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MAPPING THE GREEN ENEMY: REMOTE SENSING FOR WEED CONTROL

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INTRODUCTION

Diverse biotic communities are being threatened by invasive alien plant weed species and consequently, cost countries millions to manage. The effective management of these weed species invasions necessitates their frequent and reliable monitoring across a broad extent and over a long term. Hence, the introduction and application of a monitoring approach that meets these criteria is based on a three-stage hierarchical classification of identification, mapping, and management. So, the concept of remote sensing has been brought into consideration in the sector of agriculture. Remote sensing is the best supporting technique for the identification of weed species to a large extent of area. It potentially helped as a promising tool for the field of precision weed management. Various tool software has been developed for easy monitoring and mapping of invasive weed species.

NEED FOR WEED MAPPING

Weeds hinder navigation and recreation, elevate water losses, cut water flow rates, and reduce light penetration into the water body. Hence, the Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) of aquatic species cannot be met because of floating weeds in aquatic bodies. So weed mapping is done to determine its location and so we can go for management measures.

Similarly, in the case of weed infestation in land mass conditions, a huge loss of economic yield in the agriculture sector was found. Also as weed species sometimes don't cover the entire field, there exists wastage in the application of herbicides. Hence precision technology support is much more needed to reduce the input cost of herbicides. So, weed mapping is necessary to easily identify the location of weeds and further go for precise weed management.

The principle of detecting the spatial and temporal variability is being adapted to study weed species' location by which precision weed management could be done. Regular monitoring of invasive alien weeds is needed to promote targeted, feasible, and effective management. Consequently, there is an urgent need for techniques that enable consistent, frequent, and accurate monitoring of weeds.

ROLE OF REMOTE SENSING

Remote sensing plays a crucial role in weed management by providing valuable data and insights that aid in the detection, monitoring, and control of weed infestations.

Early Detection and Mapping: Remote sensing technologies, such as satellite imagery and drones, enable the early detection and mapping of weed infestations over large areas.

By analyzing spectral signatures and vegetation indices, remote sensing can differentiate between weed species and healthy vegetation, allowing for timely intervention.

Monitoring Weed Spread and Dynamics:

Remote sensing allows for the monitoring of weed spread and dynamics over time, capturing changes in weed populations, growth rates, and distribution patterns. This longitudinal data helps experts assess the effectiveness of control measures, anticipate future weed outbreaks, and adapt management strategies accordingly.

Precision Weed Control: Remote sensing supports precision weed control by identifying specific areas of high weed density within fields or landscapes. By integrating remote sensing data with geographic information systems (GIS) and Global Positioning System (GPS) technologies, experts can implement site-specific control measures, such as targeted herbicide applications or mechanical weed removal, reducing costs and minimizing environmental impacts.

Risk Assessment and Prediction Modeling:

Remote sensing data supports weed risk assessment and prediction modeling by identifying environmental factors associated with weed infestations, such as soil properties, climate conditions, and land use patterns. By analyzing spatial relationships and modeling potential weed habitat suitability, experts can prioritize areas at high risk of weed establishment and spread, guiding proactive management interventions.

Integration with Decision Support Systems:

Remote sensing integrates with decision support systems (DSS) to provide real-time, data-driven recommendations for weed management decision-making. By combining remote sensing data with weather forecasts, soil information, and agronomic models, DSS assists managers in optimizing the timing and intensity of weed control interventions, minimizing herbicide use, and maximizing crop yields.

HOW COME WEED MAPPING IN PLAINS DIFFERS FROM WATER BODIES?

Weed mapping can differ between plains and water bodies due to differences in environmental conditions, vegetation types, and the presence of water.

IN THE CASE OF PLAINS

Weed mapping in plains typically involves analyzing satellite imagery or conducting field surveys to identify and locate weed species within agricultural fields, grasslands, or other open areas. In plains, weeds may compete with crops for nutrients, water, and sunlight, affecting agricultural productivity. Mapping weeds in plains helps farmers to target weed control measures effectively and optimize crop management practices. Remote sensing technologies such as satellite imagery and drones are commonly used to detect and map weeds in plains. These technologies can capture large areas efficiently and provide valuable data for weed management decisions.

IN THE CASE OF WATER BODIES

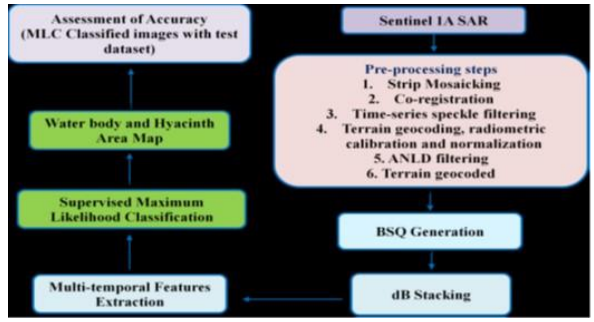
Weed mapping in water bodies focuses on identifying and monitoring aquatic or semi-aquatic weed species such as water hyacinth, water lettuce, etc. Weeds in water bodies can form dense mats, obstruct water flow, and degrade water quality, impacting aquatic ecosystems, navigation, and recreational activities. Therefore, mapping weeds in water bodies is essential for effective weed control and habitat restoration efforts. Remote sensing techniques, such as multispectral or hyperspectral imaging, are used to detect and monitor aquatic weeds in water bodies. These techniques can distinguish between different types of vegetation and assess the extent of weed infestations. Additionally, field surveys and manual mapping may be necessary for water bodies to accurately locate and characterize weed populations, especially in areas with dense vegetation or complex underwater terrain.

Though the principles of weed mapping apply to both plains and water bodies, the methods and techniques used may vary depending on the specific characteristics and challenges associated with each environment.

PROCEDURE

QGIS weed mapping in water bodies

QGIS is free source cross-platform software used for viewing, editing, printing, and analyzing geospatial data. It was launched in July 2002. It can be used in multiple Operating systems like Windows, Linux, Mac, and Android. It works in C++ and Python. It is a Multilingual Language Setup. It is used for mapping the weeds. It also can be used for making thematic maps.



STAGE 1: SURFACE WATER DETECTION

In this, manual observations of water bodies are taken. This is done by visual observation once reaching that water body spot. The latitudes and longitudes are noted by using the mobile compass. We have to give an approximate area coverage estimation of aquatic weeds in that water body by visual observation. For example, if half of the water body is covered with weed mats, then we can say that the weed coverage is 50% in that water body.

STAGE 2: QGIS Software mapping

Step 1: Here three basic operations are considered which include the polygon, line, and points (So called SHAPE FILES). We need to download the navigation map and overlay it in the worksheet. And then we need to download the shapefile for our area of interest. Once it is downloaded, it is set as a base map for our working purpose.

Step 2: Once the base map for working with the area of interest is made, the latitude and longitude co. ordinates that were noted using the mobile compass are framed in the BOOK – FEAT option. Once it is processed we can able to map the exact location of the water bodies and in particular we can identify the weed mats specifically.

By this, we can finally map the exact location of the water bodies with water hyacinth weed mats and this could be highlighted using point shapefiles respectively.

STAGE 3: AREA COVERAGE ESTIMATION

This can be done using the GOOGLE EARTH mobile application.

- By using this we can estimate the total weed coverage area on the surface of all the water bodies available in the interested region.
- The MEASURE ICON helps to demarcate the plot border to estimate the area of the water body.
- By plotting the area border of all the water bodies, we can easily estimate the total aquatic weed coverage in the interested area.

MERITS OF WEED MAPPING

- Sampling theory of statistics works here. Once we get the sample level data in the interested region, we can go for population level with widespread areas. For this, we need to go for remote sensing technology where the data is fed and it helps in seeking similar reflection patterns of weed species over a large area.
- Also time consumption and resource usage are minimised. For instance, going manual weed survey is a tedious process. But once weed mapping is done at the sample level, it could be taken for the population level as we know a good sample should be the best representative of the population community. By this time consumption is minimized and work is made easier. Quick management support could be done to overcome weed infestation.

CONSTRAINTS OF WEED MAPPING

Weed mapping, like any scientific endeavor, comes with its own set of challenges and constraints. Here are some common constraints faced in weed mapping:

Spatial and Temporal Resolution: The spatial and temporal resolution of available satellite imagery or remote sensing data may not be sufficient to accurately detect and map small or rapidly changing weed populations. Limited resolution can lead to difficulties in distinguishing weeds from other vegetation or background features.

Spectral Signatures: Weed species may exhibit similar spectral signatures to other plants or background materials, making it challenging to differentiate them using remote sensing data alone. This issue can complicate the process of accurately identifying and mapping specific weed species.

Seasonal Variability: Weed populations can exhibit seasonal variability in growth, density, and distribution, influenced by factors such as weather conditions, agricultural practices, and natural disturbances. Mapping weeds throughout the growing season requires frequent data acquisition and monitoring to capture these temporal changes effectively.

Scale and Coverage: Weed mapping efforts may face limitations in terms of the scale and coverage of the area being surveyed. Balancing the need for high-resolution mapping at the local level with broader coverage across larger landscapes can be challenging, especially with limited resources or technology constraints.

Data Integration and Analysis: Integrating and analyzing diverse datasets from multiple sources, such as satellite imagery, field surveys, and geospatial databases, can be complex and require advanced analytical techniques. Ensuring compatibility, consistency, and accuracy across different data sources is essential for robust weed mapping analyses.

Privacy and Legal Considerations: Accessing and sharing geospatial data, particularly in sensitive or protected areas, may be subject to legal restrictions, privacy concerns, or proprietary interests. Compliance with relevant regulations and ethical guidelines is essential to ensure responsible and transparent weed mapping practices.

By overcoming these challenges, weed mapping efforts can contribute to more effective weed management strategies, sustainable agriculture practices, and environmental conservation initiatives.

CONCLUSION

The utilization of remote sensing for weed mapping offers a promising avenue for effective and efficient weed management strategies. Through the integration of various remote sensing technologies such as multispectral and hyperspectral imaging, LiDAR, and UAVs, researchers and practitioners have been able to accurately detect, identify, and map weed infestations over large and diverse landscapes. These advancements have facilitated timely and targeted interventions, leading to improved resource allocation, reduced herbicide usage, and enhanced crop yields. Moreover, the integration of machine learning and GIS techniques has further enhanced the accuracy and scalability of weed mapping efforts.

SOFTWARE USED FOR WEED MAPPING

Feature	MAPscape RIICE	ArcGIS/QGIS	DSSAT
Type	Satellite Image Interpretation Software	GIS Software	Crop and Weed Growth Simulation Software
Cost	Approximately 13 lakhs/system	Free and Open Source	Cost may vary, not specified
Radiation Study	Reflection	Reflection	N/A
Functionality	Determines reflection patterns for weed species distribution evaluation	Positioning water bodies/land masses, mapping weed species	Crop and weed growth simulation, studying growth stages
Data Retrieval	Retrieves backscattering images based on dB values	Manual observation for latitude and longitude coordinates	Simulation modeling for crop and weed growth
Application	Weed species distribution evaluation	Mapping weed species locations	Studying weed growth stages for management
Additional Features	N/A	Cross-platform support	Wide range of crop and weed species models
Suitability	Satellite image analysis for weed distribution	Mapping spatial data including water bodies and land masses	Simulating crop and weed growth for management decisions