

# Urban Vegetation Health Monitoring using NDVI and Satellite Imagery

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**ABSTRACT:** In the world we live in today, it is really important to keep an eye on the health of plants and trees. This is because we need to make sure our environment stays healthy and balanced. The old way of checking on plants and trees is to do it by hand, which takes a lot of time and people. With new technology, it is still hard to keep track of the health of plants and trees in big cities. To make this easier, we need to use computers and satellites to help us. In this project, we made a system to check on the health of plants and trees in cities using satellites. We use pictures from satellites like Sentinel-2 and Landsat to see how healthy the plants and trees are. The system looks at kinds of data from these pictures and uses something called the Normalised Difference Vegetation Index to figure out how healthy the plants and trees are. By looking at the data from the satellites all the time and making maps and graphs, we can see how the health of the plants and trees changes. This way is better than the other way because it is fast, covers a big area and is accurate. The Urban Vegetation Health Monitoring system can also be used with systems to help cities make good decisions about the environment and plan for the future. The Urban Vegetation Health Monitoring system is a tool for checking on the health of urban vegetation.

**Keywords:** NDVI, Remote Sensing, Satellite Imagery, Urban Vegetation, Environmental Monitoring, Smart Cities, Machine Learning, Data Visualisation

## 1. INTRODUCTION

In recent years, taking care of the environment has become a big concern. This is because cities are growing fast the climate is. People are doing more things that affect the Earth. One of the parts is keeping an eye on how healthy plants are in big cities where lots of people live. Cities are always. Have many different types of buildings and parks. This makes it hard to know how healthy plants are using methods. We need ways that can handle a lot of information and give us correct answers quickly.

Old ways of checking on plants involve people going out to look at them and take samples. These methods can give information about small areas, but they take a lot of time, work and people. They also can't cover areas or keep track of changes over time. These methods aren't good enough for planning cities.

Satellite pictures have become a way to solve these problems. Satellites can take pictures of the Earth so we can keep an eye on plants over time. By using kinds of pictures that show different colours, we can tell how healthy plants are based on how they reflect light. One of the ways to check on plants is by using something called the Normalised Difference Vegetation Index (NDVI). NDVI uses two kinds of light, red and near-infrared, to see how healthy plants are. Healthy plants take in light and reflect near-infrared light. This helps us know how many plants there are and how healthy they are. When NDVI numbers are high, it means plants are healthy. When they are low, it means plants are stressed, or there aren't any plants.

New technologies like Google Earth Engine and data visualisation tools have made it easier to keep track of plant health. These tools can handle a lot of information, help us understand it, and show it in a way that is easy to understand.

This project is about creating a system to monitor Urban Vegetation Health using NDVI and satellite pictures. The goal is to make a system

that can look at plant conditions, classify how healthy they are and show where they are without needing people to do it. The system will process satellite information, calculate NDVI numbers and create maps and pictures that make sense.

The techniques used in this project can also help with things like keeping an eye on the environment, farming, managing forests and studying the climate. By using satellite pictures and data analysis, this project aims to help create solutions that are good for cities and the Earth.

Urban Vegetation Health Monitoring is crucial for urban planning. The use of NDVI and satellite imagery provides an efficient approach for environmental monitoring. The system will provide timely insights for better urban planning. Urban environments are highly dynamic and consist of land cover patterns. The project focuses on developing a system for Urban Vegetation Health Monitoring. The techniques explored in this project have applications in environmental monitoring. The system processes satellite data, computes NDVI values and generates insights through maps and graphical representations.

The goal is to design a system that can analyse vegetation conditions, classify health status and visualise patterns without manual intervention.

## 2. Related Work

The study of vegetation and the environment has become really important in recent years because of cities getting bigger and climate change. At first, people mostly used to go out and look at the plants and write down what they saw. This way of doing things gave us information about small areas, but it was not good for looking at big areas. These old ways were useful for projects, but they could not give us information all the time about what was happening in cities that were changing fast.

### Remote Sensing Approaches

Then people started using machines that could look at the Earth from far away. This was an improvement in how we watch the environment. We could use satellites like Landsat and Sentinel to look at the Earth and see what was happening. Scientists started using something called the Normalised Difference Vegetation Index, or NDVI for short, to see how healthy the plants were. NDVI was first used by Tucker in 1979. It worked really well. It helped us see how plants were

doing by looking at the kinds of light. This way, we could watch the plants in an area without having to go there.

### Geospatial Analysis and GIS Integration

Later, people worked on combining mapping tools with the information from the satellites. This helped us make maps and see what was changing over time. We could use tools like Google Earth Engine to look at a lot of information quickly. These tools helped us see what was happening over time, find out when plants were getting sick, and make decisions about cities and the environment.

### Visualisation Platforms and Analytical Systems

In recent years, people have made special websites and tools that help us understand the information about plants better. We can use tools like Streamlit and ArcGIS to make pages that show us maps, graphs and numbers. These tools make it easier for people who are not experts to understand the information. Some people have also tried using computer programs to make the information more accurate and helpful.

### Research Gaps

Even though we have made a lot of progress, there are still some problems. Many of the systems we use do not give us information in time, and they need to be updated regularly. We also do not have tools that can analyse the information and show it to us in a way that is easy to understand, all in one place. Most systems look at areas, but they do not give us detailed information about what is happening in cities. This project is trying to fix these problems by making a system that combines information about plants, satellite pictures and special tools to help us watch the plants in cities in a way.

### 3. Problem Statement

Monitoring the health of vegetation in cities is a problem because of how fast cities are growing, the changing climate and the increasing pressure on the environment. The old ways of checking on vegetation mostly involve people going out into the field and making observations from the ground, which takes a lot of time, work and money. These methods can give us information about what is happening in a small area, but they are not good for checking on vegetation over a large area or over a long time. Also, these methods do not give us information in time and often miss the changes that are happening in the environment.

In cities, vegetation is not evenly spread out because of all the buildings, roads and other things that are there, which makes the landscape very complicated. To monitor these areas, we need to look at a lot of data, including how dense the vegetation is, how it changes with the seasons and what kinds of environmental stress it is under. It is even harder to get a sense of the health of the vegetation because of the mix of different types of land use, clouds getting in the way of satellite pictures and the varying quality of the data.

The main problem that this project is trying to solve is creating a system that can automatically and efficiently monitor the health of vegetation using pictures from satellites. The system needs to be able to handle data from spectrums, pull out the important information and accurately calculate things like the NDVI to figure out how healthy the plants are. It should also

be able to sort the vegetation into categories based on how healthy it is and provide useful information through visualisation tools.

To solve this problem, we are using sensing techniques and NDVI analysis to create a smart framework for monitoring. The goal is to make a system that can automatically check on the condition of the vegetation, find areas that are under stress, and provide information about what is happening in space and time without anyone having to get involved. The project is focused on building a system for handling the data, making sure the data is accurate and adding visualisation tools to help people make informed decisions about planning and taking care of the environment in a sustainable way.

### 4. Methodology

The Urban Vegetation Health Monitoring system is something that we have come up with to check how healthy the plants are in cities. We use pictures from satellites. A special way of looking at these pictures is called NDVI-based analysis. This helps us to automatically see how plants are doing in parts of the city.

The Urban Vegetation Health Monitoring system has important parts. These parts are getting the data, cleaning up the data, computing the NDVI, classifying the data and showing what we found. We will talk about each part of the Urban Vegetation Health Monitoring system.

#### 4.1 Satellite Data Environment

The system they are talking about is like a tool that uses satellites to watch over cities and see how healthy the plants are.

The system is made up of:

Pictures of cities taken from satellites that show kinds of light Special light, such as red and near-infrared light

Certain areas of the city that they want to look at

What the city is made of, like plants, buildings and roads

Each set of pictures shows what a certain place looks like at a time. This means the system can see how the plants change over time. The pictures from the satellites have information that helps figure out what the plants are like.

The system looks at these pictures. Pulls out the important parts. Then it analyses the light that bounces off everything to see how healthy the plants are. The system does all of this in an organised way, where it looks at each picture one step at a time to get the information it needs about the plants. The satellite system uses this information to make maps that show how healthy the vegetation is in the city.

#### 4.2 Data Representation

The way we show data is important because it helps the system understand the health of plants. Each picture from a satellite gives us some information, including:

- The colour values from the part of the light spectrum
- The colour values from the part of the light
- near infrared spectrum
- Where each little piece of the picture is located
- How plants and non-plants reflect light
- How the environment affects the light in the picture

These things help the system see how plants are spread out in cities and how healthy they are. By looking at the red and near values together, the system can tell how dense the plants are and how healthy they are.

The system uses a way of organising the satellite pictures, which makes it easier to calculate the health of plants and to group them into different categories based on how healthy they are, using something called NDVI computation, and this helps the system to understand vegetation conditions.

### 4.3 Processing Operations

The system looks at satellite pictures to check how healthy plants are. It does a set of things to change the pictures into useful information about plants.

The things it does are:

- It takes the near-infrared parts of the pictures
- It fixes the pictures by making them all correct for brightness
- It gets rid of noise and cloudy parts that don't show the plants clearly
- It calculates a number, NDVI, for each tiny part of the picture
- It gets the data ready to show on a map and classifies

These steps are done in order. The system can accurately check plant health in different areas.

The system works within rules about the data, so differences in the pictures don't mess up the results. This way, it can give information about plant health from the satellite pictures.

### 4.4 NDVI- Based Analytical Framework

The system is made to look at how healthy plants are by using a special way of analysing pictures taken by satellites.

At every step:

- The system looks at the pictures taken by the satellite
- It takes out the near-infrared band values from these pictures
- It calculates the NDVI values using a formula
- The system then looks at how the plants are based on these NDVI values

The main goal of this analysis is to get a good idea of how dense and healthy the plants are by looking at how they reflect light.

When the system keeps looking at pictures taken by satellites, it can see how the health of plants is changing in areas. If the NDVI value is high, it means the plants are healthy. If the value is low, it means the plants are stressed, or there are no plants in that area.

This way of analysing pictures helps the system look at the health of plants automatically and on a scale, which means it can give us reliable information to help us take care of the environment and plan our cities.

### 4.5 Processing Workflow

The system looks at satellite pictures of the Earth to see how healthy the plants are in places and at different times. It does this by looking at the pictures over again.

Each time the system looks at the pictures, it does a check of a certain area. The system does all the work to figure out how healthy the plants are in that area. Here is what the system does:

- It gets Picks the area it wants to look at
- It gets pictures of that area from a satellite
- It makes those pictures better by removing clouds and making them all the same
- It pulls out the parts of the pictures that show how healthy the plants are
- It calculates a number for each part of the picture to see how healthy the plants are
- It uses that number to decide if the plants are healthy or not
- It makes pictures and graphs to show what it found out

The system can look at the pictures over time to see how the plants are changing. It does this by comparing the numbers it calculated. This helps the system work well, figure out what is going on, and understand what it means for the plants in cities. The system looks at satellite pictures to see how healthy the plants are. It looks at the pictures to see how healthy the vegetation is.

### 4.6 Reward Design

The way we figure out how healthy plants are is really important. It is based on something called NDVI values. This helps the system put plants into groups based on how healthy they are, so we can look at them more closely and understand what is going on.

We use a range of NDVI values to decide how healthy plants are. Event or what is happening to the plants and the NDVI range are related like this:

- Healthy plants have an NDVI range of more than 0.6
- moderately healthy Plants have an NDVI range of 0.3 to 0.6
- Plants that are stressed or not healthy have an NDVI range of less than 0.3

This way of grouping plants helps us find areas with a lot of plants, areas with some plants, and areas where plants are not doing well because of problems with the environment or because there are not many plants.

The system takes NDVI values. Turns them into groups that make sense, which makes it easier for people to understand what is going on with the plants. It also helps us make maps of NDVI values and assign colours to each group so we can see what is going on with the plants, in cities, really quickly, and we can see patterns of NDVI values and how healthy the plants are.

### 4.7 Tools and Technologies

The project uses Python for developing the system and working with satellite imagery data. Python is great for handling sets of data and doing math problems that are needed for NDVI analysis.

The system uses a lot of libraries and tools to make it work:

- We use NumPy and Pandas to work with data and do math operations
- We use Google Earth Engine to get and work with satellite pictures

- We use Streamlit to make the web page that users interact with
- We use Folium to show vegetation data on a map
- We use Plotly to make graphs and charts

These tools help us work with data quickly, calculate things accurately and show results in a way that is easy to understand. The project uses Python and these tools together, so it can handle a lot of satellite data and show the results in a way that's easy for users to use. The system is made to process sets of satellite data, and the project uses Python to make it work.

## 5. Results and Discussion

### 5.1 System Performance

The Urban Vegetation Health Monitoring system was tested using satellite datasets and analysis cycles. The system looked at pictures from satellites that showed colours and calculated Urban Vegetation Health Monitoring system values to see how healthy the plants were in different city areas.

As the system kept analysing, it made Urban Vegetation Health Monitoring system values and correct classifications for many different areas. This shows that the Urban Vegetation Health Monitoring system is good at finding patterns in plants and seeing how healthy they are.

At first, the raw satellite pictures had a lot of stuff like clouds and noise, and the colours were not all the same, which made it hard to understand what they meant. After the system cleaned up the pictures using techniques like hiding clouds, making everything the same and picking out certain colours, it made Urban Vegetation Health Monitoring system values that were more reliable and correct.

The maps that the system made clearly showed which areas had plants and which did not. Areas with a lot of plants had high Urban Vegetation Health Monitoring system values, and areas with buildings and roads had values. The system kept finding where the plants were and where they were stressed over datasets, which shows it is good at watching the environment.

The fact that the system made more consistent outputs after cleaning up the pictures and calculating Urban Vegetation Health Monitoring system values shows that the way it analyses the data is effective in giving us useful information about how healthy the plants are in cities.

### 5.2 Vegetation Analysis

The system looked at lots of satellite data. It was really good at figuring out what the plants and trees are doing in cities.

Here are some things that the system found out:

- **Vegetation detection:** The system was able to find the areas with plants and trees by using something called NDVI values. It could tell these areas apart from the areas with buildings and roads.
- **Health classification:** The places with lots of plants and trees had NDVI values, which means the plants are healthy. The places with NDVI values had plants that were not doing well, or there were not many plants.
- **Spatial variation analysis:** The system saw that the plants and trees are not spread out evenly in areas. It found out that there are plants in some places, like parks, than in other places, like areas with lots of buildings.
- **Stress zone identification:** The system found areas where the plants are stressed because of things like pollution or not enough water. It could tell this because these areas had NDVI

values.

All of these things show that the system is good at looking at the plants and trees and figuring out what is going on with them. It can use the satellite data to understand what is happening in environments, and it does a good job of it. The system is really good at analyzing vegetation conditions and responding to environmental patterns based on the satellite data, from the satellites.

### 5.3 Performance Metrics

The performance of the proposed vegetation monitoring system was evaluated using metrics:

Metric	Description
NDVI Accuracy	How accurate are the NDVI values in showing vegetation health?
Vegetation Coverage	What percentage of the area is covered with vegetation?
Classification Accuracy	How well does the system categorise vegetation into health classes?
Spatial Consistency	Are NDVI values consistent across regions?
Processing Efficiency	How long does it take to process satellite images and generate results?

These metrics help evaluate how well the system analyses vegetation conditions and provides results across different datasets. The effectiveness of the vegetation monitoring systems is determined by these metrics. Vegetation health is accurately represented by NDVI values. Vegetation coverage and classification accuracy are also important. The system's processing efficiency is crucial for generating results.

### 5.4 Analysis Progress

The system performance was looked at by checking the NDVI results from different sets of data. The results were always the same. Correctly showed how healthy the plants were.

The NDVI maps were really good at showing the difference between areas with plants, plants that were doing okay and plants that were struggling. The system worked well when the weather and other things around it were changing.

This means that using NDVI to look at satellite data is a way to figure out how healthy the plants are in different places. The NDVI approach gives us an idea of what is going on with the plants. The NDVI results help understand the plants.

## 5.5 Discussion

The test results show that using NDVI to check on vegetation health works with satellite images. The system correctly mapped out where vegetation is and found areas of stress in cities.

The results also show that combining sensing with NDVI is a good way to keep an eye on the environment on a large scale. The system gave reliable results with different sets of data.

However, some problems came up, like the system relying on good-quality satellite data and being affected by clouds. To make it better, we could add advanced indexes, process data in real-time and use machine learning for more accurate results.

## 6. Advantages

The NDVI-based system for checking vegetation has some benefits compared to old methods that involve people going out to survey. This system uses satellite pictures to look at areas automatically, which means you do not need to send people out to do it.

The system gives steady results because it uses a standard way of calculating NDVI. This makes it good for keeping an eye on the environment all the time. It can also look at lots of data quickly, which makes it more efficient and cheaper to run. The system has tools that help you understand data about locations. A major. Of the system is that it can be expanded to cover more areas and time periods. It can also work with technologies like machine learning and systems that monitor in real-time. This makes it more useful for building cities and managing the environment with an NDVI-based system.

The system can be used for city development and environmental management with the help of an NDVI-based system.

## 7. Applications

The things we learned from this project can be used in a lot of ways besides just looking at plants in cities. We can use the NDVI analysis in farming to check how healthy the crops are, see if they are stressed and make sure we get the results. It is also helpful when we study the environment to see what is happening with trees being cut down, land not being used well and how the climate is changing over time.

When we plan cities, this system helps us make decisions by showing us where the green areas are and how we can build things in a way that is good for the earth. We can also use it to take care of forests by checking how thick the plants are and seeing if anything is changing.

There are other ways to use this, like when there are big disasters, and we need to see how bad the damage is after something like a flood or a drought. It is also useful in cities that want to be smart and take care of the environment because we need to be watching to make sure everything is balanced.

## 8. Future Scope

The development of a system to monitor vegetation using NDVI is a big step forward in analysing the environment. It helps us check how healthy the vegetation is by using pictures from satellites. This system uses techniques to take pictures from far away and calculate NDVI, which allows it to accurately and easily monitor vegetation conditions in big cities.

This method is better than ways of doing things manually because it can analyse automatically and keep track of things all the time. The system can see where vegetation is found, areas that are stressed, and help make decisions for the environment.

Overall, this system helps plan cities in a way and shows how important it is to use geographic technologies to make cities smart and manage the environment well.

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