URBAN GREENSPACE ENHANCEMENT

An Engineering Project in Community Service

Phase – II Report

Submitted by

1. **21BAI10123 - Ritika Sah**
2. **21BAI10111 - Dhanushraj M**
3. **21BAI10329 – Sahil Agarwal**
4. **21BAI10100 – Neena Varghese**
5. **21BAI10316 – Abhinav Banerjee**
6. **21BAS10007 - Manan Gupta**
7. **21MIM10008 – Pari S**
8. **21MIM10009 – Harshitha P**
9. **21BCE10584 – Dinesh Sirvi**

in partial fulfillment of the requirements for the degree of
Bachelor of Engineering and Technology

VIT Bhopal University Bhopal Madhyapradhesh

March, 2024.

Bonafide Certificate

Certified that this project report titled "**URBAN GREENSPACE ENHANCEMENT"** is the bonafide work of "**21BAI10123** Ritika Sah**,** **21BAI10111** Dhanushraj M, **21BAI10329** Sahil Agarwal**, 21BAI10100** Neena Varghese, **21BAI10316** Abhinav Banerjee, **21BAS10007** Manan Gupta, **21MIM10008** Pari S, **21MIM10009** Harshitha P, **21BCE10584** Dinesh Sirvi" who carried out the project work under my supervision.

This project report (Phase II-Final) is submitted for the Project Viva-Voce examination held on 10th May, 2024.

15/05/24

Dr. Arindam Ghosh
Supervisor

Suchetana

Dr. Suchetana Sadhukhan
Comments & Signature (Reviewer-1)

15/05/2024

Dr. Vinod Kumar Jatav
Comments & Signature (Reviewer-2)

Declaration of Originality

We, hereby declare that this report entitled **"Urban Green-Space Enhancement"** represents our original work carried out for the EPICS project as a student of VIT Bhopal University and, to the best of our knowledge, it contains no material previously published or written by another person, nor any material presented for the award of any other degree or diploma of VIT Bhopal University or any other institution. Works of other authors cited in this report have been duly acknowledged under the section "References".

Date: **10/05/2024**

Reg No & Name

21BAI10123 – Ritika Sah

21BAI10111 – Dhanushraj M

21BAI10329 – Sahil Agarwal

21BAI10100 – Neena Varghese

21BAI10316 – Abhinav Banerjee

21BAS10007 – Manan Gupta

21MIM10008 – Pari S

21MIM10009 – Harshitha P

21BCE10584 – Dinesh Sirvi

ABSTRACT

Rapid urbanization has led to the depletion of green spaces in many cities, impacting the well-being of residents and overall environmental health. This proposes an innovative approach to enhance urban green spaces by employing a comprehensive framework that integrates land use classification, machine learning (ML) training, model deployment, and Google Cloud Platform (GCP) integration and a scalable approach for identifying, planning, and implementing green space enhancements offers a holistic solution for cities seeking to prioritize and optimize their green infrastructure in the face of increasing urbanization. The outcomes of this research contribute to the development of data-driven strategies for urban green space enhancement, fostering sustainable urban development and improving the overall quality of life for urban residents. The proposed framework serves as a valuable tool for city planners, environmentalists, and policymakers seeking innovative solutions to address the challenges associated with urbanization and its impact on green spaces.

By amalgamating environmental considerations, community engagement, and sustainable design principles, the project seeks to craft detailed plans for the establishment of new parks, gardens, and communal green areas. The objectives encompass enhancing the cityscape with ecologically sound green spaces, fostering community health and connectivity, mitigating environmental stressors, and fostering a renewed appreciation for nature within the urban milieu. Through collaboration with local stakeholders and the integration of technological innovation, this endeavor aspires to weave a verdant tapestry across the city, cultivating a more livable, resilient, and harmonious urban landscape for the residents of Bhopal.

Acknowledgement

We extend our heartfelt gratitude to all those who have contributed to the successful completion of this project report on "Urban Greenspace Enhancement."

First and foremost, we would like to express our sincere thanks to Dr. Arindam Ghosh, our project supervisor, Dr. Suchetana Sadhukhan and Dr. Vinod Kumar Jatav, our reviewers, for their invaluable guidance, encouragement, and support throughout the duration of this project. Their expertise and insights have been instrumental in shaping the direction of our work and ensuring its quality.

We are also immensely thankful to the entire team at Urban Greenspace Enhancement for deciding upon the opportunity to work on such a meaningful project. Their dedication to organizing an unorganized sector has been both inspiring and motivating.

Additionally, we would like to extend our appreciation to our friends and family for their unwavering encouragement and understanding during the challenging phases of this project. Their moral support has been a constant source of strength for us.

We extend heartfelt gratitude to Piyush Karmhe for his invaluable assistance during a critical phase of the Urban Greenspace Enhancement Project. His expertise and dedication were instrumental in overcoming technical challenges, keeping the project on track. Thank you, Piyush, for your exceptional support and friendship.

Last but not least, we express our gratitude to all the individuals and organizations who have generously shared their time, resources, and expertise with us, making this project possible.

Thank you all for being a part of this journey towards creating a positive impact in our community through our project.

TABLE OF CONTENTS

1. INTRODUCTION

Urban greenspace enhancement is crucial in city areas for various reasons. Firstly, it promotes physical and mental well-being by providing spaces for recreation, exercise, and relaxation, helping mitigate the stresses of urban life. Urban green spaces, crucial for sustainable community development and improved environmental conditions, are depleting due to rapid urbanization. The framework integrates land use classification, machine learning training, model deployment, and Google Cloud Platform integration.

A study on enhancing urban green spaces amidst rapid urbanization shows:

- Innovative Approach,
- Framework Components
- Scalable Solution
- Sustainable Development

It provides a scalable solution for identifying, planning, and implementing green space enhancements, thereby fostering sustainable urban development and improving the quality of life for urban residents. This data-driven strategy serves as a valuable tool for city planners, environmentalists, and policymakers seeking to optimize green infrastructure in the face of increasing urbanization. The outcomes of this research contribute to the development of strategies for urban green space enhancement, creating vibrant, healthy, and sustainable urban environments.

1.1 Motivation

Embarking on the journey of Urban Green Space Enhancement isn't just about transforming the landscape; it's about reshaping lives and redefining communities. It's a pursuit that transcends the mere addition of greenery—it's an endeavor to breathe life into concrete jungles, fostering harmony between urban development and nature's embrace. By envisioning and implementing this project, we aren't just planting trees; we're sowing seeds of change. It's about creating spaces where children play, families gather, and individuals find solace amidst the bustling cityscape. It's about combating pollution, nurturing biodiversity, and instilling a sense of belonging in every resident. This project symbolizes a collective commitment to crafting a greener, healthier, and more vibrant future for Bhopal—a future where every leaf planted today embodies a promise for a sustainable tomorrow.

1.2 Problem Statement

The problem statement is about addressing the lack of green spaces in urban areas and the neglect of natural spaces in rural areas. The proposed solution is a visionary model that analyzes geographic images to identify underutilized spaces within urban landscapes. The goal is to transform these spaces into mini-forests or tranquil walking parks, contributing to sustainable biodiversity and creating resilient ecosystems. This approach aims to balance urban development with environmental stewardship, promoting sustainability and biodiversity conservation.

1.3 Objectives

The objectives of urban green space enhancements encompass a comprehensive approach to address environmental, social, and economic challenges associated with urbanization. Firstly, these initiatives aim to foster environmental sustainability by preserving and promoting green spaces that enhance biodiversity, improve air and water quality, and mitigate urban heat. Secondly, the creation of accessible and welldesigned green spaces serves to improve public health and well-being by encouraging physical activity and reducing stress.

Moreover, urban green space enhancements strive to foster social inclusion and community building, providing communal areas that cater to the diverse needs of residents. Economically, these initiatives enhance property values, attract businesses, and contribute to local economic development. They also play a crucial role in building urban resilience, helping cities adapt to climate challenges and public health crises.

Additionally, green spaces contribute to the aesthetic appeal of urban areas, offering recreational opportunities and promoting biodiversity conservation. By involving communities in the planning and maintenance processes, these enhancements ensure that green spaces align with the specific preferences and needs of local residents. Overall, urban green space enhancements aim to create sustainable, resilient, and livable cities that prioritize environmental health and community wellbeing.

2. Literature Review

Ref No	Title of the paper	Name of the Author & Year	Method used	Merits	Demerits
1.	How do people perceive the City’s Green Space? A view from Satellite Imagery (In Hanoi, Vietnam)	**Author:** Thi Thanh Hien Pham and Dong-Chen He. **Year:** 2008	The study employed an object-oriented classification approach with Definiens 5.0, identifying four distinct classes—Agriculture, Park trees, Street trees, and Isolated trees. For the satisfaction comparison, a map was generated based on household interview surveys, where people's satisfaction was ranked from 1 to 4.	Novelty and Gap Filling: The research addresses a gap in the existing literature by studying the relationship between green space types.	people's satisfaction is not specifically developing countries in Asia, with a focus on Hanoi, Vietnam
2.	Hot spots for improvements: Where to implement new green spaces?	Author: Gyula Kothencz, Andreas Petutschnig, Márton Kiss Year: 2017	The research employed a method to address urban green space imbalances. Key steps included identifying vegetation classes using highresolution satellite imagery, pinpointing areas with societal demand for green spaces, measuring distances using OpenStreetMap road data, and comparing potential travel distances with actual ones.	The research addresses a significant issue related to urban planning and environmental justice, focusing on the unequal distribution of green spaces in urban areas.	The study assumes that communities with a higher proportion of families with children or senior citizens have increased demand for green spaces.
3.	Analysis of Urban Green Spaces Based on Sentinel2A: Case Studies from Slovakia	Author: Monika Kopecká, Daniel Szatmári, Konštantín Rosina Year: 2017	The study aimed to extract information on urban green spaces (UGS) in Slovakia using Sentinel-2A satellite imagery. The researchers employed a supervised maximum likelihood classification to identify UGS polygons based on land cover	The research paper introduces a novel approach to urban green space (UGS) extraction using Sentinel-2A satellite imagery.	The paper relies on visual interpretation for some aspects of UGS classification, introducing subjectivity

4.	Extraction of Urban Green Spaces Based on Gaofen-2 Satellite Imagery	Authors: Babar Khan, Shuwen Yang, Weili Hong, and Heng Yan from the Faculty of Geomatics, Lanzhou Jiaotong University, Gansu, China. Year: 2021	Data Collection: The study uses high-resolution imagery data from the Gaofen-2 satellite. Classification: Different combinations were checked to classify the Gaofen-2 satellite imagery of Lanzhou cit y.	The paper proposes a new method of extracting Urban Green Spaces (UGS) from highresolution imagery data of Gaofen-2 satellite.	Studies on the use of very high-resolution images for UGS extraction are comparatively limited.

5. **.**	Emerging trend of urban green space research and the implications for safeguarding biodiversity: a viewpoint	Authors: Sanjay Gairola, Noresah Mohd Shariff Year: 2010	Biodiversity Assessment: Evaluating the variety of species present in urban green spaces and their conservation value. Ecosystem Services Evaluation: Analyzing the benefits provided by urban green spaces, such as air and water purification, carbon sequestration, and microclimate regulation.	Importance of Urban Green Spaces: The paper highlights the significance of urban green spaces for human wellbeing and ecosystem services.	Lack of Comprehensive Studies: The paper mentions that comprehensive studies on urban green spaces, especially in Malaysia, are yet to be conducted.
6.	Mapping Urban Green Spaces at the Metropolitan Level Using Very HighResolution Satellite Imagery and Deep Learning Techniques for Semantic Segmentation	Author: Roberto E. Huerta, Fabiola D. Yépez, Diego F. Lozano-García, Víctor H. Guerra Cobián, Adrián L. Ferriño Fierro, Héctor de León Gómez, Ricardo A. Cavazos González, and Adriana VargasMartínez Year: 2021	Deep Learning Models: Two deep learning model techniques were evaluated for semantic segmentation of UGS polygons. U-Net Architecture: Different convolutional neural network encoders on the U-Net architecture were used.	Efficient Mapping: The use of VHR satellite imagery and deep learning techniques allows for efficient and accurate mapping of	Data Imbalance: The study mentions the challenge of data imbalance due to the background non-UGS pixels, which could affect the accuracy of the model.
7.	Effects of the COVID-19 pandemic on the use and perceptions of urban green space: An international exploratory study	Author: Francesca Ugolini, Luciano Massetti, Pedro Calaza-Martínez, Paloma Cariñanos, Cynnamon Dobbs, Silvija Krajter Ostoić, Ana Marija Marin, Maja Simoneti, Andrej Verlič, Dijana Vuletić, and Giovanni Sanesi. Year:2020	Sampling: Non-probability samples were obtained through an unrestricted selfselected survey. The distribution of the online questionnaire started through the authors' networks and proceeded through a snowball effect.	The paper conducted an international exploratory study in six European countries, providing a broader perspective on the effects of the pandemic on urban green spaces.	Limited sample size: The paper did not provide information about the exact number of respondents in each country.

8.	Green spaces and mortality: a systematic review and meta-analysis of cohort studies.	Author: David Rojas-Rueda, Mark J Nieuwenhuijsen, Mireia Gascon, Daniela Perez-Leon, and Pierpaolo Mudu Year:2019	Systematic Review Process: The authors conducted a comprehensive search of the MEDLINE database and other sources to identify relevant studies. Meta-analysis Approach: The included studies provided hazard ratios (HRs) as the measure of association between greenness and mortality.	The paper is the first and most comprehensive synthesis to date on the association between green spaces and allcause mortality.	Language restriction: The search for studies was restricted to those published in English. This may introduce language bias and potentially exclude relevant studies published in other languages.

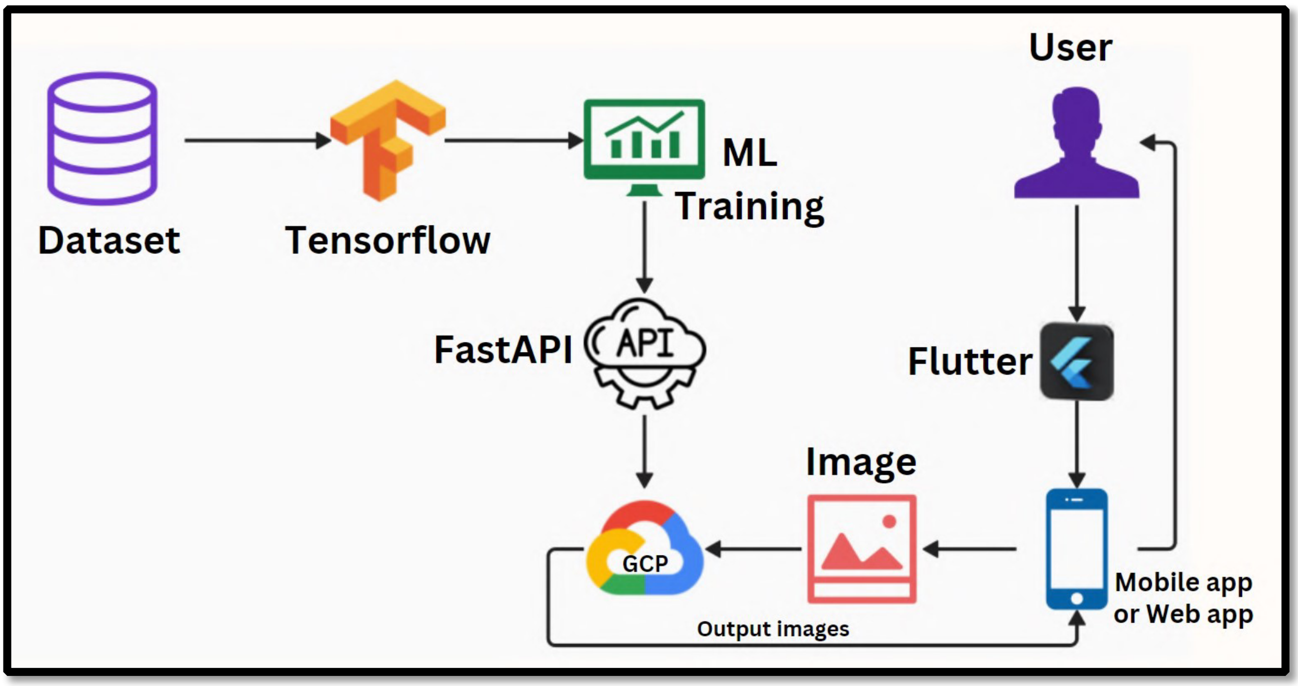
9.	Green Space and Social Capital: A Systematic Review	Author: Vicken Hillis Jennings and Oluwafemi Babatunde Year:2019	As the level of social cohesion can exhibit spatial and temporal variation [76], some scholars recommend the use of longitudinal study designs and attempts to understand the role of active and passive uses of green space [82]."	Reduction of bias: Systematic reviews typically employ strict inclusion and exclusion criteria, minimizing the potential for bias in the selection of studies.	Systematic reviews may be influenced by publication bias, as studies with positive or significant results are more likely to be published.
10.	Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'	Author: By Jennifer R. Wolch, Jason Byrne, Joshua P. Newell Year:2014	Health Data Analysis: could include examining physical activity levels, rates of mental health issues, or other relevant health outcomes. Environmental Justice Assessment: This could involve evaluating whether disadvantaged communities have equal access to quality green spaces.	Social Cohesion: Green spaces can act as gathering places for communities, fostering social interactions and community engagement.	Unequal Distribution: One of the challenges is the unequal distribution of green spaces, with marginalized communities
11.	Urban Green Spaces and an Integrative Approach to Sustainable Environment	Author: Shah Md. Atiqul Haq Year:2011	This could include considerations such as biodiversity enhancement, air and water quality improvements, and mitigation of urban heat islands. This could involve examining historical policies, zoning regulations, and urban planning strategies to understand their impact on the distribution of green spaces.	Social Inclusion: Integrative approaches prioritize inclusivity, aiming to provide green spaces that are accessible to all members of the community.	Implementation Challenges: Integrative approaches may face challenges in terms of implementation

12.	Urban Green Spaces and an Integrative Approach to Sustainable Environment.	Author: Shah Md. Atiqul Haq. Year: 2011	Geographic information systems (GIS) and remote sensing techniques as foundational methodologies. Incorporation of modeling, machine learning, and artificial intelligence in recent UGS research methodologies.	The role played by green spaces in urban environments is important for environmental sustainability. Green spaces contribute to improving the lifestyles of urban people.	Challenges in providing sufficient green spaces in highly populated countries. Difficulty in measuring the appropriate amount of required land and allocating land for green spaces.
13.	A systematic review of urban green space research over the last 30 years: A bibliometric analysis.	Author: Jenő Zsolt Farkas, Edit Hoyk, Mariana Batista de Morais, György Csomós Year: 2023	Utilization of social media data analysis, sentiment analysis, questionnaire surveys, and GPS data from mobile phones.	Comprehensive analysis of three decades of urban green space research. Conducted a bibliometric analysis	Limitations acknowledged regarding the inability to extract and analyse data from various cities.
14.	"Place-Keeping in the Park: Testing a Living Lab Approach to Facilitate Nature Connectedness in Urban Greenspaces	Author: Katharine Willis and Ashita Gupta. Year: 2023	Baseline evaluation of perceptions through a survey on greenspace engagement, attitudes towards nature, and technology use. Living Lab approach utilizing a Nature Data Probe toolkit designed for nature connectedness.	Focuses on enhancing connections between people and urban greenspaces through citizen science and a Living Lab approach.	Limited demographic representation, focusing primarily on a group of female students from a secondary school.
15.	Progress and Gaps in Research on Urban Green Space Morphology: A Review	Authors: Wu, J., Wang, S., & Zhang, Y. (2023)	Method: Critical review of existing literature on UGS morphology. Analysis: Examined research methodologies, data collection techniques, key findings, limitations, and future research directions. Data: Analyzed case studies, quantitative studies, and theoretical frameworks from various geographical contexts.	Specific focus: Offers a dedicated analysis of UGS morphology, a crucial aspect of green space design and planning.	Limited scope: May not be relevant to researchers interested in other aspects of UGS beyond morphology. Accessibility: Academic language and technical terms may limit accessibility for nonspecialist readers.

16.	Green space in compact cities: the benefits and values of urban ecosystem services in planning	Authors: Kabisch, N., van den Bosch, M., & Lafortezza, R. (2016).	Method: Mixed-methods approach combining literature review, case studies, and expert interviews. Analysis: Evaluated the economic, social, and environmental benefits of UGS in compact cities through various data sources.	Focuses on the concrete benefits of UGS implementation in compact cities. Highlights the positive economic and social impacts UGS can bring to urban environments.	Less emphasis on the ecological benefits of UGS compared to other aspects. May not be directly applicable to all urban contexts due to varying urban characteristics.

3. Design Methodology

3.1 System Design/Architecture



3.2 Working Principle

The working principle of creating an app for the "Urban Green Space Enhancement" project using Flutter involves integrating the satellite imagery analysis and machine learning outcomes into a user-friendly application. Here's an overview of the working principle:

1. Satellite Imagery Integration:

- **Retrieve and Display Satellite Imagery**: Utilize Flutter to retrieve and display high-resolution satellite imagery of Bhopal within the app interface.
- **Interactive Map Interface**: Implement an interactive map interface within the app using Flutter's widgets to allow users to navigate and explore different areas of the city.

2. Machine Learning Integration:

- **Land Use Classification:** Incorporate the machine learning model's land use classification results into the app. Display categorized land use areas (e.g., residential, commercial, industrial, existing green spaces) overlaid on the satellite imagery.

3. User Interaction and Features:

- **User Input and Feedback**: Provide interactive elements for users to select or highlight areas of interest on the map, enabling them to provide feedback or suggestions for potential green space expansion.
- **Information Display**: Offer detailed information or pop-ups about identified areas, showcasing proposed plans, environmental benefits, and community impact.

4. Community Engagement:

- **Engagement Tools**: Integrate community engagement tools such as surveys, forums, or feedback forms within the app to gather input from residents and stakeholders regarding green space preferences.
- **Notifications and Updates**: Implement features to provide updates and notifications about ongoing or upcoming green space enhancement initiatives, fostering community involvement.

5. Visualization and Planning Tools:

- **Conceptual Design Showcase:** Incorporate visualizations or renderings of proposed green spaces based on machine learning outputs and design concepts, allowing users to visualize the planned enhancements.
- **Planning Resources**: Provide resources or links within the app for users to access further details about sustainable design principles, environmental benefits, and urban planning guidelines.

6. Accessibility and Usability:

- **User-Friendly Interface**: Design an intuitive and user-friendly interface using Flutter's widgets to ensure ease of navigation and interaction for users of varying technical backgrounds.
- **Multi-Platform Deployment**: Leverage Flutter's capabilities for crossplatform development to ensure accessibility across different devices and operating systems.

7. Data Security and Privacy:

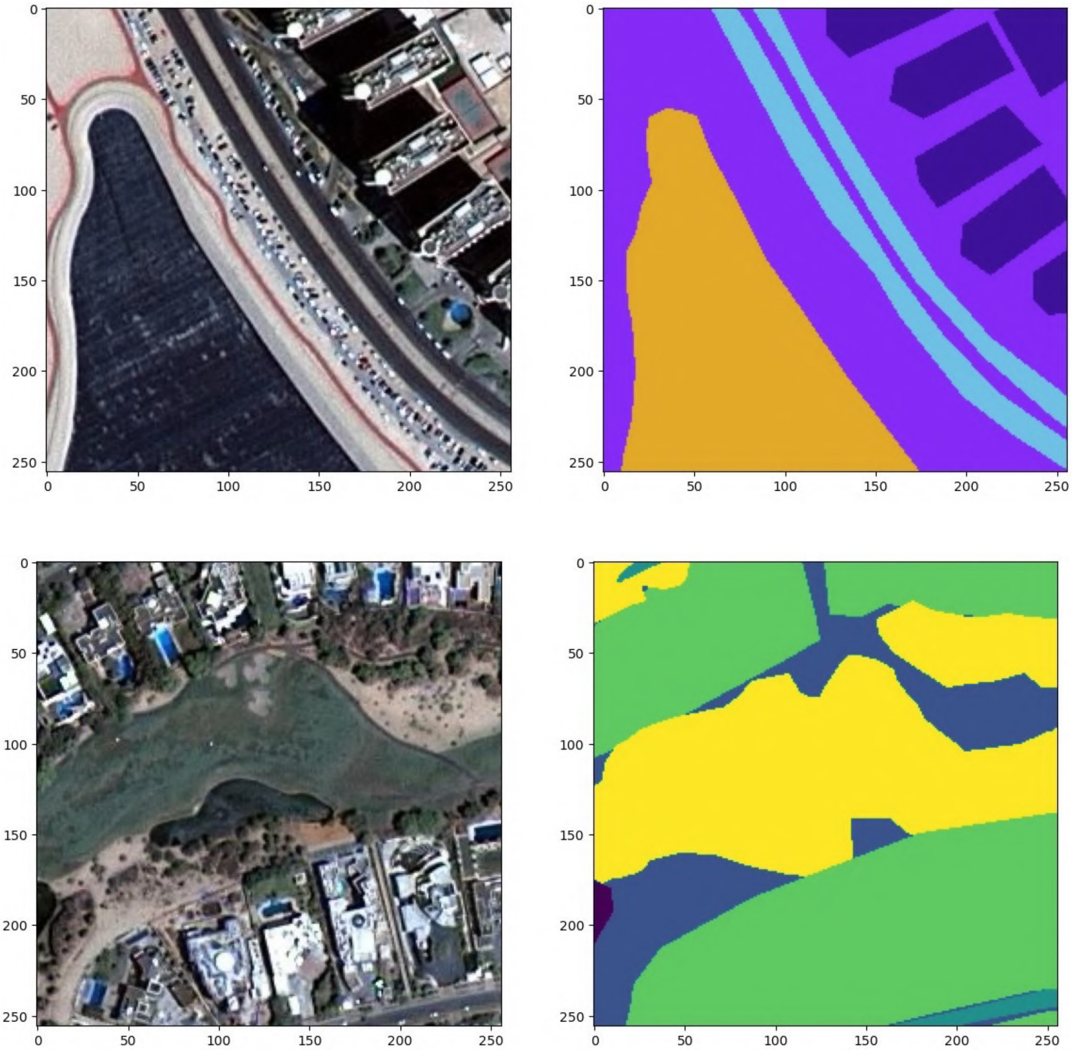
- **Secure Data Handling**: Implement secure data handling practices to protect user inputs, feedback, and any sensitive information collected through the app.
- **Privacy Compliance**: Ensure compliance with privacy regulations and obtain necessary permissions for data collection and usage within the app.

By leveraging Flutter's flexibility and capabilities for creating interactive and cross-platform mobile applications, this approach facilitates community engagement, visualization of green space plans, and seamless user interaction, thereby promoting awareness and participation in the "Urban Green Space Enhancement" project.

3.3 Existing Work

Backend:

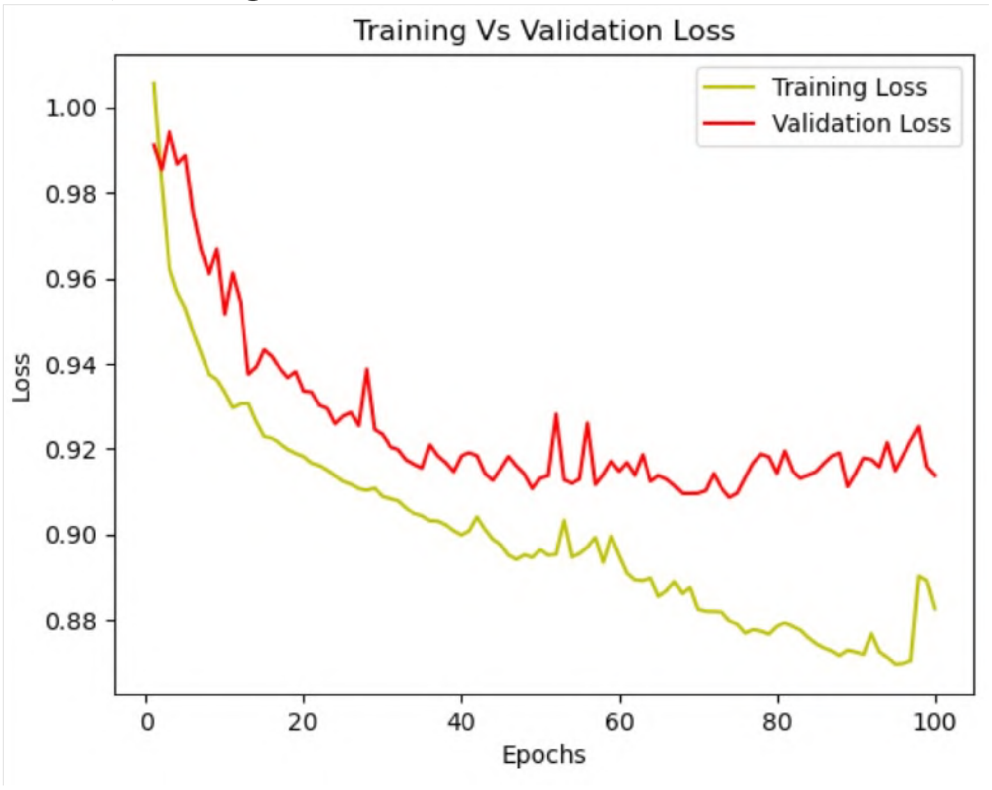
a)Training Data Images:



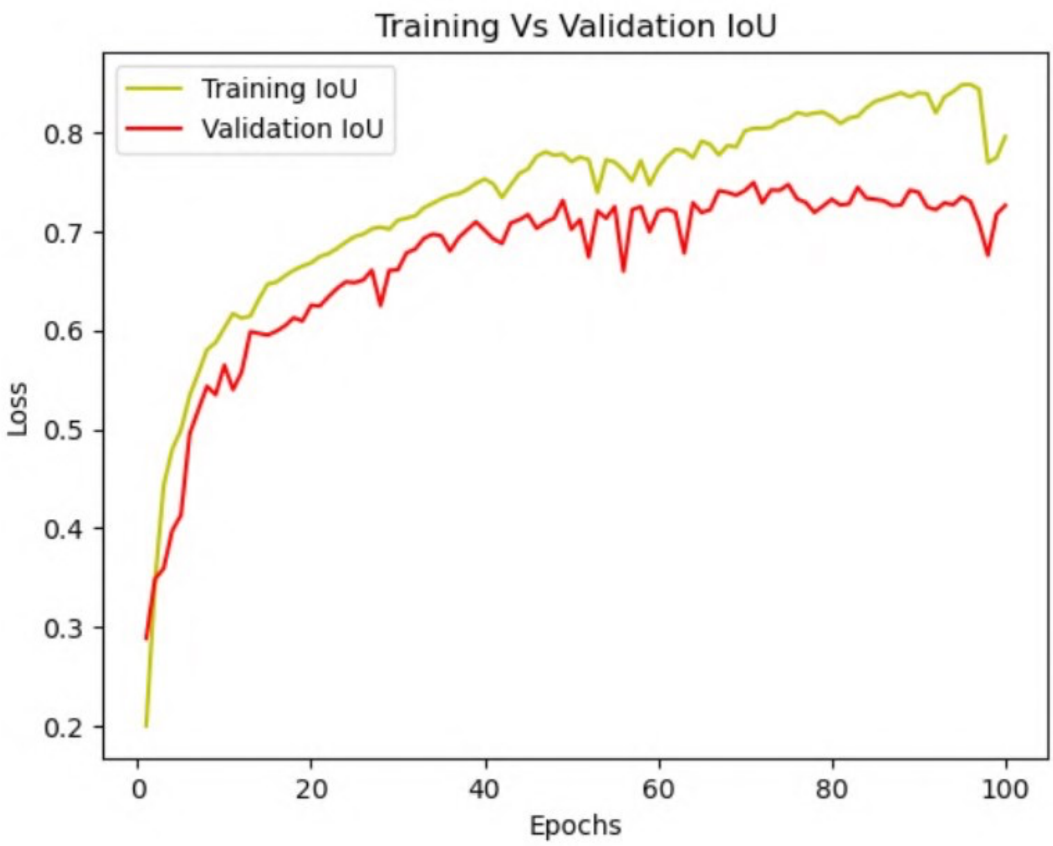
b) Network Building:

```python
In [47]:
def multi_unet_model(n_classes=5, image_height=256, image_width=256, image_channels=1):

    inputs = Input((image_height, image_width, image_channels))

    source_input = inputs

    c1 = Conv2D(16, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(source_input)
    c1 = Dropout(0.2)(c1)
    c1 = Conv2D(16, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(c1)
    p1 = MaxPooling2D((2,2))(c1)

    c2 = Conv2D(32, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(p1)
    c2 = Dropout(0.2)(c2)
    c2 = Conv2D(32, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(c2)
    p2 = MaxPooling2D((2,2))(c2)

    c3 = Conv2D(64, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(p2)
    c3 = Dropout(0.2)(c3)
    c3 = Conv2D(64, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(c3)
    p3 = MaxPooling2D((2,2))(c3)

    c4 = Conv2D(128, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(p3)
    c4 = Dropout(0.2)(c4)
    c4 = Conv2D(128, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(c4)
    p4 = MaxPooling2D((2,2))(c4)

    c5 = Conv2D(256, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(p4)
    c5 = Dropout(0.2)(c5)
    c5 = Conv2D(256, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(c5)

    u6 = Conv2DTranspose(128, (2,2), strides=(2,2), padding="same")(c5)
    u6 = concatenate([u6, c4])
    c6 = Conv2D(128, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(u6)
    c6 = Dropout(0.2)(c6)
    c6 = Conv2D(128, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(c6)

    u7 = Conv2DTranspose(64, (2,2), strides=(2,2), padding="same")(c6)
    u7 = concatenate([u7, c3])
    c7 = Conv2D(64, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(u7)
    c7 = Dropout(0.2)(c7)
    c7 = Conv2D(64, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(c7)

    u8 = Conv2DTranspose(32, (2,2), strides=(2,2), padding="same")(c7)
    u8 = concatenate([u8, c2])
    c8 = Conv2D(32, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(u8)
    c8 = Dropout(0.2)(c8)
    c8 = Conv2D(32, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(c8)

    u9 = Conv2DTranspose(16, (2,2), strides=(2,2), padding="same")(c8)
    u9 = concatenate([u9, c1], axis=3)
    c9 = Conv2D(16, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(u9)
    c9 = Dropout(0.2)(c9)
    c9 = Conv2D(16, (3,3), activation="relu", kernel_initializer="he_normal", padding="same")(c9)

    outputs = Conv2D(n_classes, (1,1), activation="softmax")(c9)

    model = Model(inputs=[inputs], outputs=[outputs])
    return model
```

c)Training Vs Validation Loss:



d)Training Vs Validation IoU:



e)Saving the Model:

```
In [96]: from keras.models import load_model
```

```
In [97]: saved_model = load_model('satellite-imagery_new.h5',
                                  custom_objects=({'dice_loss_plus_1focal_loss': total_loss,
                                                   'jaccard_coef': jaccard_coef}))
```

```
In [98]: saved_model

<keras.engine.functional.Functional at 0x1e7ea148550>
```

f)Prediction using Custom(VIT - Bhopal) Dataset:

```
In [129]: plt.imshow(Image.open('vitb2.jpg'))

<matplotlib.image.AxesImage at 0x1e7fab03730>
```

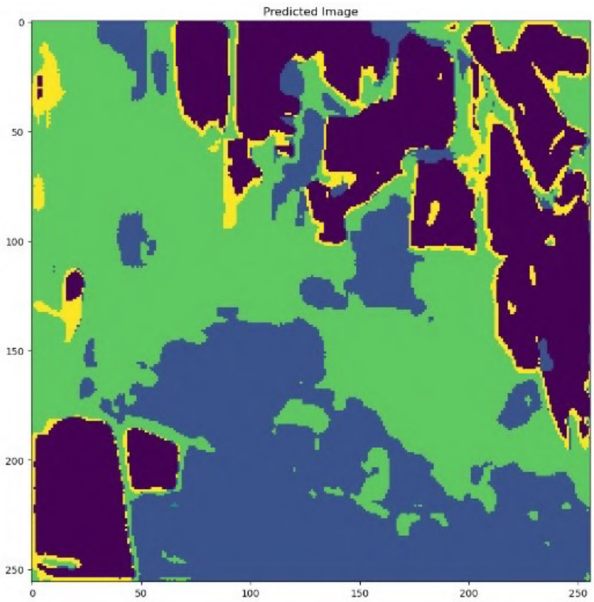
g)Predicted image array:

```
In [135]:
predicted_image = np.argmax(prediction, axis=3)
predicted_image = predicted_image[0,:,:]
```

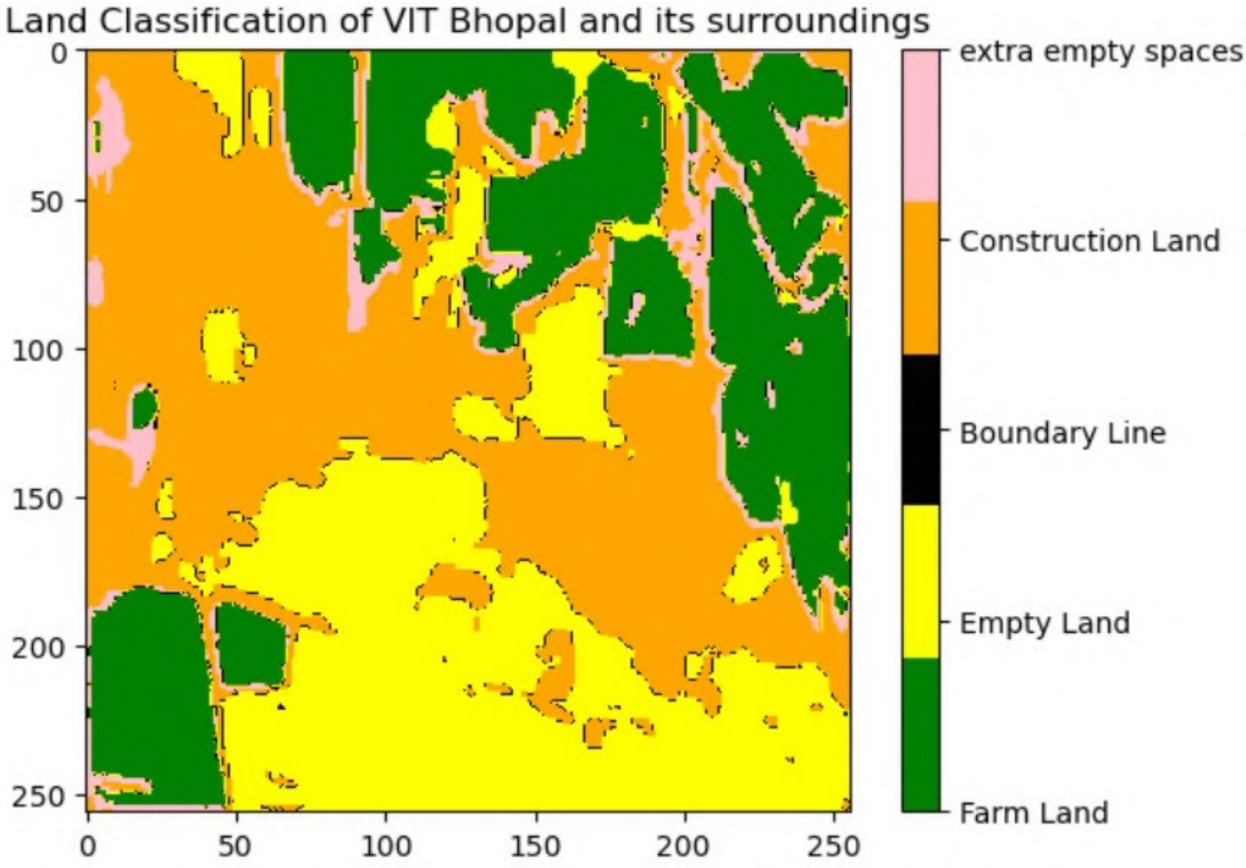
```
In [136]:
predicted_image
```

```
array([[3, 3, 3, ..., 3, 3, 3],
       [3, 3, 3, ..., 3, 3, 3],
       [3, 3, 3, ..., 3, 3, 3],
       ...,
       [3, 3, 3, ..., 1, 3, 3],
       [3, 3, 3, ..., 3, 3, 3],
       [3, 3, 3, ..., 1, 3, 1]], dtype=int64)
```

h) Predicted Image Segmentation:



i) Land Classification of VIT Bhopal:



API Development:

Model File:

```python
import os
import cv2
import numpy as np
import os
os.environ["SM_FRAMEWORK"] = "tf.keras"
#from tensorflow import keras
import segmentation_models as sm
from matplotlib import pyplot as plt
import random
from keras import backend as K
import tensorflow.keras.backend as k
from keras.models import load_model
```

```python
def jaccard_coef(y_true, y_pred):
  y_true_flatten = K.flatten(y_true)
  y_pred_flatten = K.flatten(y_pred)
  intersection = K.sum(y_true_flatten * y_pred_flatten)
  final_coef_value = (intersection + 1.0) / (K.sum(y_true_flatten) +
                                              K.sum(y_pred_flatten) - intersection + 1.0)
  return final_coef_value
```

```python
weights = [0.1666, 0.1666, 0.1666, 0.1666, 0.1666, 0.1666]
dice_loss = sm.losses.DiceLoss(class_weights = weights)
focal_loss = sm.losses.CategoricalFocalLoss()
total_loss = dice_loss + (1 * focal_loss)
current_directory = os.getcwd()
satellite_model = load_model(f"{current_directory}\satellite-imagery_new.h5",
                             custom_objects=({'dice_loss_plus_1focal_loss': total_loss,
                                              'jaccard_coef': jaccard_coef}))

satellite_model.get_config()
```

```python
def predict(ImagePathUplaoded):
    current_directory = os.getcwd()
    print("Current Directory:", current_directory)

    image = cv2.imread(f"{current_directory}/uploaded_images/{ImagePathUplaoded}")
    image = cv2.resize(image, (256, 256))
    image = np.array(image)
    image = np.expand_dims(image, 0)
    print("Uploaded Image : ",image)

    prediction = satellite_model.predict(image)
    predicted_image = np.argmax(prediction, axis=3)
    predicted_image = predicted_image[0,:,:]
    predicted_image = predicted_image * 50
    print("Predicted Image : ",predicted_image)

    # Save the predicted image to a file using OpenCV
    predicted_image_path = "uploaded_images/predicted_image.jpg"
    cv2.imwrite(predicted_image_path, predicted_image.astype('uint8'))


    return predicted_image_path

predict("vitb2.jpg")
```

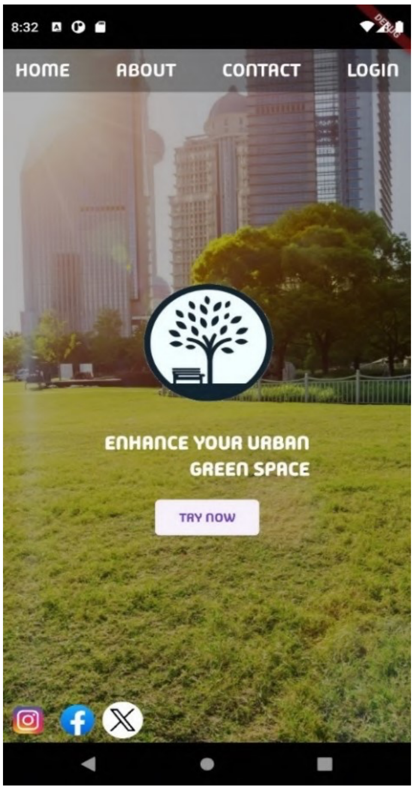
```
def process_input_image(image_source):
    image = np.expand_dims(image_source, 0)

    prediction = satellite_model.predict(image)
    predicted_image = np.argmax(prediction, axis=3)

    predicted_image = predicted_image[0,:,:]
    predicted_image = predicted_image * 50
    return 'Predicted Masked Image', predicted_image
```

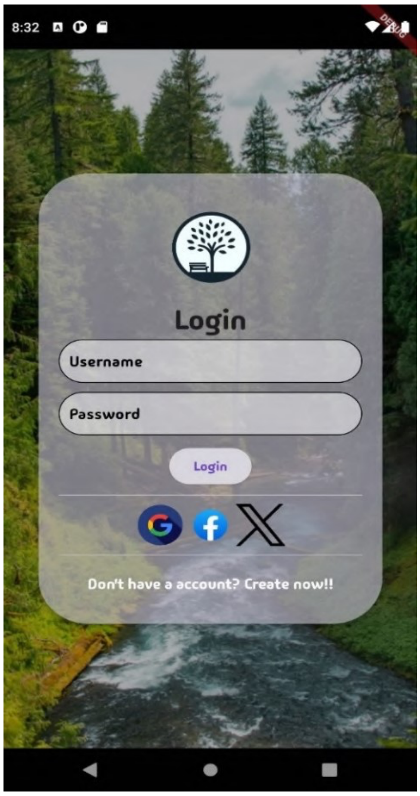
Main File:

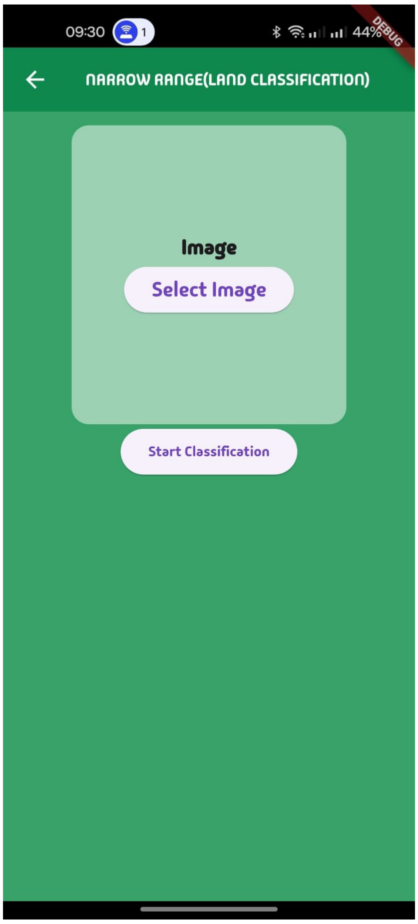
```
from fastapi import FastAPI, File, UploadFile, Request
from typing import List
import shutil
import os
from fastapi.middleware.cors import CORSMiddleware
from fastapi.responses import HTMLResponse
from fastapi.staticfiles import StaticFiles
from model import predict

app = FastAPI()

# Create a directory to store uploaded images
UPLOADS_DIRECTORY = "uploaded_images"
os.makedirs(UPLOADS_DIRECTORY, exist_ok=True)

# Mount the directory to serve static files
app.mount("/static", StaticFiles(directory=UPLOADS_DIRECTORY), name="static")

app.add_middleware(
    CORSMiddleware,
    allow_origins=["*"],  # Allow requests from any origin
    allow_credentials=True,
    allow_methods=["*"],  # Allow all HTTP methods
    allow_headers=["*"],  # Allow all HTTP headers
)
```

```
@app.post("/upload-image/")
async def upload_video(files: List[UploadFile] = File(...)):
    saved_file_paths = []

    # Save uploaded files and print their paths
    for file in files:
        file_path = os.path.join(UPLOADS_DIRECTORY, "uploaded_image.jpg")
        saved_file_paths.append(file_path)
        with open(file_path, "wb") as buffer:
            shutil.copyfileobj(file.file, buffer)
        print("Uploaded image saved at:", file_path)
        response = predict(file_path)

    # Return the file paths of saved images
    return {"output": "/static/predicted_image.jpg"}
```

Frontend (UI/UX):






09:30
44%
DEBUG
NARROW RANGE(LAND CLASSIFICATION)
Image
Select Image
Start Classification


09:30
44%
DEBUG
NARROW RANGE(LAND CLASSIFICATION)
Start Classification


09:30
44%
DEBUG
NARROW RANGE(LAND CLASSIFICATION)
Please Wait While We Process your request!!


12:21
DEBUG
NARROW RANGE(LAND CLASSIFICATION)
Want to Classification Something Else??

Result and Discussion:

The development of the mobile application using Flutter, coupled with API deployment for the machine learning model of land classification, has yielded several significant outcomes and implications for environmental management and urban planning.

1. Efficient Land Classification:

The integration of a machine learning model for land classification into the mobile application has enabled users to classify land types quickly and accurately. Real-time data processing through API deployment ensures efficient classification directly from users' mobile devices, eliminating the need for complex computations and data storage on local devices.

2. Improved Environmental Monitoring:

By providing users with the ability to analyse and categorize land types, the application facilitates enhanced environmental monitoring and assessment.
Users can identify and track changes in land use patterns, helping to monitor deforestation, urban sprawl, agricultural expansion, and other land-related activities with implications for biodiversity and ecosystem health.

3. Informed Decision-Making:

The application empowers users, including urban planners, policymakers, researchers, and community members, to make informed decisions regarding land use and management. Insights generated through land classification can inform urban planning processes, infrastructure development, conservation initiatives, and natural resource management strategies, leading to more sustainable and resilient communities.

4. Citizen Science and Community Engagement:

The user-friendly interface and interactive mapping features of the application promote community engagement and citizen science initiatives.
Users can actively contribute to environmental monitoring efforts by reporting land observations, sharing data, and participating in collaborative mapping projects, fostering a sense of ownership and stewardship of natural resources.

5. Scalability and Future Directions:

The mobile application's scalability and flexibility allow for future expansion and refinement of features to meet evolving user needs and technological advancements. Potential future directions may include integrating additional machine learning algorithms, expanding geographic coverage, enhancing visualization capabilities, and fostering partnerships with stakeholders to maximize the application's impact.

4. Conclusion

Employing advanced technology and precise data analysis, this phase establishes a foundation for strategic planning to improve urban green spaces in Bhopal. Leveraging sophisticated satellite imagery, we've comprehensively assessed the city's current landscape, identifying distinct land-use categories and their spatial distribution.

Implementation of machine learning models for land-use classification enables the precise delineation of residential, commercial, industrial, and green spaces. This analysis serves as a cornerstone for subsequent project phases, guiding the selection of locations for green space expansion and environmentally conscious urban planning.

The development of the mobile application using Flutter, coupled with API deployment for land classification, marks a significant milestone in leveraging technology for environmental management and urban planning. Through efficient land classification, improved environmental monitoring, and informed decisionmaking, the application empowers users to contribute to sustainable land management practices.

By promoting community engagement and citizen science initiatives, the application fosters a sense of ownership and stewardship of natural resources. Its scalability and potential for future expansion open doors to innovation and collaboration, ensuring its relevance and effectiveness in addressing evolving challenges. While challenges such as data privacy and algorithm accuracy must be addressed, continued collaboration with stakeholders and user feedback mechanisms will be essential for maximizing the application's impact and reliability.

In conclusion, the mobile application represents a powerful tool for creating more sustainable and resilient communities, where informed decision-making and active citizen participation drive positive change for the environment and society as a whole.

5. References

1. Gairola, Sanjay & Shariff, Noresah. (2010). Emerging trend of urban green space research and implications for safeguarding biodiversity: A viewpoint. Nature and Science. 8.
2. Khan, Babar & Yang, Shuwen & Hong, Weili & Yan, Heng. (2021). Extraction of Urban Green Spaces Based on Gaofen-2 Satellite Imagery. IOP Conference Series: Earth and Environmental Science. 693. 012119. 10.1088/1755-1315/693/1/012119.
3. Huerta, Roberto & Yépez, Fabiola & Lozano-García, Diego & Cobián, Víctor Hugo & Ferriño, Adrian & De Leon-Gomez, Hector & González, Ricardo & Vargas-Martínez, Adriana. (2021). Mapping Urban Green Spaces at the Metropolitan Level Using Very High-Resolution Satellite Imagery and Deep Learning Techniques for Semantic Segmentation. Remote Sensing. 13. 10.3390/rs13112031.
4. Bayram Cemil Bilgili and Ercan Gökyer (2012). Urban Green Space System Planning, Landscape Planning, Dr. Murat Ozyavuz (Ed.), ISBN: 978-953-51-0654-8, InTech, Available from: http://www.intechopen.com/books/landscape-planning/urban-green-space-system-planning
5. Chen, Wei & Huang, Huiping & Dong, Jinwei & Zhang, Yuan & Tian, Yichen & Yang, Zhiqi. (2018). Social functional mapping of urban green space using remote sensing and social sensing data. ISPRS Journal of Photogrammetry and Remote Sensing. 146. 436-452. 10.1016/j.isprsjprs.2018.10.010.
6. Pham, Thi-Thanh-Hien & He, Dong-Chen. (2008). How do People Perceive the City's Green Space? A View from Satellite Imagery (In Hanoi, Vietnam). 3. 1228-1231. 10.1109/IGARSS.2008.4779579.
7. Kothencz, Gyula & Kiss, Márton & Petutschnig, Andreas. (2017). Hot spots for improvements: Where to implement new green spaces? 1-4. 10.1109/UIC-ATC.2017.8397576.
8. Kopecka, Monika & Rosina, Konstantin & Szatmári, Daniel. (2017). Analysis of Urban Green Spaces Based on Sentinel-2A: Case Studies from Slovakia. Land. 6. 10.3390/land6020025.
9. Rustamov, Jaloliddin & Rustamov, Zahiriddin & Zaki, Nazar. (2023). Green Space Quality Analysis Using Machine Learning Approaches. Sustainability. 15. 7782. 10.3390/su15107782.
10. Moreno-Armendáriz, Marco & Calvo, Hiram & Duchanoy, Carlos & López-Juárez, Anayantzin & Vargas-Monroy, Israel & Suarez-Castañon, Miguel. (2019). Deep Green Diagnostics: Urban Green Space Analysis Using Deep Learning and Drone Images. Sensors. 19. 5287. 10.3390/s19235287.
11. Bolte, Anna-Maria & Kötter, Theo & Schuppe, Sophie. (2019). Can you see green or blue? On the necessity of visibility analysis of urban open spaces using Remote Sensing techniques and Geographic Information Systems. 1-4. 10.1109/JURSE.2019.8808936.
12. Wolch, Jennifer & Byrne, Jason & Newell, Joshua. (2014). Urban green space, public health, and environmental justice: The challenge of making cities `just green enough'. Landscape Urban Plann. 125. 10.1016/j.landurbplan.2014.01.017.
13. Wang, Jingxia. (2020). Urban Green Infrastructure Planning: Multifunctional Networks for Sustainable Urban Development.
14. Jabbar, Muhammad & Yusoff, Mariney & Aziz, Shafie. (2021). Assessing the role of urban green spaces for human well-being: a systematic review. GeoJournal. 87. 1-19. 10.1007/s10708-02110474-7.

15. Farkas, Jeno & Hoyk, Edit & Morais, Mariana & Csomós, György. (2023). A systematic review of urban green space research over the last 30 years: A bibliometric analysis. Heliyon. 9. e13406. 10.1016/j.heliyon. 2023.e13406.
16. Hao, Zou & Wang, Xiaojun. (2021). Progress and Gaps in Research on Urban Green Space Morphology: A Review. Sustainability. 13. 1202. 10.3390/su13031202.
17. Jansson, Märit. (2014). Green space in compact cities: the benefits and values of urban ecosystem services in planning. Nordic Journal of Architectural Research. 2014. 139-160.
18. Atiqul Haq, Shah Md. (2011). Urban Green Spaces and an Integrative Approach to Sustainable Environment. Journal of Environmental Protection. 02. 601-608. 10.4236/jep.2011.25069.
19. Willis, Katharine & Gupta, Ashita. (2023). Place-Keeping in the Park: Testing a Living Lab Approach to Facilitate Nature Connectedness in Urban Greenspaces. Sustainability. 15. 9930. 10.3390/su15139930.
20. Ives, Christopher & Oke, Cathy & Hehir, Ailish & Gordon, Ascelin & Wang, Yan & Bekessy, Sarah. (2017). Capturing residents' values for urban green space: Mapping, analysis and guidance for practice. Landscape and Urban Planning. 161. 32-43. 10.1016/j.landurbplan.2016.12.010.