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Software Development Group Project

Coursework 01 - Group Report

Group CS-152

LandLytics

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I. Declaration

We hereby certify that this project report and all its artefacts associated with it is our own work and it has not been submitted before nor is it being submitted for any other degree programs.

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II. Abstract

Land evaluation and construction planning in Sri Lanka are processes that require many elements to be taken into consideration, such as ensuring the plan complies with countless regulations, avoiding environmental risks and abiding by zonal restrictions. Several industry surveys have reportedly proven that parties attempting to abide by the mentioned elements have experienced challenges while doing so, which leads to inefficiencies, project delays and financial losses.

The LandLytics project exists to address the many challenges faced in this regard by providing the relevant parties with an innovative web-based application, developed specifically to give the users a comprehensive, location-based insight into the regulations, environmental risks and property design feasibility applicable to their land.

The application includes three key features to assist in simplifying the land evaluation process- namely, generating reports that filter the regulatory information based on specific land locations and construction types, generating a risk awareness and analysis report using geospatial data and satellite mapping to identify various risks and providing the user with property plan annotations which highlight violations and provide suggestions for adjustments.

We aim to provide a diverse set of stakeholders, including land buyers, architects, developers and legal advisors with a basis to make informed decisions, to bridge the knowledge gap among stakeholders and reduce the likelihood of project rejections by relevant government departments. With the integration of technologies such as Natural Language Processing (NLP), Geographic Information Systems (GIS), Computer Vision and several others which are elaborated throughout this report, LandLytics will transform the land and construction industry with a user-centric platform that adheres to the project goals as well as regulatory and environmental safety standards.

Keywords: Land evaluation, Construction planning, Regulatory compliance, Environmental risk analysis, Geospatial data, Property annotation.

III. Acknowledgement

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VII. Table of Abbreviations

Abbreviation	Explanation
API	Application Programming Interface
DDD	Domain Driven Design
DFD	Data-Flow Diagram
GIS	Geographic Information System
IDE	Integrated Development Environment
MLM	Multimodal Language Models
MLP	Multilayer Perception
NBRO	National Building Research Organization
NLP	Natural Language Processing
NLTK	Natural Language Toolkit
OCR	Optical Character Recognition
OOD	Object Oriented Design
SSAD	Structured System Analysis and Design
UDA	Urban Development Authority

Chapter 1: Introduction

1.1 Chapter Overview

The first chapter provides an overview of the essential elements involved in the project. It includes the background and context of the problem, a clear problem statement, and an outline of the proposed solution. Additionally, this chapter gives insight into the project's goals, defines the project scope, and presents a rich picture diagram that helps to visualise the problem context. It also outlines the resources required. The chapter concludes with a summary, encapsulating everything necessary for the system development.

1.2 Problem Background

1.2.1 Legal Requirement for Proposal Approval

In Sri Lanka, the government mandates that all building proposals must be reviewed and legally approved before any construction begins.

As per the section 8(j) of Urban Development Authority Amendment Act No. 04 of 1982 any development activity with in a declared urban development area, as per the provisions given under Development Authority Act No. 41 of 1978, is required to obtain an approval from the Urban Development Authority (Urban Development Authority, Sri Lanka, 2024)

In addition to the legal requirement, this regulatory step is critical to ensure that construction projects align with urban planning, safety standards, and environmental considerations.

However, navigating the complex approval process can be challenging for many applicants. An article, discussing 'Making Residential Buildings in Sri Lanka Sustainable through Building Regulations', notes the issues with the current government approval process for buildings and

constructions. It mentions the lack of support and convenience provided by both the government and the approval process. (Senadeera, Gunasekara and Perera, 2019)

	Steps	Procedure	Negative impacts
01	Commencement of the process	Obtain clearance from the relevant authorities.	• **Insufficient encouragement received from the government and political issues** • **Technical issues** • **Clients' lack of knowledge** • **Financial issues** • **Insufficient support received from the management** • **Social and cultural differences unique to Sri Lankans** • **Drawbacks of the Sri Lankan education system**
02	Submission of documents for preliminary clearance	Submit the clearance report along with the application.	
03	Granting of the Approval	Grant approval if documents comply with the relevant requirements.	
04	Submission to get the plan approved	Get the design certified by professionals.	
05	Analysis of the application and other documents	Obtain reports from the relevant government officials.	
06	Approval (by the UDA/ local authority)	Grant approval if the documents comply with the relevant rules and regulations.	
07	Approval/rejection by the Planning Committee (local authority/ UDA)	Provide the final decision by either approving or rejecting the application after considering the problems/issues that have arisen.	
08	Issuing of the building permit	Get the building permit from the UDA/ local authority.	
09	Issuing of the Certificate of Conformity(COC)	Get the Certificate of Conformity (COC) from the UDA/ local authority.	

Figure 1 - Negative Impacts of the Plan Approval Process on Ensuring the Sustainability of Residential Buildings (Senadeera et al., 2019)

1.2.2 The Need for Land Evaluation

Land evaluation plays a crucial role in ensuring that a land is suitable for an intended project/purpose. LandLytics's significance is highlighted by the challenges faced when land is not properly assessed and construction regulations are not accurately met, often resulting in proposals that do not meet the necessary criteria and are in turn rejected by urban development authorities. Such issues can lead to regulatory non-compliance, environmental risks, and ultimately unexpected costs and project delays, thereby emphasising the importance of thorough land evaluation before initiating construction projects or investing in land purchasing decisions.

Going into a construction project with as much information as possible can help to make sure work runs smoothly and without delays. Site investigations, such as an analysis of soil conditions and existing infrastructure, can provide valuable insight that helps inform the design process.
Detailed drawings which definitively identify material assortment, locations and sizes can also help everyone be on the same page before any construction begins. By taking the time to research and plan, projects can move forward without worrying that something wasn't thought of. Investing in quality information helps keep everyone productive and efficient (Burns, 2023).

1.2.3 Issue of Rejection

Despite the legal requirement, a notable number of building proposals are rejected annually.

Regulations are very detailed and are issued under a vast number of categories. The current system in Sri Lanka for issuing regulations only requires the government to gazette and publicise these regulation documents as hard copies. The issue lies in the fact that only a selected number of these legal documents are conveniently available on government websites as soft copy documents for convenient reference. Additionally, whenever new regional regulations are passed, they are unlikely to be updated in the websites in a timely manner. Therefore, the complexity of the regulations and the inconvenient availability of them to the public is the major issue the Municipal bodies and authorities have noticed as the number one cause of building proposal rejections (Head Public Health Officer, Moratuwa Municipal Council, personal communication, 31st October 2024).

Land evaluation plays a crucial role in ensuring that land is suitable for intended projects/purposes. This project's significance is highlighted by the challenges faced when land is not properly assessed, often resulting in proposals that do not meet the necessary criteria and are subsequently rejected by urban development authorities. Such issues can lead to regulatory non-compliance, environmental risks, and unexpected costs, underscoring the importance of thorough land evaluation before making investment decisions.

In Sri Lanka, there is currently no solution offering a comprehensive land evaluation tool. Although a few documents exist, none provide a full-service platform that addresses these issues. This project aims to introduce a new approach by offering a reliable system that fills this gap, providing land buyers and architects with the necessary tools to evaluate land and comply with regulations before committing to constructions.

1.2.4 The Problem

The lack of a comprehensive land evaluation and optimisation system in Sri Lanka has led to numerous issues for land buyers and developers.
Prospective land buyers and developers often encounter significant obstacles, including;

1. **Challenges of manual sorting and verifications**
   The process of manually sorting and cross-referencing these regulations is tedious and impractical and increases the risk of errors and omissions, complicating the planning process.

2. **Increased likelihood of plan rejections**
   Due to the complexities and manual processing, there is a higher chance that property plans will be rejected when submitted to the UDA for approval.
   Rejections can result from overlooked regulatory requirements or incomplete documentation.

3. **Regulatory prioritisation**
   Identifying which regulations are given priority during the approval process remains unclear, adding to the complexity of securing approvals.

1.2.5 Example Scenarios

1. **Land buyers/Real estate/Investors/clients**

   A land buyer invests in property for commercial construction, assuming it meets general regulations. However, upon submitting the project for approval, it was rejected due to failure to comply with commercial regulations. After attempts to gain illegal approval, the construction proceeds, leading to legal and financial complications post-build.

   Example: A client plans to build a press in Ratmalana, purchasing land that meets general rules. After approval, the construction type becomes an issue due to environmental concerns like chemical and sound impact, forcing the client to abandon the project after substantial investment.

2. **Architects**

   An architect starts the design process with general regulations in mind, but upon submission, discovers it does not meet specialised regulations, leading to costly and time-consuming redesign.

   Example: An architect plans a coastal construction with a 60% plot coverage, only to learn that tourism projects are limited to 30%, forcing the entire design to be reworked from scratch.

3. **Government Authorities**

   Authorities review each project for compliance, a repetitive and time-consuming process. After rejection, they must re-evaluate updated submissions, and regulatory inconsistencies across authorities delay real-time feedback.

1.2.6 The Significance of the Project

The significance of this project lies in its potential to revolutionise land evaluation and optimisation by introducing a centralised, data-driven.

Key contributions of this project include:

1. **Streamlined Land Evaluation**

   The platform simplifies the land assessment process, offering real-time data on conservation areas, regulations, and environmental impacts, allowing users to make quicker, well-informed decisions.

2. **Advanced Analytical Tools**

   Utilising analytics and location-based insights, the project provides forward-looking recommendations to specific lands.

3. **Informed, Compliant, and Sustainable Decisions**

   By providing comprehensive data, the platform supports land buyers, designers, and regulatory authorities in making decisions that comply with legal standards, reduce project delays, and are environmentally responsible.

4. **Efficiency and Resource Optimization**

   The platform encourages efficient land use by reducing costly project delays and promoting resource optimization.

5. **Promotion of Sustainable Development**

   As an innovative solution, this project fosters responsible land development practices, helping users stay informed on environmental impacts while advancing resource efficiency.

1.2.7 The Magnitude of the Problem

Securing approval for land use and ensuring that proposed building design aligns with specific land requirements are critical steps in real estate development. Navigating these processes can be complex, as they involve multiple stages, from regulatory compliance to technical feasibility assessments. Key issues, such as limited access to submission records, unclear approval criteria, and inconsistent availability of data create significant obstacles for prospective land buyers and developers.

A research conducted by The Institution of Engineers in Sri Lanka, on the “Causes and Effects of Delays in Construction of Medium Drinking Water Supply Projects in Sri Lanka", ranked the major causes for design related project delays, in respect to the project proposal drawings of the projects in question. (Perera and Halwatura, 2017)

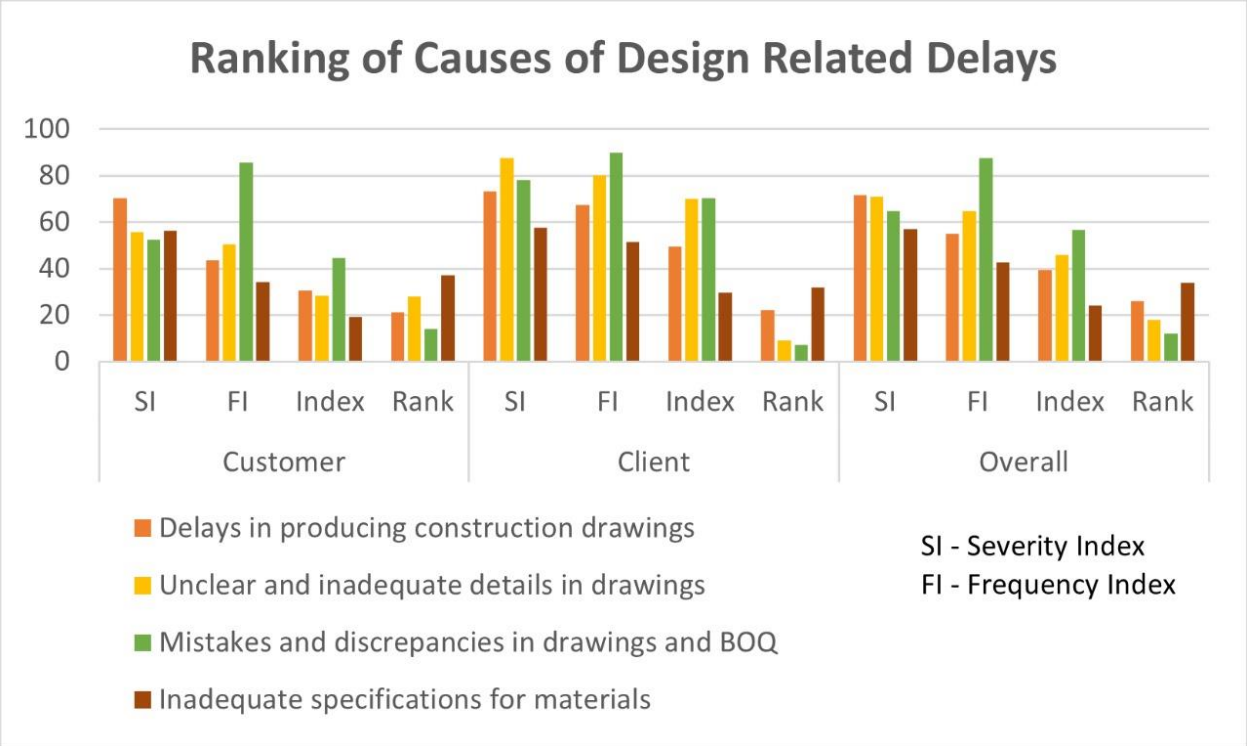


Figure 2 - Causes and Effects of Delays in Construction of Medium Scale Drinking Water Supply Projects in Sri Lanka, (Halwatura and Perera 2017)

A research published by the Faculty of Civil and Environmental Technology at the University of Sri Jayewardenepura, on the "Study on Time Overrun related to Construction Projects in Sri Lanka', listed the top 14 reasons identified for the delay of construction project completions. (Arulvel and Widisinghe, 2022) Five of the fourteen listed reasons are related to the plan proposal and land evaluation issues; highlighting the significant contribution these factors have towards construction delays and issues in Sri Lanka.

No	Factor	Rank	Group
1	Improper planning	1	Contractor
2	Mistakes during construction	2	Contractor
3	Preparation and approval of drawings	2	Consultant
4	Weather condition	4	External
5	Site management	5	Contractor
6	Change orders	6	Contract
7	Owner interference	7	Client
8	Slow decision-making by owners	8	Client
9	Shortage	9	Material
10	Lack of communication between the parties	10	Contract Relationship
11	Change owners/consultant	11	Contract
12	Finance and payments of completed work	12	Client
13	Waiting time for approval of tests and inspections	12	Consultant
14	Labor supply	12	Labour

Figure 3 - Top fourteen factors for time overruns related to construction projects in Sri Lanka. (Arulvel and Widisinghe, 2022)

A survey, conducted and published by a student research team in the Department of Quantity Surveying at the General Sir Kotelawala Defence University, highlighted the opinions of clients, contractors, consultants and other related parties on the factors affecting the delay in building construction projects in Sri Lanka. (Muthumalki et al., no date) This survey placed 'changes in government regulations and laws' as the most significantly identified reason while 'delay in obtaining approvals from government regulated bodies' had been agreed as a significant contributor as well.

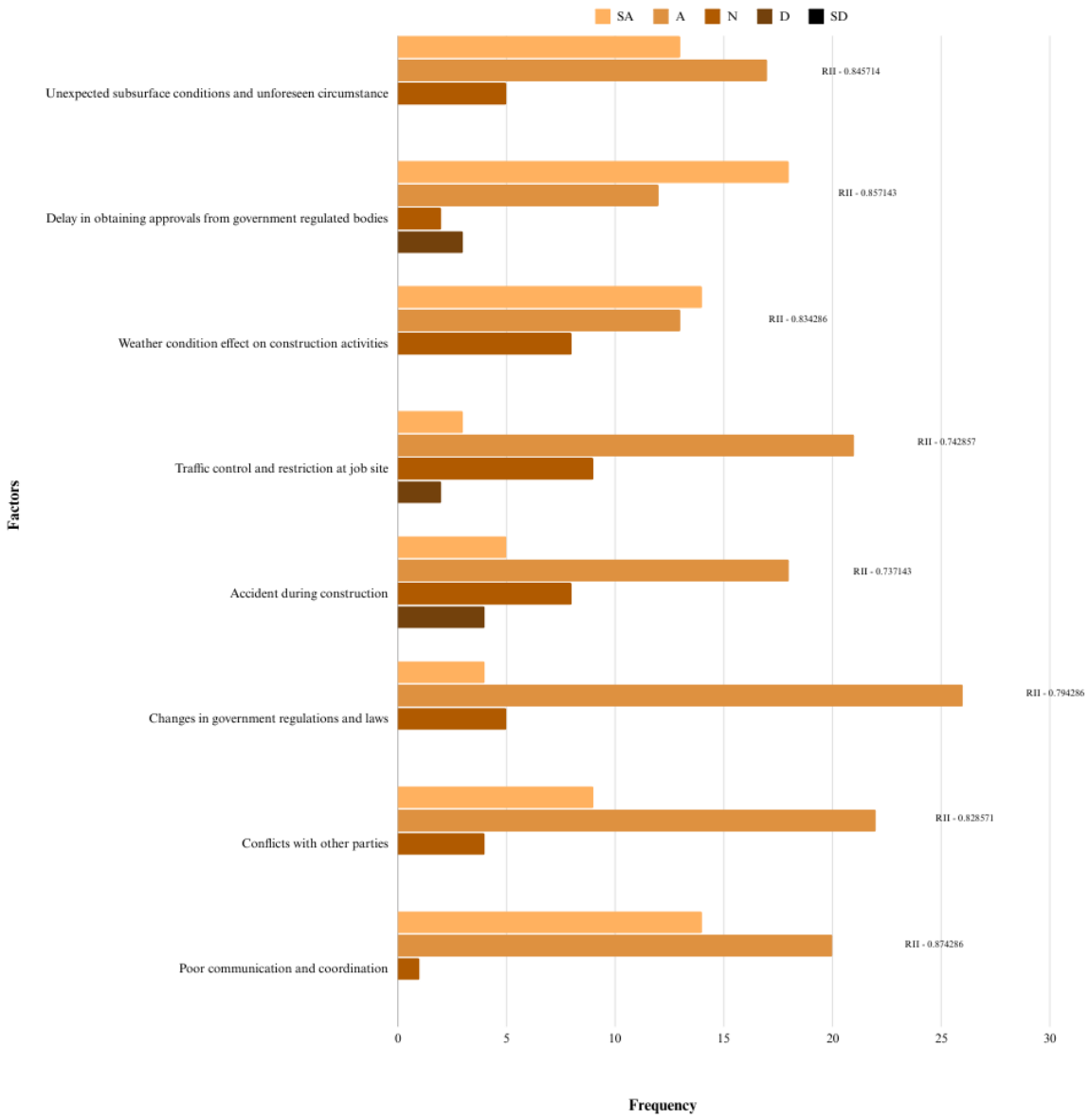


Figure 4 - Category based ranking of factors causing delays in construction projects in Sri Lanka (Muthumalki et al., no date)

These findings emphasise the challenges in achieving project accuracy and underscore the significance of systematic documentation and technology in improving project outcomes.

1.3 Problem Statement

The process of obtaining approval for land use and verifying that proposed building designs are suitable for the designated land area is fraught with challenges.

The lack of a comprehensive land evaluation and optimisation system in Sri Lanka has led to numerous issues for land buyers and developers. Without proper insights into land regulations, environmental factors, and feasibility, projects often face costly delays and regulatory rejections.

1.4 Proposed Solutions

1. **Providing real-time details of conservation areas, regulations, and solutions related to the land**

   This provides users with up-to-date information on conservation areas and land-use regulations. It also offers solutions to ensure compliance with environmental laws, making land assessment more comprehensive.

2. **Predicts maximum building size based on land size**

   This system will be developed to calculate the maximum allowable building size based on zoning laws, land area, and other relevant factors. It helps users determine the most efficient use of the land and avoid costly planning mistakes.

3. **Automated legal/permit assistance and local contractor recommendations**

   This system aims to offer automated guidance on obtaining legal permits and complying with local regulations.

1.5 Aim

To **design, develop and evaluate** a web-based user-friendly application that helps users locate land, associated risk factors and generate annotated building plans and test the system to ensure functionality, accuracy in risk assessment, and usability in diverse scenarios.

1.6 Project Scope

The scope of this project is to create a platform that simplifies the understanding of policies related to land buying & evaluation.

1.6.1 In-Scope

1. Provide land owners and architects insights into land quality and highlight benefits and potential uses.
2. Assess the effects of proposed land use change on the environmental impact.
3. Generate automated reports based on evaluations.
4. Sync with government databases for up-to-date information on policies or land changes.

1.6.2 Out-of-Scope

1. This project does not have the authority to grant or deny approvals for land development proposals.
2. The app functions independently from any government agencies, including the Urban Development Authority (UDA), and does not offer official endorsements, approvals, or rejections of property plans.

1.7 Rich Picture Diagram

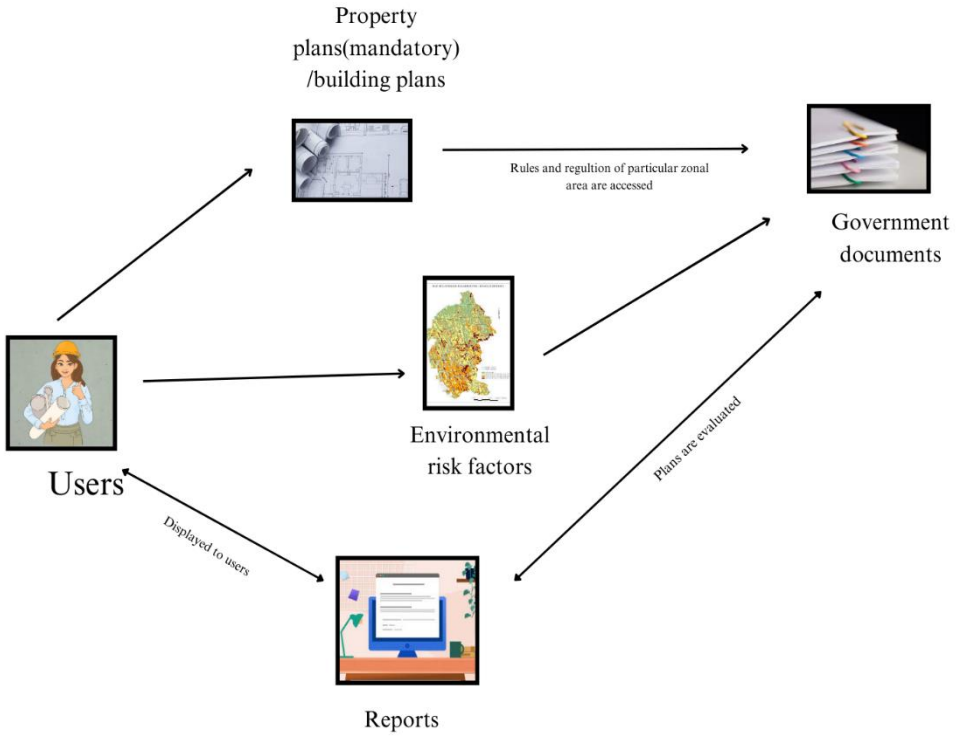


Figure 5 - Rich Picture Diagram for the LandLytics Project

1.8 Resource Requirements

1.8.1 Hardware Requirements

Hardware	Minimum Requirement	Purpose
Device	Laptop/computer with at least Intel Core i5 or higher	Should be capable of multitasking, as many software are used image processing is needed for map analysis, property plan analysis, and large datasets of regulations are analysed to display as a report.

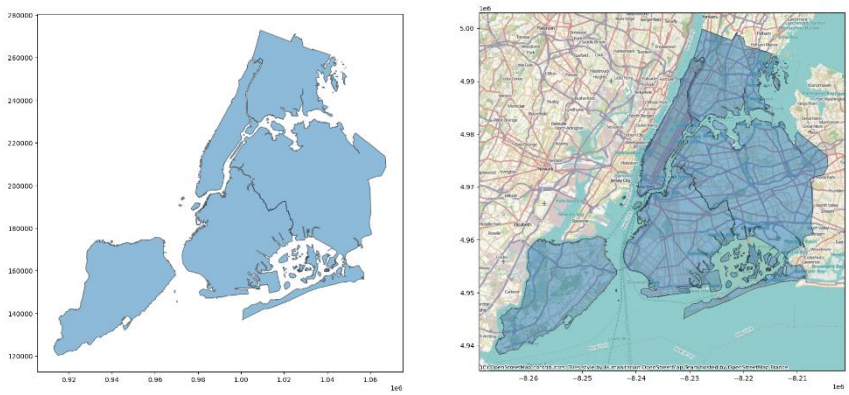
Memory / RAM	8 GB RAM or higher	For complex image processing including interactive maps using computer vision libraries and storing the large datasets.
Graphics Processing Unit (GPU)	8 GB GPU VRAM	For complex image processing, storing and managing graphics-related data when analysing maps and property plans.
Storage (SSD)	256 GB SSD, 512 GB SSD better	For high-resolution image processing, handling large datasets for complex map analysis and handling large datasets.
Network Infrastructure	Routers, Switches, Load balancers. High-speed and stable Wi-Fi	To transfer data continuously, a high-speed and stable Wi-Fi connection is required. When handling the user inputs and the large datasets related to the location of the land, load balancers are required to maintain reliability and to adjust according to the scalability.
Operating System	Windows 10/11	Compatible with large dataset handling, image processing, and other requirements.
Server	AWS(Amazon Web Services) / Google Cloud	A cloud-based server will be used to store data, as it allows adjustment according to the scalability and usability of large datasets while providing remote access.

Table 1 - Table 1 - Hardware Requirements for the LandLytics Project

1.8.2 Software Requirements

Software Requirement	Purpose of the Requirement
Programming Languages	
Python	For the LandLytics app, Python language is used to extract regulations as texts from PDFs using PyMuPDF and Natural Language Processing (NLP) libraries to identify the regulations accurately. Python can be used for image processing by OpenCV algorithms, satellite mapping, retrieving coordinates, and for GeoPandas machine learning library to easily work with geospatial data. Additionally, Python is used with the MapReader library to analyse and annotate the property plan provided by the user.
JavaScript	For the Risk analysis feature, an interactive geospatial satellite map in GeoJSON format should be analysed to identify the risk areas when the user inputs the location, then the coordinates should be retrieved and mapped with the risk map to see if there are landslide risks in that area.
IDEs/ Tools	
PyCharm	LandLytics application will be hosted as a web application and includes machine learning libraries. PyCharm is a suitable IDE for both python development and web development including Next.js when using machine learning libraries. Additionally, Git can be integrated with PyCharm for version control. PyCharm supports database development using SQL plugins which will be needed to store large data sets of regulations. PyCharm also

Git/ Github	Using Github for hosting software application development and using Git to control the versions.
APIs and Libraries	
PyMuPDF, Tesseract OCR	To store the regulations in a database, the regulations should be extracted from the related documents on the UDA website. To extract regulations from formatted PDF documents and even from tables in that document, PyMuPDF can be used. Tesseract OCR can be used to extract texts from images accurately.
spaCy, NLTK	The extracted texts of the documents should be analysed to identify the regulations and filter them from the texts. Natural Language Tool Kit can analyse the meaning of the texts to identify regulations while the spaCy library analyses the regulations from the keywords provided.
OpenCV.ai (Computer Vision)	OpenCV library can be used as computer vision to analyse the interactive risk analysis map accurately and identify the user's property boundaries and segment them. These can also be used to analyse the high-quality images within documents and to analyse the property plan of the user.
Google Maps JavaScript API	Google Maps JavaScript API is a web API that can be used in web applications and can be customised with graphics, custom data layers, and animations. This can be used to display a map for the user to input the land location and enter the land boundaries. It also displays the data layers of the landslide risks, air quality analysis.

GeoPandas software	GeoPandas is a free and open-source software that also provides web APIs for satellite mapping purposes. For the risk analysis feature, a Google map is displayed for the user to locate their land, then the risk zones are displayed as an overlay over the user's map using GeoPandas software. Additionally, over the user's map, selected risk zones can also be displayed as a background map or as an overlay.  *Figure 6 - An overlay being displayed over a map using GeoPandas (GeoPandas, 2024)*
NBRO Landslide risk zones API /NBRO Rainfall analysis API / NBRO subsurface API	To display the landslide risk zones, rainfall analysis, and soil analysis on the user's map, those data should be retrieved from the existing interactive maps of the NBRO website. NBRO provides an API service to retrieve these data from the interactive map they have published.
Google Air Quality API/NBRO Air Quality API	Google Maps provides an Air Quality API which provides real-time hourly air condition, heatmaps, history, and hourly forecast based on the country and region. For the land risk analysis feature, this API can be used to overlay a data layer of the air quality in the user's map.
Distance Matrix API	To analyse the property plan of the user to check whether it aligns with the regulations, the distance of the property locations to several

	other important locations matter such as the distance to the coastal line. Distance Matrix API helps with calculating the distances using coordinates.
MapReader	After analysing the property plan, the regulations, and the risk zones, the MapReader Python library can be used to display the risk zones and conservation areas on the property plan provided by the user.
Frameworks	
Next.js	Next.js is a react framework suitable for large projects with high processing power and can be used to display the regulation analysis report and land risk reports as data visualisations.
Database Systems	
MySQL	In PyCharm, the MySQL database management system plugin can be used to store the regulations identified related to specific zones or categories, to store user account logs, and also to maintain and update the database.

Table 2 - Software Requirements for the LandLytics Project

1.9 Business Model Canvas

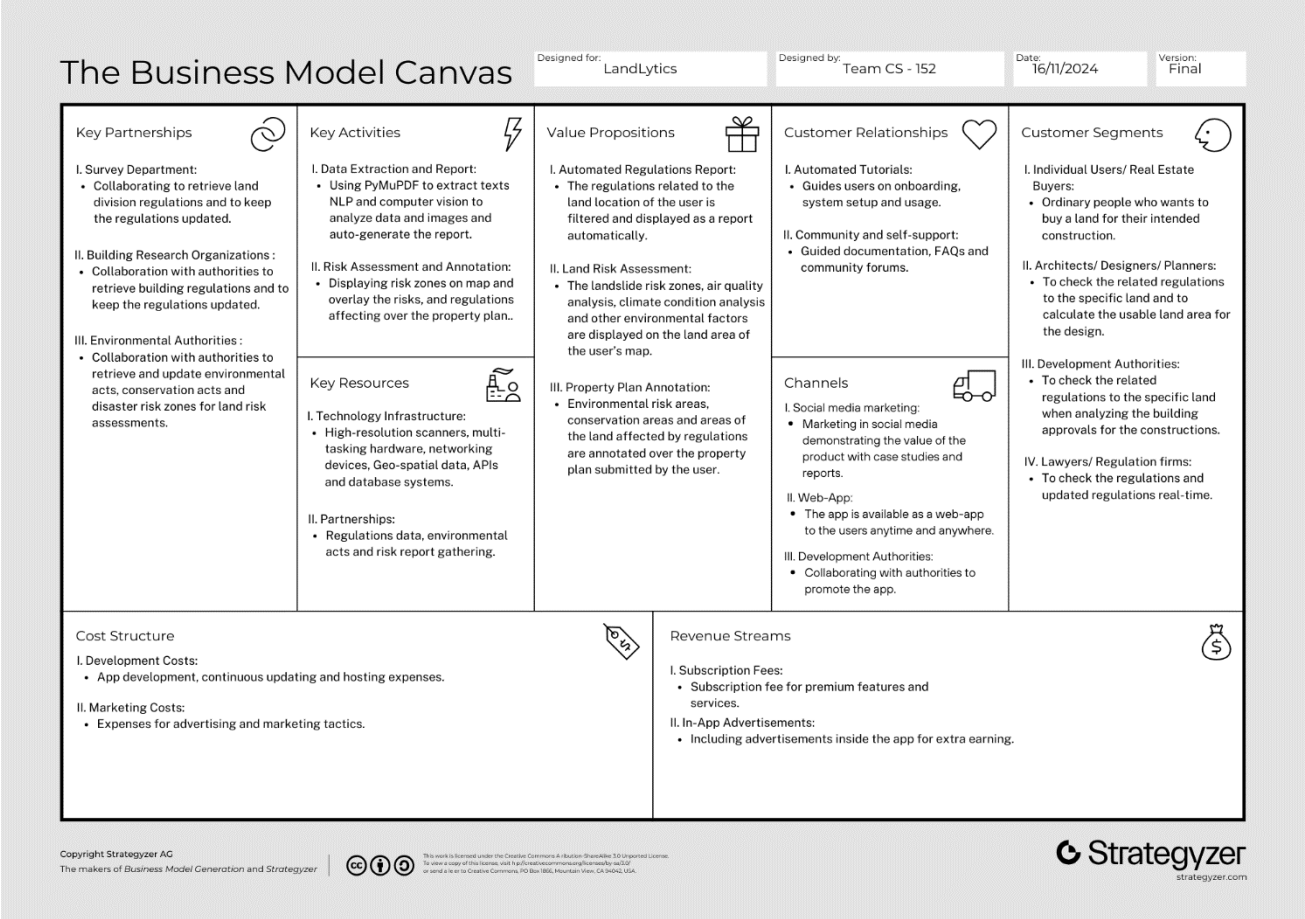


Figure 7 - Business Model Canvas for the LandLytics Project

1.10 Chapter Summary

This chapter discussed the overview of the project including the problem background, challenges faced by the target audience, and the proposed solutions to be provided by this project. Example scenarios show the real-world scenarios and the gravity of this problem. The scope of this project is discussed including its core functionalities and what functionalities belong outside of the project scope. Necessary hardware and software requirements for the implementation of this project are discussed. Additionally, the business canvas model shows the operational structure detailing the key components of the target audience and the operational strategy.

Chapter 2: Existing Work

2.1 Chapter Introduction

This chapter aims to cover the currently existing solutions for land evaluation, risk assessment and compliance with regulations in property purchasing and construction planning. The tools and technologies that will be used for the implementation of the proposed solution will also be discussed here.

2.2 Existing Work

2.2.1 Urban Development Authority (UDA) Website

The information about regulations applicable for land evaluation and construction planning are publicly available on the UDA website of Sri Lanka. The relevant land regulatory information, zoning laws and building regulations are found in the form of PDFs based on the provinces, districts and zones of Sri Lanka.

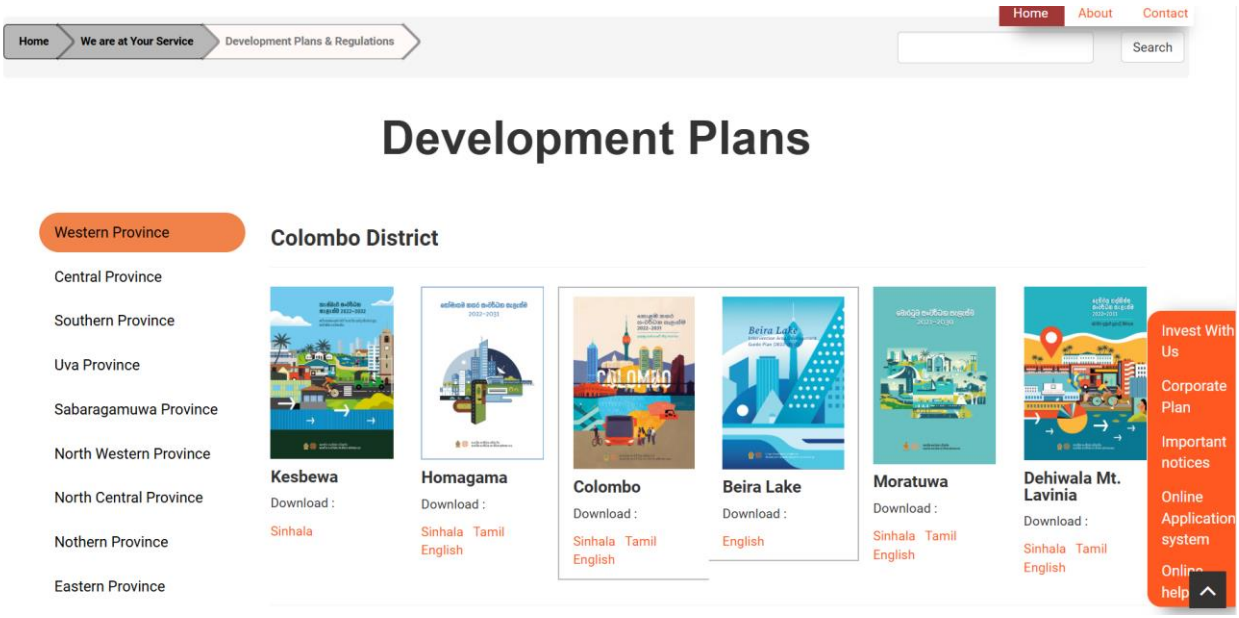


Figure 8 - UDA Development Plans (Urban Development Authority, Sri Lanka, and (no date))

Using this as the foundational regulatory data, our web application aims to integrate this data into a more user-friendly platform, making filtering of regulations based on their needs easier for users, without altering any of the information obtained from the website

2.2.2 National Building Research Organisation (NBRO) Website

The NBRO website of Sri Lanka is a vital resource in accessing geospatial data and environmental risk information. It provides detailed maps, reports and datasets that highlight the potential risks of an area based on its topography.

By utilising these publicly available resources, our web application intends to provide users with a reliable and accurate, location-specific risk awareness report. This will allow users to make well-informed decisions in construction planning to minimise environmental and safety risks.

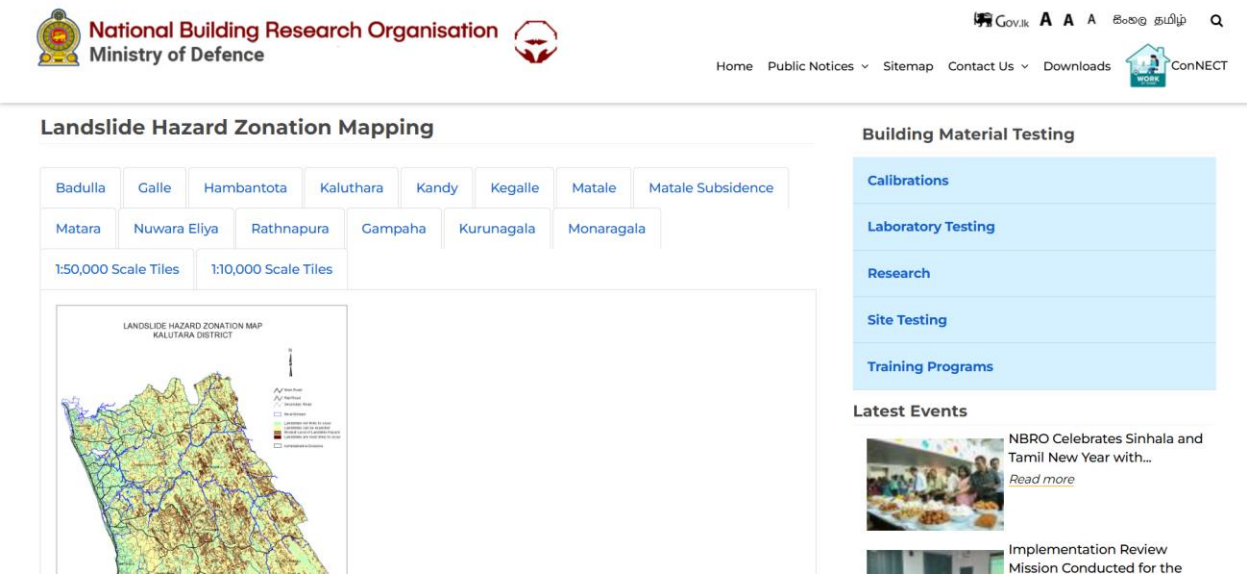


Figure 9 - NBRO Landslide Risk Maps for specific areas (The NBRO Website, (no date))

Refer to Appendix A for examples of Risk and Hazard maps provided by the NBRO.

2.2.3 Solutions of Competitors and Feature Comparison

There are applications and websites primarily used in countries like the United States and the United Kingdom which consist of regulations applicable to those specific regions only. These software have region specific datasets and cannot be used globally, or in Sri Lanka, without the integration of custom data. Moreover, there are certain software which provide risk reports.
These applications/websites do not contain all features of the proposed solution and hence, cannot be considered as direct competitors. Nevertheless, they provide partial solutions to some of the problems at hand.

Given below is a table comparing the existing solutions of potential competitors and the features that can be added to the proposed solution application.

Competitor	**Filtered regulations report**	**Land risk assessment report**	**Property plan annotation**	**Details**
Realtor.com	No	Yes	No	Provides flood and wildfire risk data based on factors like vegetation and property vulnerability.
FloodSmart	No	Yes	No	Provides flood and landslide risk assessments, and recommendations for risk mitigation.
LandInsight	Yes	Yes	No	Provides data for property evaluation

				and real-time insights on land and housing values. Can overlay geographic data for risk assessment.
LandVision	Yes	No	No	Provides demographic, environmental, and regulatory data specific to land development.
Land.id	No	No	Yes	Creates custom property maps with layers for zoning and environmental factors.
LandLytics	Yes	Yes	Yes	Provides a filtered regulatory report that is region specific. Provides a land risk assessment report. Provides an annotated property plan.

Table 3 - Comparison of Existing Solutions of Competitors and the Features that can be added

2.3 Tools and Implementation

The goal of this project is to create a comprehensive web-based platform called LandLytics that facilitates land evaluation by providing tailored regulation reports, risk analysis, interactive maps and property plan annotations for users including land buyers, architects, researchers and government agencies. By integrating geospatial data analysis, natural language processing (NLP), and advanced visualisation tools, LandLytics aims to enhance decision-making, minimise risks, and ensure compliance with zoning and environmental regulations.

2.3.1 Technology Stack and Development Approach

To ensure flawless functionality, powerful backend processing, processing geospatial analysis and an intuitive frontend interface are combined by the technology architecture of LandLytics:

1. **Programming Languages**
    - **Python** - Python is used for backend development including data extraction, regulation analysis, and geospatial calculations for the machine learning and GIS capabilities, python libraries such as OpenCV, GeoPandas and spaCy are used.
    - **JavaScript** - JavaScript is used for the frontend development and geospatial activity via frameworks such as Next.js and APIs such as Google Maps JavaScript API.

2. **Libraries and Frameworks**
    - **PyMuPDF and Tesseract OCR** - Used to extract textual data from PDFs and images.
    - **OpenCV.ai** - Used for image segmentation and analysis in property plan annotations.
    - **spaCy and NLTK** - Used for Natural Language Processing (NLP) tasks such as regulation identification and filtering.

- **GeoPandas** - Used to process and analyse geospatial data for risk assessments.
- **Next.js -** Used to enable real-time updates and representation of visual data on the frontend.

3. **APIs**
    - **Google Maps APIs -** Used to display user maps, risk zones, and provides relevant data such as landslide zones and air quality.
    - **NBRO APIs -** Used to get official environmental data for landslides, rainfall and soil analysis

4. **Database**
    - **MySQL -** Used to store structured data such as regulations, risk zones and user logs.

5. **Version Control**
    - **Git/GitHub -** Used to manage code changes and enable teamwork during development.

2.3.2 Key Features and Core Technologies

LandLytics consists of 3 key features which include filtered regulation reports, risk awareness reports and ability for property plan annotations. When these features are combined, it creates a powerful platform which makes the process of land evaluation easier. LandLytics allows users to make informed, compliant and risk-aware decisions.

1. **Filtered Regulation Report**
    - LandLytics offers a powerful feature for generating Filtered Regulation Reports, providing easy access to rules and regulations information of specific locations.

- This feature provides brief, customised reports tailored to the user's land location or project type by extracting and filtering relevant data from government documents, zoning laws and environmental policies.
- In order to accomplish these tasks advanced technologies such as PyMuPDF and Tesseract OCR are used to extract text from PDFs, images and tables, while Natural Language Processing (NLP) tools such as spaCy and NLTK analyse the content to identify and categorise regulatory clauses based on keywords and semantic context.
- This process allows users to skip through complex and time consuming paperwork, ensuring they have quick and easy access to the essential information and regulations. By providing relevant and accurate information, enables users to minimise the risk of violating regulations and make well-informed decisions more efficiently and effectively.

2. **Risk Awareness Report**
    - LandLytics offers users a feature that provides the users with critical insights into environmental and geographical risks in regard with their land.
    - This feature highlights areas which are prone to landslides, floods, air pollution and other environmental hazards by overlaying interactive geospatial satellite maps.
    - Risk data is collected from APIs such as NBRO Landslide Risk Zone API, NBRO Rainfall Analysis API and Google Air Quality API, combining the user's input location with the collected data. In order to provide users with precise visualisation, GeoPandas and Google Maps APIs are used to process geospatial data and view the risk zones as overlays on the user's map.

3. **Property Plan Annotation**
    - This feature allows for the user to submit their property plan to be analysed for any discrepancies or violations of construction regulations and practices.
    - This will utilise Computer Vision technology to analyse the user's property plan and compare them with the regulation database of the application. Any identified regulatory violations, such as constructions made over declared conservation zones,

violations against mandatory distance requirements between construction components like property borders and building walls, will be highlighted and annotated in a visually comprehensive format and provided to the user.

2.3.3 Implementation Plan

Phase 1: Research and Planning

The first phase is dedicated to laying the groundwork for the project by identifying the key requirements and setting a clear direction

1. **Stakeholder Meetings**
   Gather detailed requirements from all stakeholders (land buyers, architects, legal advisors, researchers).

2. **Feasibility Study**
   Assess technical feasibility for features like regulation filtering, risk analysis, and property plan annotations.

3. **Technology Stack Finalization**
   Finalise tools, APIs, and libraries (e.g., NLP tools, GIS platforms, OCR libraries).

Phase 2: Data Collection

The second phase will focus on collecting and preparing required data for the core features of the application.

1. **Regulation Data**
   Data is extracted from government documents using libraries like PyMuPDF or PDFPlumber.

2. **Environmental Risk Data**

   GeoJSON files or APIs from NBRO or similar sources are utilised and integrated for assessing landslide and flood risks.

3. **Preprocessing**
   - Organising and standardising text data from regulation documents for NLP analysis.
   - Identifying and selecting MLP models to train for property plan annotation.
   - Preparing 2D and 3D map overlays using GIS tools.

Phase 3: Core Feature Development

Phase 3 will be dedicated to developing and testing the core features of the application by utilising the selected technology stacks.

1. **Filtered Regulation Report**
   - Training selected NLP models (using spaCy or NLTK) to identify relevant regulations based on user inputs (e.g., land location and construction type).
   - Creating a database to store regulations and create queries for retrieving filtered results.
   - Developing a user-friendly interface to present reports.

2. **Risk Awareness Report**
   - Using GIS tools and satellite mapping APIs to overlay terrain risks on user-specified locations.
   - Integrate risk assessment models to predict threats like landslides or floods.
   - Implementing features for users to visualise risks map overlays in a comprehensive manner.

3. **Property Plan Annotation**
    - Developing an OCR-based system to read scanned property plans (using Tesseract and OpenCV).
    - Training selected MLMs to compare against regulations in the database to identify violations and provide annotations suggesting corrections.

Phase 4: Application Development

This phase focuses on building and finalising the application, incorporating developed features and developing the frontend and user-friendly UI to ensure a seamless and quality product for the end-user.

1. **Frontend Development**
    - Using Next.js to create a responsive and efficient application interface.
    - Implementing interactive elements such as dynamic and interactive maps, comprehensive data visualisations, and detailed and structured report display.

2. **Integration of Core Features**
    - Incorporating the Filtered Regulation Report, Risk Awareness Report, and Property Plan Annotation features into the application.
    - Ensuring seamless communication and functioning between the backend and frontend for all the core features.

3. **UI/UX Finalisation**
    - Developing and refining the user interface
    - Optimising the UI for efficient and user-friendly navigation and workflows for end-users.

2.4 Chapter Summary

This chapter discussed the existing works which contribute to the development of our problem solution, which include the UDA and NBRO websites of Sri Lanka. Additionally, a feature comparison was conducted to understand the direct and indirect competitors for this application.

The proposed technology stack to achieve the features of this application include Python, JavaScript and tools like GeoPandas, Tesseract and Google Maps API. The systematic development of the project has been explained in the phased implementation plan from the initial planning, research and data collection to the development of the features, application and UI/UX design.

Chapter 3: Methodology

3.1 Chapter Overview

This chapter encompasses the methodologies adopted by the team for the development, design and management of LandLytics. It details the thought process and reasoning behind the methodology selections for the project while additionally expanding on the identified benefits the selected approaches provide and how they align with the LandLytics project in particular.

3.2 Development Methodology

The team agreed that a Hybrid methodology that incorporates both a Waterfall approach as well as an agile methodology, would best suit the project's nature.

To arrive at this decision the team initially analysed the requirements and rough task rubric of the project. The requirements were thereafter compared against the pros and cons offered by each type of development methodologies the team had taken into consideration.

As the project utilises government regulations and prior records, a waterfall approach was possible for the project's planning and initial setup-stage.
Albeit, for the implementation and development phase of the project, the team proposed utilising an agile approach, to allow for better flexibility of feature buildout and testing. Additionally, such an approach in this stage would facilitate any adjustments to unforeseen setbacks or restrictions that could arise along the way.

All these considerations combined, prompted the team to select and implement the Hybrid development methodology for the LandLytics project.

1. **Waterfall Phase: Planning and Initial Setup**
   The Waterfall phase will focus on gathering requirements, creating a solid project plan, and establishing the initial system architecture.

2. **Agile Phase: Iterative Development and Feature Building**
   In this phase, Agile sprints will be used to develop the main features iteratively. The Agile approach's flexibility allows for regular feedback, especially useful for testing and fine-tuning features such as the regulation reports and property plan annotations.

3.3 Design Methodology

Utilising a design methodology is beneficial for minimising errors, avoiding complications and enhancing the overall quality of the final product. Following a structured framework when approaching problem-solving and the corresponding solution development, allows the team to identify and define clear objectives and develop a project that offers both effective and efficient solutions.

To reap the most benefit of utilising a design methodology, it was crucial for the team to initially identify which design approach was best compatible with the nature of LandLytics in particular.

The team initially took into consideration three different design methodologies to decide from; OOAD, DDD and SSAD. The below comparison chart between these three design methodologies is what contributed towards the final selection.

	OOD (Object-Oriented Analysis and Design)	**DDD** (Domain Driven Design)	**SSAD** (Structured Systems Analysis and Design)
Core Concept	Design methodology based on object-oriented principles, which organises the	Methodology which emphasises designing systems based on a project's core domain	Process-oriented methodology that focuses on defining the system in terms of

	system around 'objects' which can relate to real-life entities.	and its business logic.	data flow and structure.
Benefits	Allows the system to be flexible and reusable.	Aligns the software and features with the business's conceptual model.	Clear, sequential process with detailed and well-defined data handling.
Best Used for	Complex projects and applications which can benefit from scalability, and be mapped to real-life concepts.	Applications which prioritise meeting complex business requirements.	Applications with clearly defined goals and objectives from the project planning stage.

Table 4 - Comparison of Design Methodologies Considered by the LandLytics Team.

Following the above comparison, the team decided on implementing the SSAD design methodology for the project.

3.3.1 Selection Criteria

1. **Process-Oriented Structure**

   The SSAD methodology is particularly effective for projects with well-defined, sequential processes and clear data requirements, which closely align with the requirements of this application and allows for each feature of the application, such as filtered regulation reporting, risk assessment, and property plan annotation, to be treated as an independent process with clearly defined inputs, outputs, and data flows.

2. **Feature Addition**

   SSAD's process structure makes it simple and convenient to add new features or processes if and when the requirement arises. As example, future feature additions to the app include energy efficiency or disaster preparedness, each can be added as a new process within the SSAD framework without restructuring the entire system.

3. **Detailed Documentation**

   The SSAD methodology places emphasis on maintaining detailed documentation, thereby ensuring that each step of the project's design is thoroughly documented. This in turn can assist the LandLytics team in aspects such as team collaboration, troubleshooting, and future maintenance of the web app.

3.4 Project Management Methodology

Following our choice for the development methodology, our project consists of a structured approach for the initial analysis and setup while favouring a flexible approach for the development and implementation. Therefore, utilising the Hybrid methodology for project management was identified to be the most compatible with the development and design methodologies that had been prior adopted for LandLytics.

Using a Hybrid approach would provide the right balance between upfront planning and flexibility during development and other phases of the project.

3.4.1 Selection Criteria

1. **Core Milestones**

   A Waterfall approach ensures the project stays on track with fixed milestones and in-turn produces quality deliverables.

2. **Adaptability**

   Agile enables fine-tuning and quick adjustments as development progresses, particularly for LandLytics' property plan annotation algorithm which requires iterative testing.

3. **Risk Mitigation**

   The Waterfall approach's early planning reduces the risk of missing crucial regulatory or technical requirements, while Agile iterations provide room to adapt and improve the application's features for better end-product quality.

3.5 Teamwork Breakdown Structure (WBS)

Each main area of the report was assigned to one or more members based on their knowledge and understanding on the topics assigned. This included gathering the relevant data based on previously conducted research, conducting more in-depth research on the relevant subjects that were assigned to them and ensuring any information found was shared among the other team members.

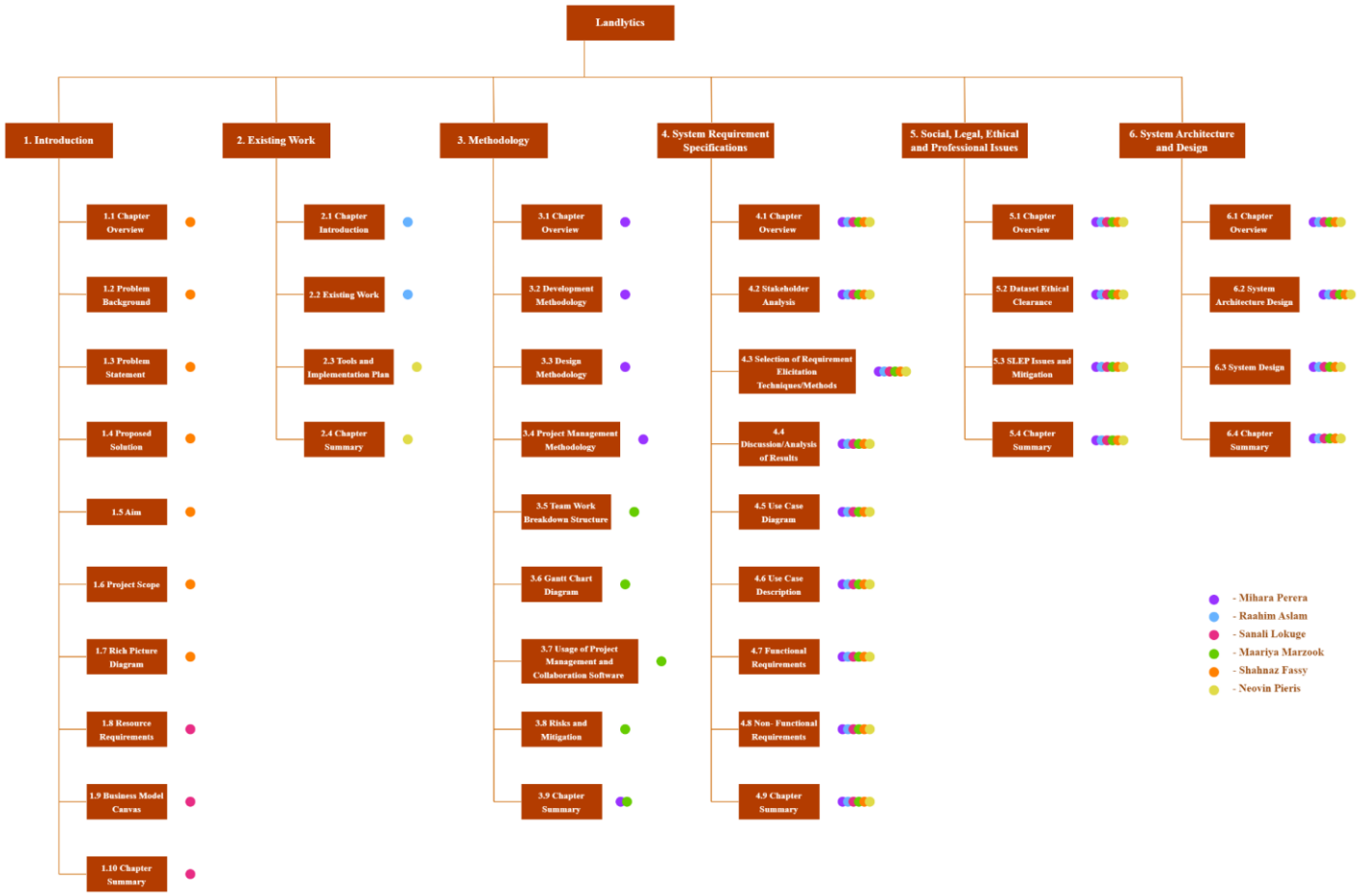


Figure 10 - Team Work Breakdown Structure for LandLytics

3.6 Gantt Chart

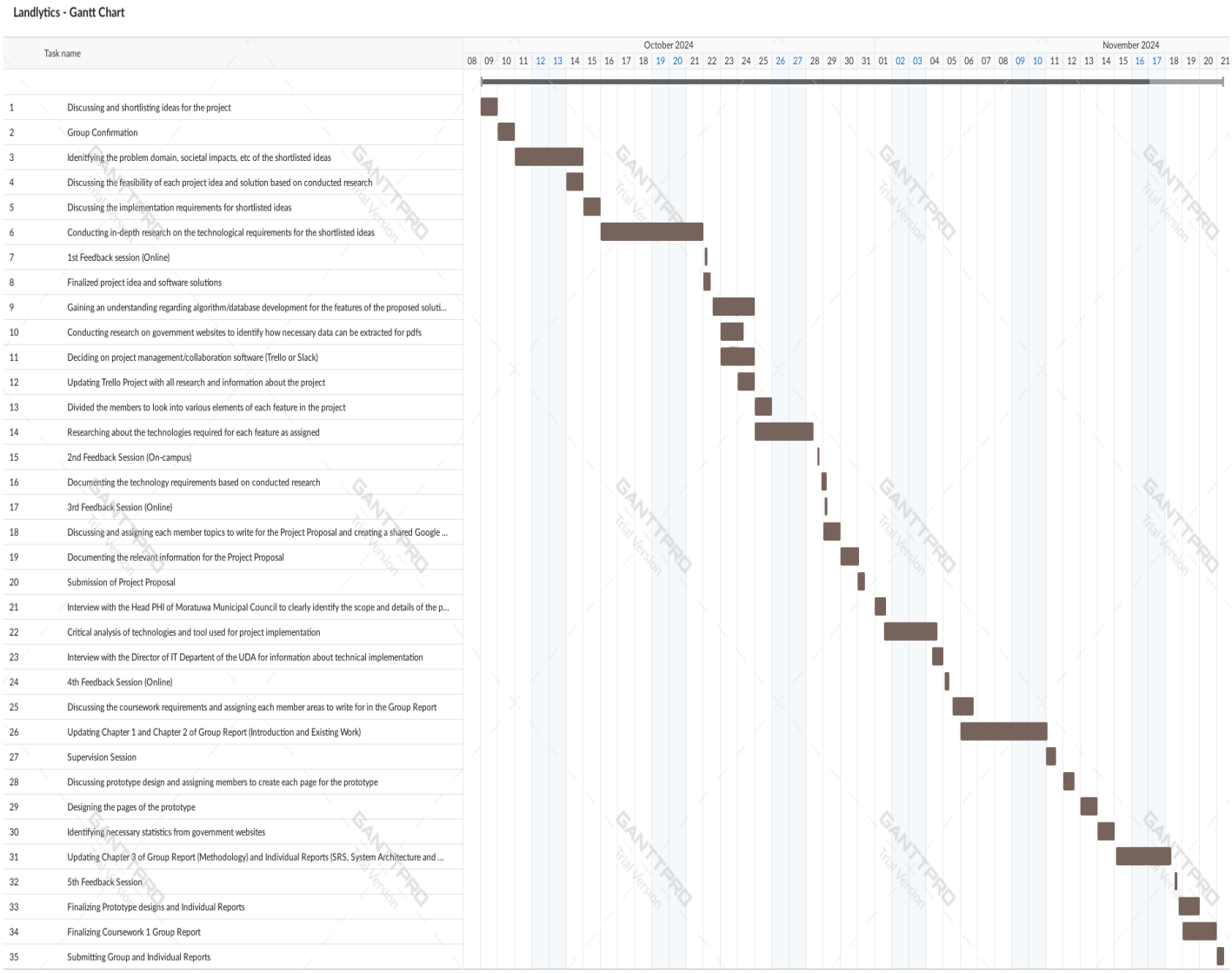


Figure 11 - Gantt Diagram for Current Progress on the Development of LandLytics (Created using GanttPro)

3.7 Usage of Project Management and Collaboration Software

3.7.1 Trello

The main Project Management software used by the team was Trello, which allows each of the members to use the board-based system to organise the research, interview and documentation information gathered throughout the software development project so far.

Information such as the project brief, resources and links to relevant government websites such as the NBRO and UDA sites, to-do lists and task allocations were clearly separated using Trello boards and updated by the members when necessary as well, making it a convenient platform for collaboration between members in the team.

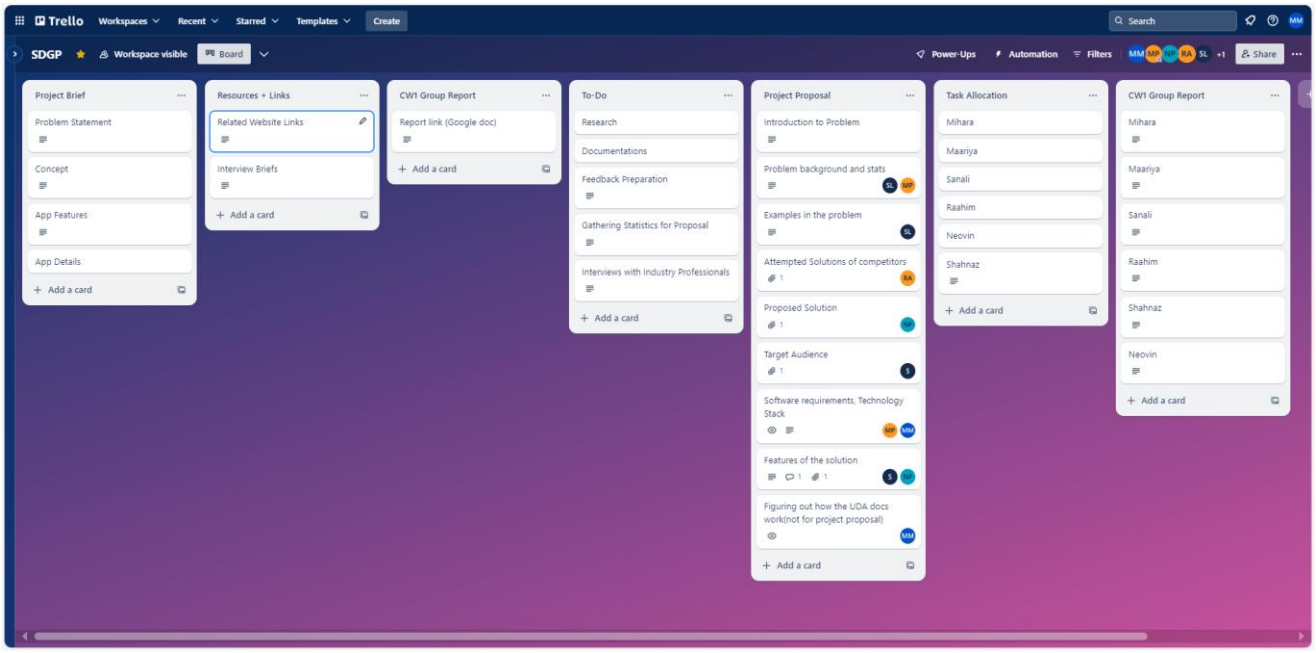


Figure 12 - Trello Board for LandLytics Team

3.7.2 Google Meets

While Trello was used to share and organise resources and documented information, the group conducted weekly meetings using Google Meets. This platform was essential for the group to communicate, discuss and present research and interview information to the members, as finding a time for the members to meet physically was not always a viable option.

Furthermore, planning and discussing the course of action to be taken regarding each element of the project was a simpler task due to the use of Google Meets.

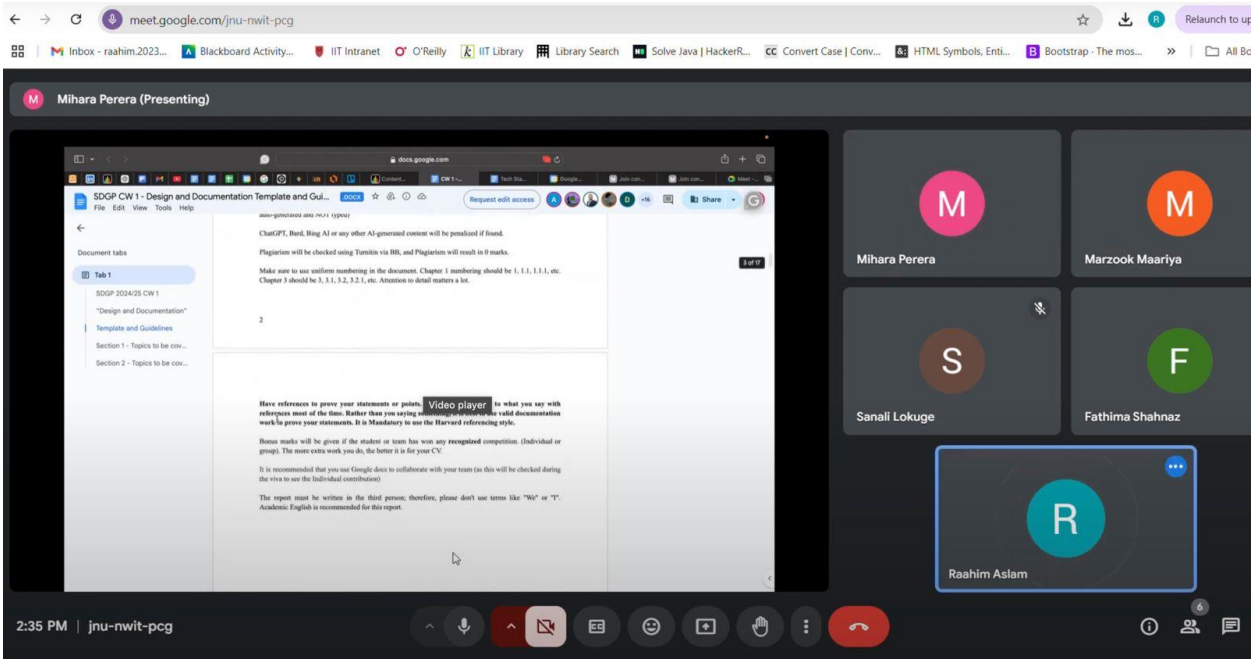


Figure 13 - Usage of Google Meets for Project Discussion

Refer Appendix B and C respectively for meeting log and discussion details.

3.8 Risk and Mitigation

Risk Item	Severity	Frequency	Mitigation Plan
Inaccuracies of annotations provided by the application.	3	3	● Appropriate technology stacks will be used to provide high accuracy in the services provided by the application. ● Providing a disclaimer to the user that the application merely provides suggestions and legal consultation with industry professionals should be done before actual proposal design.
Issues related to the use and publication of government issued regulations in the application.	4	2	● Communicated with legal officials of release departments and confirmed that the application will provide direct references to the government regulation documents whenever users are provided with the filtered regulations. ● Ensuring that no alteration will be made to the wording or context of government issued regulations.

Obtaining legal clearance for the use of government records and statistics.	5	2	• Clarifying legal procedures with individuals from the government departments such as the NBRO and UDA. • Requesting the records and relevant statistical information through formal/professional letters.
Difficulties in implementing certain features in the application.	5	1	• Prioritise the project requirements by importance, starting with the most critical and consider alternative solutions if software issues occur during the implementation of the feature. • Ensuring the implementation of the two core features, regulation filtering and risk analysis, are fully functional before handling any issues related to the property annotation feature.

Table 5 - Risks and Mitigation Plan

3.9 Chapter Summary

This chapter discussed the various methodologies used for development, design and project management used by the LandLytics team, which are the Hybrid Methodology for project development and management and the Structured System Analysis and Design (SSAD) Methodology for design. The team's work breakdown structure illustrates how each task was allocated to the members of the team. Furthermore, the report elaborates on the various project management and collaborative software used for organisation and communication between the members, such as Trello and Google Meets, as well as the project schedule so far, which has been clearly depicted using a Gantt chart. Finally, the main potential risks of the project and their mitigation plans have been highlighted to ensure the team has a pre-planned strategy to solve any issues that may arise during the implementation or planning phases of the project.

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Appendix

Appendix A

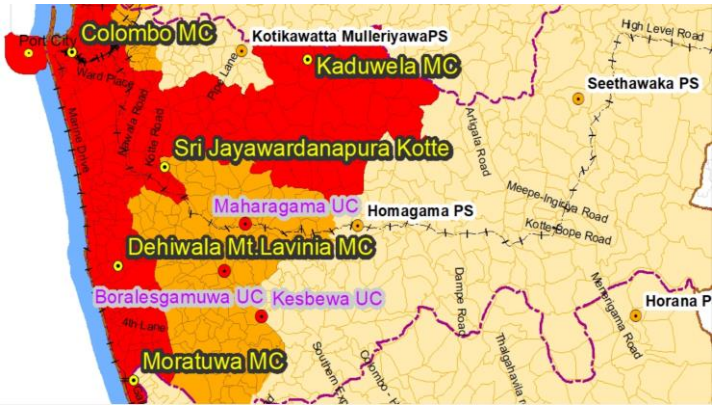

Figure 15 - UDA Declared Areas of Colombo district featuring Municipal Councils, water bodies, forest covers and etc. (The UDA Website, 2021)

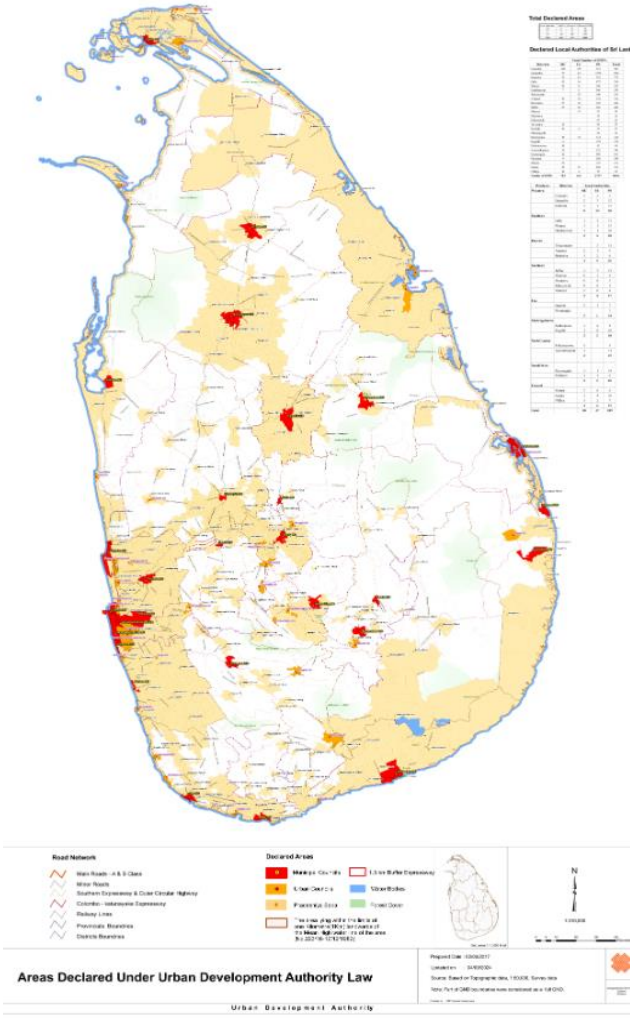

Figure 14 - UDA Declared Regions featuring Municipal Councils, Water bodies, forest covers and etc. (The UDA Website, 2021)

Source: https://www.uda.gov.lk/attachments/dev-plans-2021-2030/colombo_eng.pdf

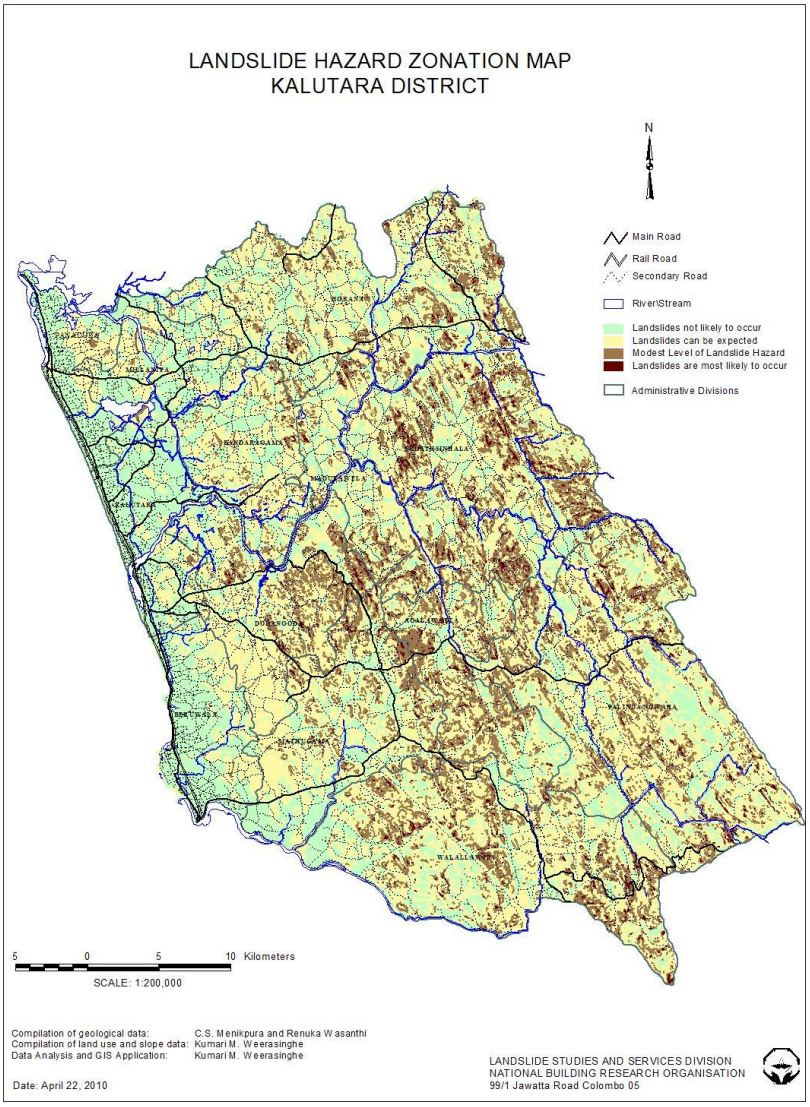

Figure 16 - Landslide Hazard Zonation map for Kalutara District (The NBRO Website, (no date))

Source:

https://nbro.gov.lk/index.php?option=com_content&view=article&id=48&Itemid=264&lang=en

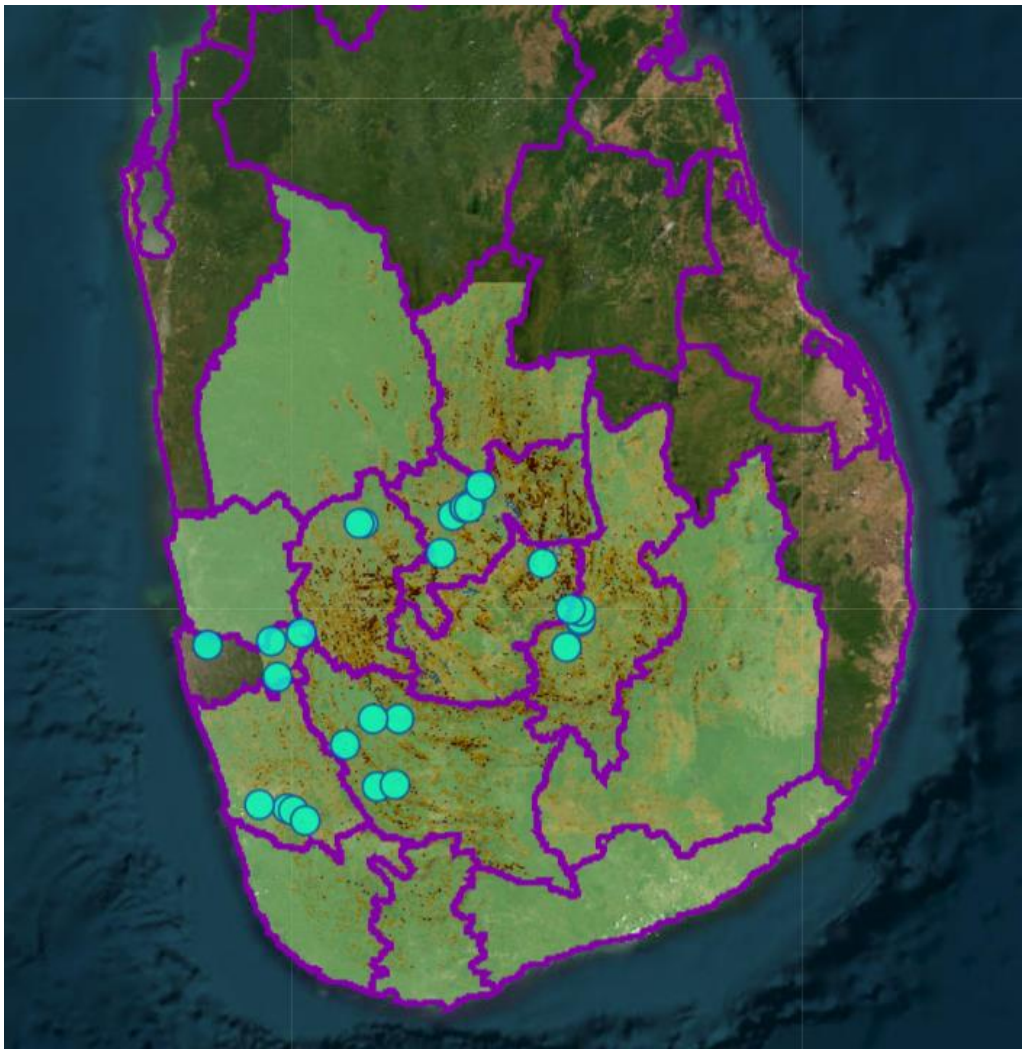

Figure 17 - Interactive Landslide Risk Information Portal (The NBRO Website, no date)

Source:
https://lrip.nbro.gov.lk/portal/apps/webappviewer/index.html?id=7524ad70c98e4124a6f4dfed6ea615fe

Appendix B

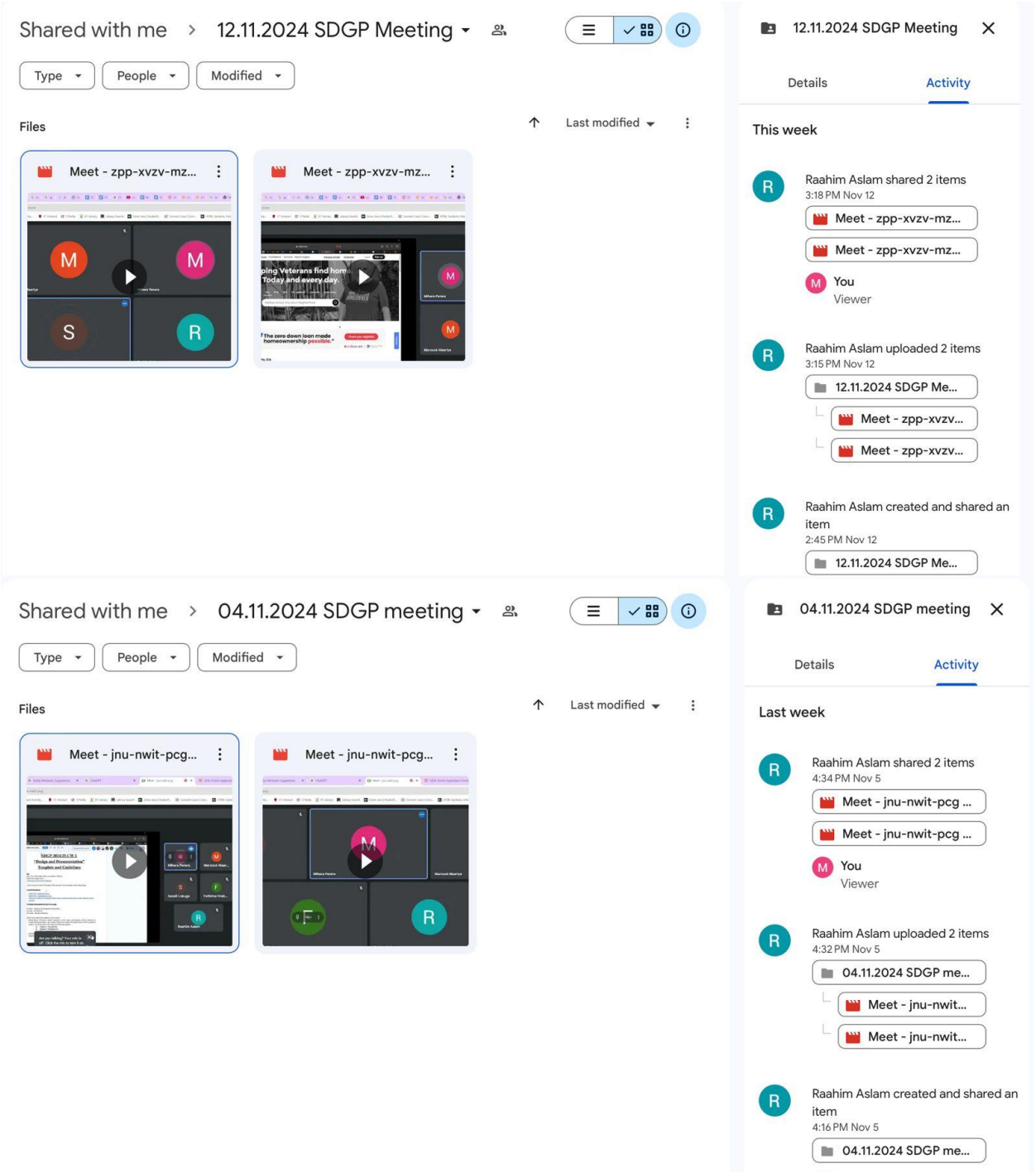

Figure 18 - Google Meets Recordings

	Conference Id	Item Type	Meeting Code	Event Id	Thread Id	Inbox Id	Call Direction	Start Time	End Time	Duration	D
2											
3											
4	UL-qrcwWXG4sKMxid8DXDxIROAIIigIgABgECA	meet:meeting	zpp-xvzv-mzm		thread_68f55f05-a125-4d75-9f99-2e9301f66532	meet		2024-11-12 06:31:42 UTC	2024-11-12 09:13:10 UTC	2:41:28	
5											
6											
7	Kl5tLQsb2tu_BP2M8zbHDxIWOAIIigIgABgECA	meet:meeting	jnu-nwit-pcg		thread_e7d078fa-9423-4007-bafd-f8c4db83d69b	meet		2024-11-05 10:03:53 UTC	2024-11-05 10:45:14 UTC	0:41:20	
8											
9											
10											
11	eU10rQfWKmw5uM6ffQIjDxIPOAIIigIgABgECA	meet:meeting	yqp-pbct-oui		thread_964a550c-3ef4-478a-b044-0fd505bd5c67	meet		2024-10-29 06:36:35 UTC	2024-10-29 07:17:58 UTC	0:41:22	
12											
13											
14	sppkKN8OvRdhFhWcsFywDxIROAIIigIgABgECA	meet:meeting	tse-ehfo-ryd		thread_b802881d-9e47-4e96-86d4-57d55ee6afd1	meet		2024-10-22 07:07:13 UTC	2024-10-22 07:51:19 UTC	0:44:06	
15											
16											
17	2zHYgAvJiMgbL9USqN9jDxIWOAIIigIgABgECA	meet:meeting	kvm-qffg-dwi		thread_8934f6fc-01ce-4dc4-9204-a562975cd582	meet		2024-10-15 05:42:14 UTC	2024-10-15 06:51:10 UTC	1:08:56	

conference_history_records

Figure 19 - Google Meets Log with Relevant Meetings Highlighted

Appendix C

No	Location/ Mode	Date	Time	Participants	Meeting Agenda
1	Google Meet	09/10/2024	8.00.p.m. - 10.20.p.m.	- Mihara Perera - Sanali Lokuge - Raahim Aslam - Maariya Marzook	• Discussing each idea provided by the members in the group, the pros & cons, feasibility, etc and allowing each member to share their opinions and thoughts. • Shortlisting the ideas for feedback purposes.
2	Informatics Institute of Technology (GP Square)	14/10/2024	12.30.p.m. - 1.30.p.m.	- Mihara Perera - Sanali Lokuge - Raahim Aslam - Maariya Marzook - Neovin Pieris - Shahnaz Fassy (via Google Meets)	• Discussing each idea provided by the members in the group, the pros & cons, feasibility, etc and allowing each member to share their opinions, thoughts and how the new ideas may add-on to any existing ideas. • Adding new member's ideas to the shortlisted ideas.

3	Google Meet	15/10/2024	11.10.a.m. - 12.10.a.m.	- Mihara Perera - Sanali Lokuge - Raahim Aslam - Maariya Marzook - Neovin Pieris - Shahnaz Fassy	• Discussing the implementation requirements for the shortlisted ideas such as: a. Is there a need to incorporate AI-bots? b. Does the app require an external database? c. Cloud sharing and security requirements.
4	Google Meet	22/10/2024	12.30.p.m. - 1.30.p.m.	- Mihara Perera - Sanali Lokuge - Raahim Aslam - Maariya Marzook - Neovin Pieris - Shahnaz Fassy	• Finalised project idea "Land Evaluation & Purchase Optimization Application" based on provided feedback (refer CS-152 feedback session document). • Discussed how the team will be moving forward with the project. Plan included: a. All members should do research regarding the basics about building a database for an application.

					b. All members should do research regarding the development of an algorithm for the features of the finalised project idea. c. Deciding on the use of a project management / collaboration platform to set up the project and future tasks related to the project. (The selected platform was Trello).
5	Google Meet	26/10/2024	7.00.p.m. - 8.45.p.m.	- Mihara Perera - Sanali Lokuge - Raahim Aslam - Maariya Marzook - Neovin Pieris - Shahnaz Fassy	• Discussing the features for the project based on research conducted. • Divided the members to look into various elements of each feature: a. Creating a database for regulation filtering. b. Using satellite mapping for the risk report.

					c. Getting the property plan from the user as a PDF for annotation purposes and suggestions.
6	Informatics Institute of Technology (Spencer Building)	28/10/2024	1.30.p.m. - 3.30.p.m.	- Mihara Perera - Sanali Lokuge - Raahim Aslam - Maariya Marzook - Neovin Pieris - Shahnaz Fassy	• Discussing the possible software and technologies which may be used for the implementation of the application features the features for the project based on research conducted. • Ensuring each member documents the technology requirements based on conducted research.
7	Google Meet	29/10/2024	12.00.p.m. - 12.50.p.m.	- Mihara Perera - Sanali Lokuge - Raahim Aslam - Maariya Marzook - Neovin Pieris - Shahnaz Fassy	• Discussing the information to be added to each topic in the Project Proposal. • Assigning each member topics to write for the Proposal and creating a shared Google Doc file for

					every member to update their progress into.
8	Google Meet	05/11/2024	3.30.p.m. - 4.00.p.m	- Mihara Perera - Sanali Lokuge - Raahim Aslam - Maariya Marzook - Shahnaz Fassy	• Discussing each group and individual element in the coursework report in detail. • Assigning each member in the team a topic to write on for the Group Report.
9	Google Meet	12/11/2024	12.00.p.m. - 3.00.p.m.	- Mihara Perera - Sanali Lokuge - Raahim Aslam - Maariya Marzook	• Discussing prototype design for LandLytics web application by gaining a clear understanding of the user interface for each feature provided to the user via the application. • Analysing various designs online for inspiration and identifying key components required for the prototype. • Assigning members of the group a few pages of the prototype, namely the three

					main features provided by the application, to create.
10	Informatics Institute of Technology (Spencer Building)	18/11/2024	1.30.p.m. - 4.00.p.m.	- Mihara Perera - Sanali Lokuge - Raahim Aslam - Maariya Marzook - Neovin Pieris - Shahnaz Fassy	• Creating a project on Figma for prototype creation and collaboration using UI kits such as Shadcn. • Identifying an appropriate frontend web-development framework for the LandLytics application (Next.js)

Table 6 - Meeting Discussion: Details and Agenda