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Urban Green Space Identification and Analysis Using Sentinel-2A Data: A Study on Gudur Municipality

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Abstract: Urban Green Areas (UGS) such as parks, forests, green roofs, riverine vegetation, and community gardens are essential for the provision of a broad range of ecological services such as urban heat mitigation, storm water infiltration, food security and recreation facilities that promote the well being of the residence of these spaces. Proper evaluation and inter-city evaluation of these spaces are essential in preserving and monitoring the impact of climate change on them. Most of the UGA studies rely wholly on remote sensing data to carry out the analysis, but some studies have opted to use social function data to evaluate green areas. In this article, we present an approach to UGS from the available open-source Sentinel 2A data. The multispectral image consists of 13 spectral bands and a relatively high spatial resolution of (10 to 60m) and a temporal resolution of 10 days. For extracting the UGS, polygons supervised maximum likelihood classification was used to classify the pixels. The first step is the identification of the UGS polygons. The raster polygons are then converted into vector data, which will be used to classify the extracted.
Keywords: Urban Green Spaces (UGS), Heat Mitigation, Sentinel 2A data, Spatial resolution, Temporal resolution.

I. INTRODUCTION

The quality and diversity of Urban Green Spaces are of importance to the physical and psychological well being of the community. UGS provides a different benefit to the crucial urban ecosystem and has a modification effect on urban areas' climate. Apart from micro-climate modification, urban green spaces also provide a means of infiltration of stormwater, food security, physical recreation, and psychological well-being of the metropolitan region members. Urban Green Areas also has an economic benefit in providing revenue from tourism activities and bird watching. Ecosystem services have a societal interest; they provide a suitable condition for the general health of the residents living in urban areas. Trees and other vegetation are essential in absorbing Carbon (iv) Oxide that is emitted from vehicles and industrial regions; this regulates the air quality and temperature in these regions. Accounting for the current condition and quantity of UGS is the first essential step in maximizing the full potential of these regions. Knowing UGS's spatial distribution is the first necessary step in maintaining, realization, and improving urban greenery design. Urban vegetation is significant from semi-green vegetation because of the intense human impact on the global atmosphere. Compared to forest covers and other natural ecosystems, forest cover usually consists of impervious surfaces and polluted air and a specific microclimate 'the urban heat island.' The population in urban areas is generally vulnerable, and it depends on human maintenance and irrigation. The heterogeneous nature of the metropolitan regions consisting of vegetative areas and the impervious part is much more exceptional in urban areas than any other place. This poses a challenge in the classification of themes in medium resolution imagery of a metropolitan region. The heterogeneity is diverse in urban areas and is usually referred to as mixed pixels when a sensor of the spatial resolution of more than 20m is used.

As a result, for a long time, convectional mapping of urban areas has been dependent on the visual interpretation of vegetation themes on aerial photographs. Later the application of digital RGB and CIR (Color Infrared) aerial imagery with a high spatial resolution was being used. More recently the implementation of very high satellite sensing system has been on the rise with the use of IKONOS, Quick Bird, Geo Eye, Rapid Eye, Worldview, the Pleiades they are capable of providing imagery with similar characteristics as aerial photographs and they fill the gap for lack of reliable imagery where productive and reliable imagery lacks. High spatial resolution imagery has been applied in tons of urban green vegetation analysis for cities such as Xiamen. Multispectral imagery such as the one used in Sentinel is used to quantify the vegetation using two criteria, Vegetation cover and Vegetation Density. High spatial resolution can also be used to identify the genre of the individual trees in the urban region.

A. Study Area

The criteria obtained to select the study area ensured that the area was heterogeneous and had a mixture of both urban impervious surfaces and vegetation cover. Gadur met the suitability criteria due to the presence of both impervious urban surface as well as green regions of interest.

II. LITERATURE REVIEW

Sentinel land use/land cover database obtained from satellite imagery also has additional information on Urban Green Regions' spatial structure. Serpil studied the role of vegetation in mitigating the Urban Heat Island phenomena   use for To analyze the impact of green infrastructure on biodiversity and UHI mitigation, current information about the quantities, qualities, and configuration of UGS is needed. The most recent data on land cover, including urban green spaces, are available from Sentinel-2A (S2A), a high-resolution optical Earth observation mission developed within the Copernicus program (previously called GMES). The program is a joint initiative of the European Commission and European Space Agency to establish a European capacity for the provisioning and use of information for environmental monitoring and security applications. Fletcher (2012) provides an overview of this mission, including the technical concept, image quality, and operational applications. S2A multispectral imager is covering 13 spectral bands with a swath width of 290km and spatial resolutions of 10 m (three visible and a near-infrared band), 20 m (6 red-edge/shortwave infrared bands) and 60 m (3 atmospheric correction bands). The mission is intended to monitor variability in land surface conditions, and its full swath width and high revisit time (10 days with one satellite and five days with two satellites after Sentinel-2B is launched in 2016) will support the monitoring of changes to vegetation within the growing season. It also provides data and applications for operational land monitoring, emergency response, and security services. The coverage limits are between latitudes 56° south and 84° north. According to Drush et al. (2012), the mission the objective is to provide systematic multispectral imaging for land cover, land use, and land-use change detection maps of biogeophysical variables such as leaf chlorophyll content, leaf water content, leaf area index (LAI) risk mapping acquisition and rapid delivery of images to support disaster relief efforts.

The objective of this contribution is to explore the potential of S2A satellite imagery for UGS mapping at the city level and to illustrate a procedure of UGS extraction and classification. UGS mapping can be defined as the identification of land cover types over urban vegetated areas. Each type of land use is linked to specific patterns of built-up and greenery or other natural surfaces (e.g., water) which can be defined by their size, location, and structure recognized 13 main categories of urban vegetation structure types (UVST) that were divided into 57 subcategories by considering the structural parameters of building and greenery presented a set of indicators and metrics that have been used to assess ecosystem services in urban settings. The UGS classification presented in this contribution is based on the land use context since linking urban greenery physical structure, and its function is crucial for further identification of the municipal ecosystem services.

III. ANALYSIS AND RESULT

A. Data And Methods

1) *Input Data:* Sentinel-2A data was available since the mid-2015 from the Copernicus Sentinels Scientific Data Hub (scihub.copernicus.eu/thus). The highest processing level available for download is 1C – Radio Metrically Corrected and Orthorectified images. For further processing, all 13 contained spectral bands should be resampled to the highest of the resolutions (10 m). Native only for blue, green, red. One of the near-infrared bands) Since the proposed classification scheme of UGS is primarily land use oriented (see the next section), it is not viable to obtain the information by automatic methods. Therefore, aerial or very high resolution (VHR) satellite images are needed to perform on-screen interpretation and classification of individual UGS polygons extracted from the S2A data.Finer than 10 m spatial resolution imagery is useful (although not necessary) in the process of selecting the training samples for supervised automatic classification of the S2A imagery Methods

2) *Automatic Land cover Classification:* Given the spectral resolution and bandwidth of S2A data, we assume that it has the potential to discriminate between a small numbers of spectrally different LC types using automatic classification methods with reasonable accuracy. We suggest a simple impervious-water-vegetation classification scheme; the vegetation is further divided into tree cover and non-woody classes. A supervised approach is preferred for higher efficiency a set of manually Pre-Classified Training is used to train the automatic classifier. A sufficient number of sample plots located evenly in the study area should be created for each of the land cover classes. Finally, the commonly used maximum likelihood classifier is employed to perform the per-pixel classification. The S2A data processing and sorting were performed using ESA SNAP 3.0 and ESRI ArcGIS Desktop10 software. For the results of the initial classification.

3) *UGS Polygons Extraction from the Classified Data:* To extract the final UGS polygons from the classified images, these were reclassified into a binary form vegetation/non-vegetation. Contiguous pixels classified as vegetation were grouped (based on queen neighborhood – each pixel can have a maximum of eight neighbors) and converted to vector polygons. All polygon parts and holes smaller than 500 m2 were removed. The remaining polygons were smoothed and generalized to remove pixelated borders, reduce the size, and improve the visual appearance (see Figure 2d).

4) *Manual Classification of UGS Polygons:* From the perspective of ecosystem services and urban planning, it is essential to consider how city residents utilize the identified UGS and, degree of human cultivation/intervention, and location relative to the prevalent use of urban land (residential, public, industrial). Considering these requirements, we have recognized the following 15 classes; the class definitions are presented in the list below. UGS polygons extracted in the previous step were overlaid on top of recent aerial orthophotos and visually classified at the scale range 1:10,000 – 1:5,000. Most of the polygons were classified as such by filling the attribute values. In some cases (especially in places with abundant vegetation), the extracted polygons were spanning over larger areas and included multiple UGS classes. In such cases, the polygons were cut so that each polygon contains a single UGS class.

B. Data Presentation

Urban greenery comes in a variety of forms from green ecological sites in the urban area to green rooftops in the building. Below is a classification of all urban green areas that are most likely to be observed during classification and their corresponding description.

1) *Urban Forest:* These are areas with more than 50% woody cultivation, and it lacks paved roads.
2) *Cultivated Parks:* Are areas with more than 50% woody vegetation and having paved paths and scattered lawns.
3) *Urban Public Garden:* Are areas characterized by regular shapes of lawns, flowerbeds and scattered trees Urban Greenery Are areas that are compacted for specific public functions these are hospitals zoos and sport clubs.
4) *Complex Cultivation Patterns:* Are areas with small parcels of land for small subsidiary growth of food .
5) *Railway and Roadside Greenery:* Are grass or any other vegetation greenery accompanying a railroad.
6) *Ruderal Vegetation:* Are areas with green herbaceous plants.

C. Tree Cover Extraction

Addition information that is significant in decision making is the type of vegetation inherent in a public space; vegetation provides a wide range of ecosystem for both birds and animals in obtaining UGS polygon the following procedure was followed
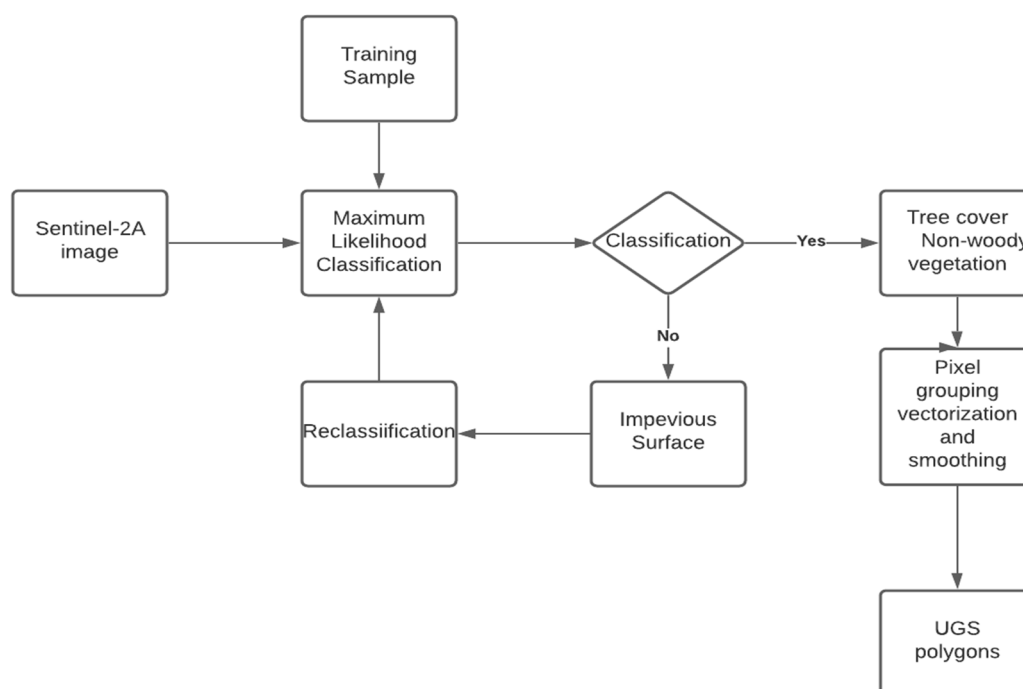

Image (1) showing the process flow in extracting UGS

IV. RESULTS

By visual comparison the results show that the accuracy of classification in employing Sentinel 2A data is much higher than the use of aerial images. Nevertheless, in comparison studies also quantitative accuracy assessment (validation) should be performed to ensure that the results are fully comparable. In particular, the distinction between a tree and non-woody vegetation may be subject to commission and omission errors. The distinction is rather of continuous than binary nature since there are many trees, shrubs, and other plant species of various ages and phenological phases.

The number of trees can also be biased by the number, location, and selection of training samples. Also, the morphology of urban fabric may affect the results. In data derived from remote sensing, the dominant classes in a particular area tend to be overestimated and vice versa.
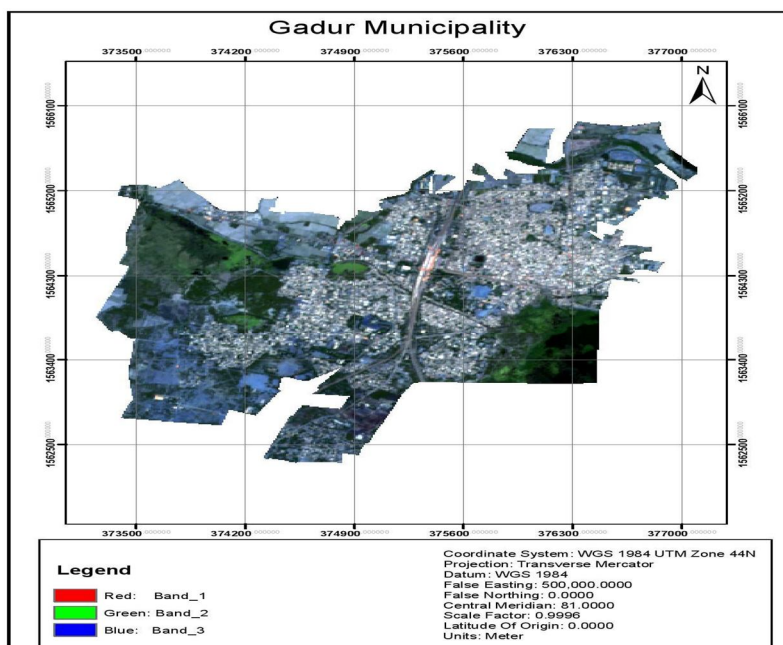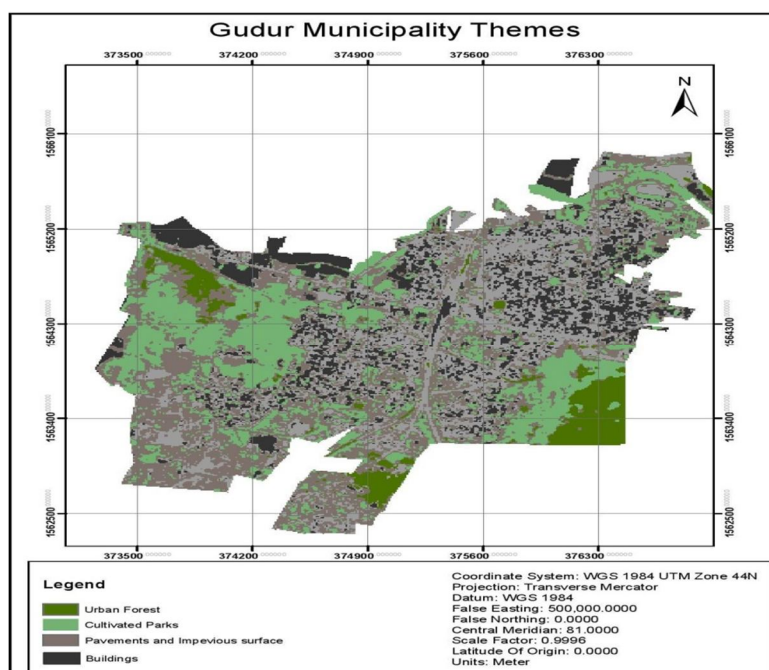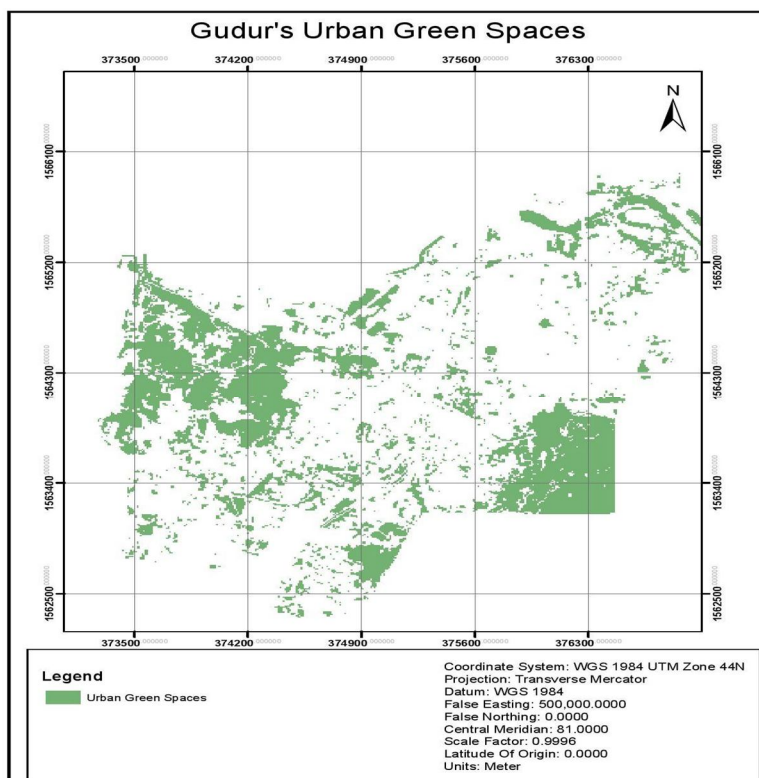

Image (a) Natural color Image

Image (b) Supervised Classified Image with all themes in Gudur.
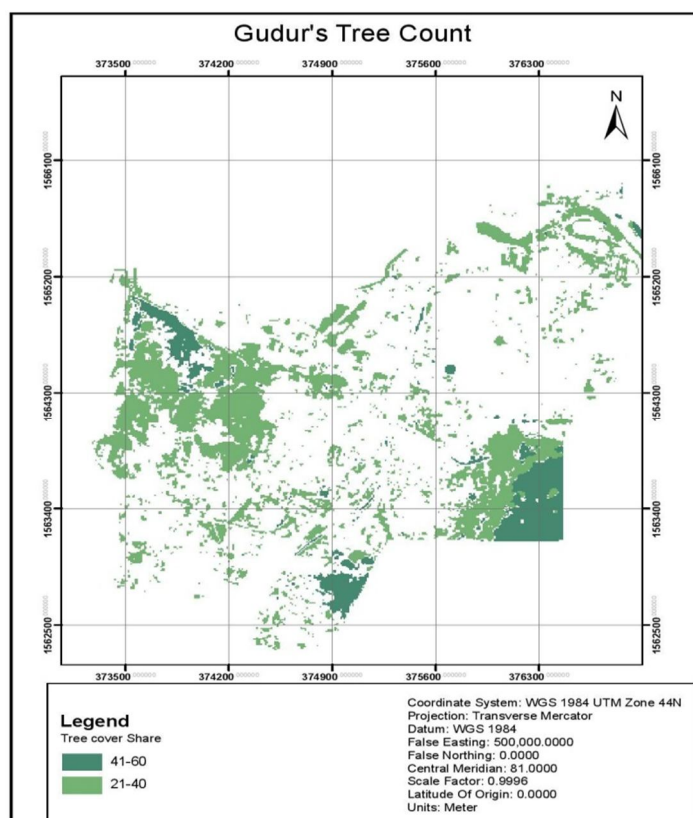
Image(c) Extracted Urban Green Regions

Image (d) Gudur's Tree Count

V. CONCLUSION

Even though carrying out UGS extraction is a hefty task, future recommendation necessitates the adoption of machine learning algorithms in identifying the green regions. An integration of the Convoluted Neural Network into the classification algorithm improves the accuracy of classification. It can detect mixed pixels and classify them appropriately depending on their spectral signatures. The latter approach is useful in classifying images of low spatial resolution, as the Landsat image in this case. Measuring the accuracy via the confusion matrix proves to be less accurate as compared to methods of statistical learning, which evaluates the efficiency of every pixel as opposed to the sampling technique pf confusion matrix, i.e. not all pixels are considered in the classification sample. However, the accuracy of classification is dependent on the spatial resolution and spectral resolution of the classified pixels.

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