Nigeria, claiming lives, property, and infrastructure. Effective flood risk management necessitates a systematic approach that incorporates multiple stakeholders, data, and processes. The goal of this study was to create an integrated model that incorporates the systems, policies, and agencies of flood risk management and land administration for the Etsako central local government region using the Unified Modelling Language (UML). The study employs a mixed-methods approach, combining both qualitative and quantitative methods. Data were collected through field observations, interviews, and questionnaires. The UML was used to model the flood risk management system and the class diagram. The study reveals that the current flood risk management in Etsako Central Local Government Area is inadequate, and there is a need for a more systematic and integrated approach to be employed to design a flood risk management system that integrates land administration and flood risk management stakeholders, data, and processes. The system was created to give accurate and up-to-date flood risk information, enabling effective flood risk management, and mitigate the effects of floods on communities. The report suggests implementing flood risk management and mitigating the effect of flooding on communities. It also suggests that stakeholders, such as local government officials, community leaders, and people, be trained to guarantee that the system is implemented effectively and sustainably.

KEYWORDS: Flood Risk Management, Land Administration, Unified Modelling Language (UML) approach, class diagram, Etsako, central

I. INTRODUCTION

A Unified Modelling Language (UML) class diagram is a graphical depiction of a system's static structure, displaying the classes, properties, and relationships between them (OMG, 2017). It is a fundamental diagram in object-oriented modelling that visualises, specifies, and documents a system's structure (Booch et al., 2005). A class diagram consists of four components: classes, characteristics, actions, and relationships. A class diagram has four sorts of relationships: association, generalisation, composition, and reliance. UML class diagrams provide stakeholders with a common language and notation for communicating and understanding the complex relationships between flood risk management components. They also make it easier to maintain and update flood risk management systems by providing a clear and concise representation of the system's structure and behaviour (Larman, 2005).

Flood risk management involves the identification, assessment, and mitigation of flood risks. Land administration plays a critical role in flood risk management by providing the spatial data and information necessary for flood risk assessment and mitigation (OMG, 2017). UML class diagrams can be used to model the relationships between land administration and flood risk management concepts, facilitating the design and implementation of effective flood risk management systems. Nigeria's flooding is primarily caused by human activities and made worse by interactions between nature and humans (Aderogba, 2012). Many elements, including socioeconomic and environmental (geographical characteristics of a place), as well as the structural and non-structural measures, might affect the adoption of a particular flood risk management plan (Adelekan 2016; Bubeck et al., 2017). Countries adopt strategies that work for their unique geographical circumstances to combat flooding (Bubeck et al., 2017). Due to flooding, many communities in Edo state have been removed and disturbed. The region's mangrove forest, which served as a natural habitat for fish and other aquatic animals, has been completely devastated by flooding. National flood management and control initiatives have received insufficient attention, and as a result, they have failed due to a lack of proper coordination (Okoye, 2019). Despite historical evidence of flood interventions, the absence of an integrated flood risk management (FRM) approach results in the adoption of suboptimal solutions, often leading to the creation of new problems. In 2017 there was unprecedented-scale flooding in areas of Port Harcourt city as a result of a faulty drain channelling to a burrow pit that overflowed during the rainy season, forcing water to pour into the nearby suburbs and causing flooding (Ezeaku, 2017).

The National Emergency Management Agency (NEMA) has a department of planning that uses Geographical Information System (GIS) to work on flood data, but there is still no effective national early warning system in place for floods at all levels of federal, state, and local government, whereas the National Meteorological Agency (NIMET) provides seasonal weather forecasts. This demonstrates that the government does not lack research institutions and agencies with the skills to design. Furthermore, there is a lack of integration and coordination among existing government organisations, which occasionally conduct flood control projects without consulting one another, resulting in control programs that are ineffective due to poor coordination (Oladokun and Proverbs 2016).

II. RESEARCH METHODOLOGY

The study focuses on the Etsako Central Local Government Area (LGA) in Edo State, Nigeria, which is prone to flooding due to its geographical and climatic conditions. Understanding the flood risk management in this area requires a systematic approach that can be effectively modeled using Unified Modeling Language (UML) class diagrams. By following this structured approach using UML class diagrams tailored specifically for Etsako Central LGA's unique challenges related to flooding, stakeholders can better understand risks and develop effective strategies for mitigation.

2.1 UML Class Diagram Development

Developing a UML class diagram involves several steps:

i. **Identify Classes:** Define key entities involved in flood risk management such as Flood Event, Risk Assessment, Mitigation Strategy, Community Response, and Infrastructure.

ii. **Define Attributes:** For each class identified, specify attributes that capture relevant characteristics. For example:

- **Flood Event** might include attributes like event ID, date Time, severity Level, affected Area.
- **Risk Assessment** could have attributes like assessment ID, risk Level, recommendations.

iii. **Establish Relationships:** Determine how these classes interact with one another:

- A **Flood Event** may relate to multiple **Risk Assessment** instances indicating various assessments conducted post-event.
- **Mitigation Strategy** may link back to specific **Infrastructure** projects aimed at reducing future risks.

2.2 Methodology Framework of the Research

For the designing of the model it depends on the collaboration and coordination between relevant government departments and agencies of land administration and flood risk management. This aspect was on integrating domains, policies and agencies of land administration and flood risk management to close the missing links between them and design a model that would be useful in management of land information in the contexts of natural disaster (flooding) and be applicable at international, national, local and community levels. The methodology was based on the actors, use case diagram and class diagram of UML. Integration of LA and FRM in the UML model emphasized the importance of land information in flood risk assessment. Accurate land information, such as land type and location, can significantly influence the assessment of flood risks. For instance, a land parcel located in a floodplain has a higher risk of flooding. By integrating these domains, it becomes possible to proactively manage flood risks, notify landowners of potential threats, and take preventive measures.

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2.3 Data Processing of the Integrated Model

Data presentation of the integrated model using the UML approach, will involve creating diagrams and models that visually represent the different components, relationships, and interactions within the land administration and disaster risk management systems. Class diagrams will be used to depict the entities involved (e.g., parcels, owners, disaster events) and Use Case diagrams will be used to outline the interactions between stakeholders and the system. The Unified Modeling Language (UML) was used in the designing of the integrated model. It is a standardized modelling language that provides a way to visualise system architectural blue prints in a diagram. UML is a powerful tool used to represent the interactions, entities, and processes involved in integrating the domains of Land Administration (LA) and Flood Risk Management (FRM). The lucidchart UML software was employed in the model design.

The research focused on the class diagram represents the static structure of the system, showing the system classes, their attributes, operations, and the relationships among objects. The classes, attributes, operations, and the relationships are:

a) Land parcel:
Attributes: (parcelID, owner, land type, area, location).
Operations: register( ), updateinfo()
b) Landowner:
Attributes: ownerID, name, contactinfo type, area, location.
Operations: registerLand(), updatelandinfo()
c) Flood disaster:
Attributes: (disasterID, type, severity, affectedArea).
Operations: (assessRisk(), notify())
d) GovernmentAgency (LA): Attributes: (agencyID, agencyName).
Operations: (updateLandInfo())
e) Flood Risk Management Authority (FRM):
Attributes: authorityID, authorityName).
Operations: (assessRisk(), notifyLandowners())
f) Relationships: Land Parcel is owned by Landowner.
Flood disaster affects land parcel.
Government Agency manages Land Parcel.
Flood Risk Management Authority assesses and manages flood disaster.
Furthermore, there is a lack of integration and coordination among existing government organisations, which periodically implement flood control projects without consulting one another, resulting in inefficient control programs due to poor coordination (Oladokun and Proverbs 2016).

2.4 Data Acquisition

The model was designed using UML's class diagram technique. Land administration and flood risk management principles, policies, and agencies served as the foundation for the design. The class diagram illustrates classes, properties, and relationships between them, whereas the use case diagram depicts interactions between actors (users or other systems) and the system under consideration. The classifications include land parcels, landowners, flood disasters, government agencies (LA), and flood risk management (FRM) authorities, whereas the players are landowners, government agencies (LA), flood risk management authorities (FRM), and the general public.

2.4.1 Data Collection and Sources

The first step in the data processing involves gathering relevant data from different systems, policies, and agencies associated with LA and FRM, including:

1. **Land Administration Data:** Collected from land registries, surveys, and land use planning systems. Data on land parcels (parcelID, owner, land type, location) and information related to ownership and land use is collected.
2. **Flood Risk Management Data:** Gathered from flood disaster records, risk assessment models, early warning systems, and disaster notification systems. Data on flood disasters (disasterID, type, severity, affected areas) is included.

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III. RESULTS AND DISCUSSION

3.1 Data Presentation of the Integrated Model

The section explains the various objects, connections, and notations used in class diagrams to integrate the Land Administration (LA) and Flood Risk Management (FRM) systems.

3.2 Class Diagram Notation and Relationships

3.2.1 Notation

When developing UML class diagrams, a variety of notations are used. The most popular class diagram notations are shown (Rumpe, 2016).

3.2.2 Class

Classes represent the system's main components. Its representation is a rectangular shape with up to three compartments. The first one shows the class name, while the middle one shows the class's attributes—that is, the features of the objects. The operations listed at the bottom represent the class's behaviour. The remaining two sections are optional. A simple class is one that only contains the class name and lacks the final two compartments as shown in Figure 3.

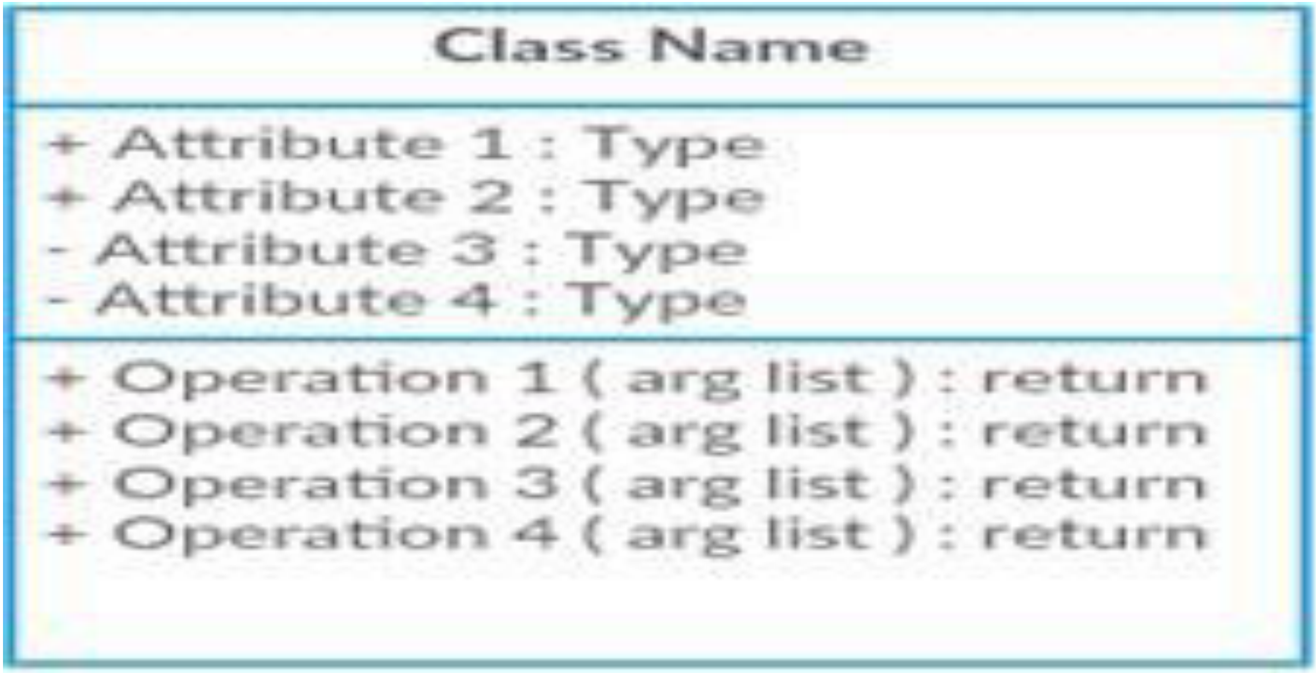

Figure 1: An example of the Class Notation

3.2.3 Interface

In class diagrams, the interface symbol denotes a collection of operations that would specify a class's responsibilities as shown in Figure 4.

Figure 2: An example of the Interface Notation

3.2.4 Package

Classes or interfaces that are related or have comparable characteristics are grouped together using the package symbol. The diagram is easier to read when these design aspects are grouped using the package symbols as indicated in Figure 5.

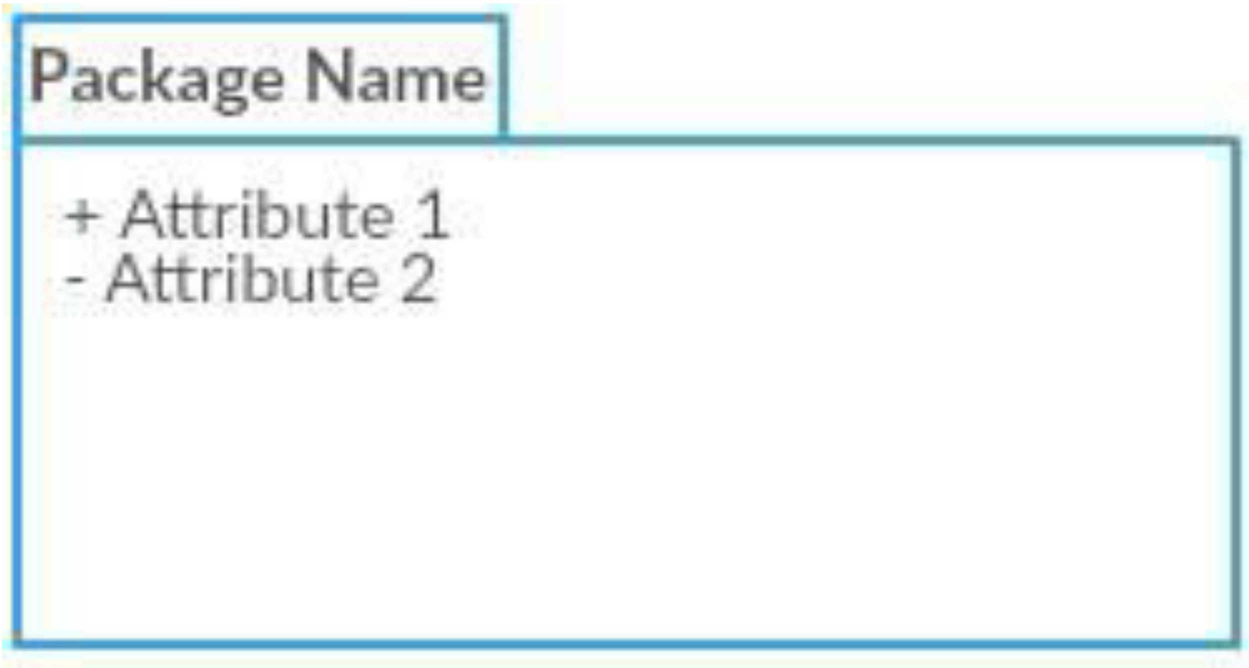

Figure 3: An example of the Package Notation

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3.2.5 Relationship

Class diagrams depict how multiple classes collaborate and interact inside a system, therefore it is critical to understanding the relationships depicted in them. UML class diagrams incorporate numerous types of relationships, as shown in Table 1.

Table 1: Class diagram relationship

Type	Notation	Description
Association		Is used to show generic relationship where one class is related to another.
Inheritance		Is a hierarchical relationship where one class inherits attributes and methods from another class (parent-child or superclass-subclass relationship).
Realization		Is used to illustrate that one class implements the behavior defined by an interface.
Dependency		Is a weaker relationship where one class depends on another but does not "own" it. This often indicates that one class uses another in some way.
Aggregation		This is a type of association that represents a whole-part relationship, where the part can exist independently of the whole.
Composition		Is a stronger form of aggregation, where the part cannot exist without the whole. If the whole is destroyed, the parts are also destroyed.

3.2.6 Class Diagram of Land Administration (LA) and Flood Risk Management (FRM)

The Class Diagram provides a detailed view of the structural relationships between different entities in the system. It highlights how data is stored, managed, and processed across the Land Administration and Flood Risk Management domains. Key classes in the system include:
Land_Parcel,
Landowner,
Flood_Disaster,
Government_Agency,
FloodRisk_ManagementAuthority, and Land_InformationSystem.

The Land_Parcel class represents individual parcels of land, containing attributes such as parcelID, land_Type, area, and location. Each land parcel is owned by a Landowner, forming a many-to-one relationship where multiple parcels can be owned by a single landowner. The Landowner class contains information such as ownerID, name, and contactInfo, which helps in identifying and managing the owner's relationship with their land parcels. The Government_Agency class represents the administrative body responsible for managing land parcels. The relationship between the Government_Agency and Land_Parcel is one-to-many, as a single government agency manages multiple land parcels. The Flood_Disaster class represents flood events that affect specific land parcels. The relationship between Flood_Disaster and Land_Parcel is many-to-many, as multiple flood disasters can affect multiple land parcels, and vice versa. Furthermore, the FloodRisk_ManagementAuthority plays a key role in assessing flood risks, establishing a one-to-many relationship with Flood_Disaster instances, as one authority assesses multiple disasters. The Land_InformationSystem acts as a central repository, storing both land data and flood risk data. This system maintains

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a one-to-many relationship with both Land_Parcel and Flood_Disaster, as it handles multiple land and disaster records within its database.

Overall, the Class Diagram illustrates how different entities are interconnected in the system, with each class contributing to the management and mitigation of flood risks. The Land_InformationSystem serves as the backbone for storing and retrieving critical data, while the Government Agency and FloodRisk_ManagementAuthority work collaboratively to ensure that land parcels are effectively managed and flood risks are accurately assessed. Figure 6 shows the class diagram for LA-FRM system.

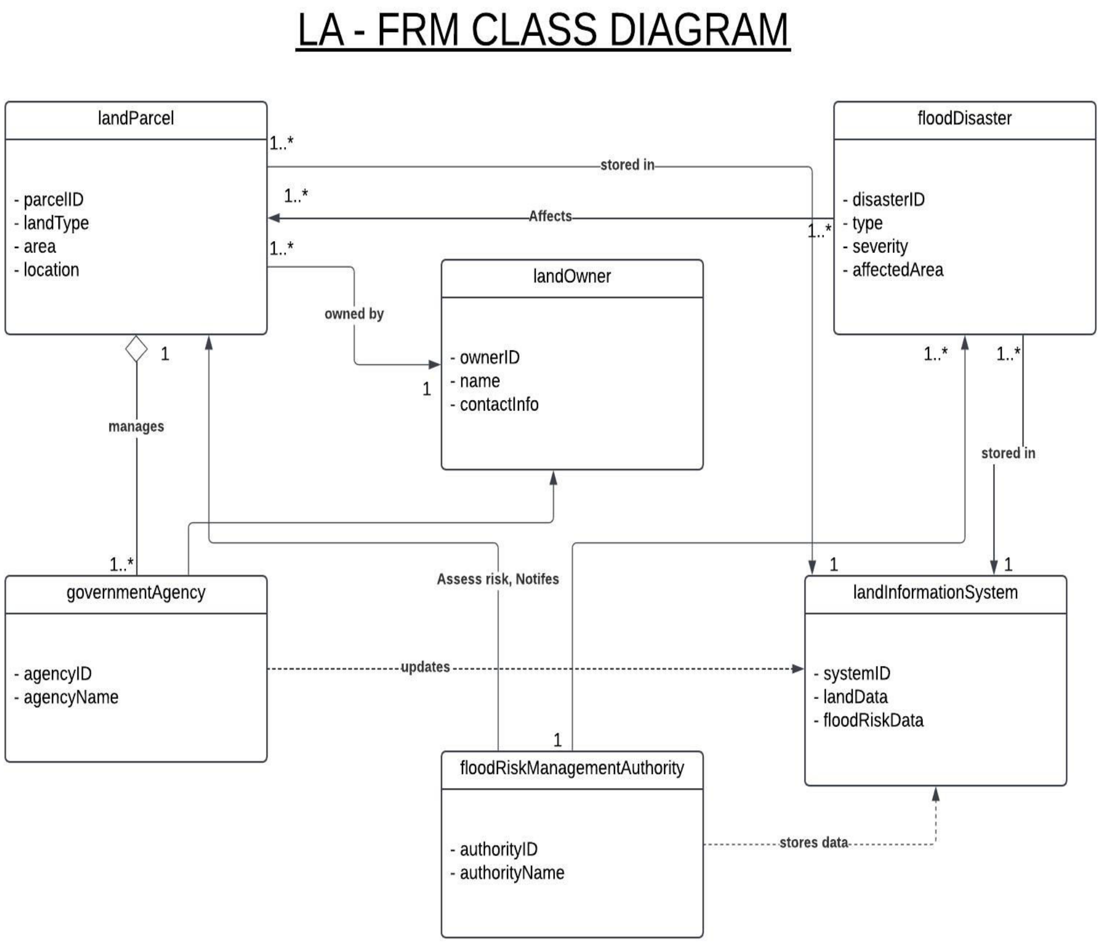

Figure 4: Class Diagram of Land Administration (LA) and Flood Risk Management (FRM)

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The Class Diagram illustrates the operational structure of the integrated flood risk management and land administration. The Class Diagram clarifies the relationships between various entities within the system. The diagram provides a comprehensive view of how land information and flood risk data are managed, ensuring a streamlined and efficient approach to disaster mitigation and land management.

IV. CONCLUSION

Flood risk management is a serious issue in Etsako Central Local Government Area, Edo State, Nigeria. UML class diagrams have been presented as a method for designing and assessing flood risk management systems. This study used UML class diagrams to depict the links amongst flood risk management and land administration principles in Etsako Central LGA. The researchers discovered that UML class diagrams may be used to identify, assess, and decrease flood threats in the study area. The use of UML class diagrams for flood risk management in Etsako Central LGA, Edo State, has proven to be effective. The use of UML class diagrams provides a structured approach to modelling and assessing flood risk management systems, allowing for the identification of possible flood risks and the creation of effective mitigation strategies. The study advises using UML class diagrams to reduce flood risk in Etsako Central LGA and other flood-prone locations.

V. RECOMMENDATIONS

The following recommendations were made that:

1. Edo State Government and the Etsako Central LGA should adopt the use of UML class diagrams as an instrument for risk management of flood.
2. Edo State Government and the Etsako Central LGA should provide training and capacity-building programmes for stakeholders on the use of UML class diagrams for flood risk management.
3. The UML class diagram should be integrated with existing flood risk management systems and land administration systems in Etsako Central LGA.
4. Edo State Government and Etsako Central LGA should continuously monitor and evaluate the effectiveness of the UML class diagram in flood risk management.
5. The Edo State Government and the Etsako Central LGA should engage with the local communities to raise awareness about flood risk management and use of UML class diagrams.

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