



CAN THO UNIVERSITY



Prof. Vo Quang Minh and Prof. Kohei Cho

Scientific Conference Proceedings

THE 42nd ASIAN CONFERENCE ON REMOTE SENSING

ACRS2021

**REMOTE SENSING FOR DISASTER RISK
AND RESOURCES DEGRADATION REDUCTION
TOWARD SUSTAINABLE DEVELOPMENT**



CAN THO UNIVERSITY PUBLISHING HOUSE
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PREFACE

More than Forty years have passed since the first Asian Conference on Remote Sensing (ACRS), a conference for Asians, by Asians and with Asians, was held in Bangkok in December 1980. The overwhelming success of the ACRS series has strongly encouraged us to organize the 42nd Asian Conference on Remote Sensing (ACRS2021) at Can Tho University from November 22- 24th, 2021.

The establishment of ACRS2021 based on the spirit of mutual cooperation and openness. The conference is expected to be an interdisciplinary forum for leading researchers and students in related areas to present the latest developments, works, and applications, to discuss cutting-edge technology, to exchange research ideas, and to promote international collaboration in this field.

The main theme of ACRS2021, "Remote Sensing for Disaster Risk and Resources Degradation Reduction toward Sustainable Development" will focus on Sensor and Platform, Algorithm and Image Processing, Geographic Information Systems (GIS) and Web GIS, Cloud Computing, Big data and AI in Remote Sensing, Disaster Monitoring and Prevention, Environmental Domain, Remote Sensing Application for Public Health, Remote Sensing & Mapping, and Education and Training.

We would like to sincerely acknowledge the encouragement and support that we have received in abundance thus far. We would like to particularly thank to Prof. Fuan Tsai, Dr. Sameer Saran, Dr. Nguyen Dinh Duong for their support on ACRS2021 preparation. We are grateful to Prof. Ha Thanh Toan, rector of Can Tho university, Assoc. Prof. Nguyen Van Cong, dean of College of Environment and Natural Resources, Can Tho university for their strong support and motivation.

We thank the contributors for presenting papers of high caliber. We would also like to record our sincere gratitude to the committee members of ACRS2021 and staff of CTU for their cooperation and unstinting support. We express our deepest thanks to all the supporters and participants of ACRS2021, without their cooperation, organizing ACRS2021 would not be possible.

We sincerely hope that the ACRS2021 would kindle many innovative ideas and further new collaborations and friendships. We seek your continued support and cooperation.

Prof. Vo Quang Minh, ACRS2021 Chair
Prof. Kohei Cho, AARS General Secretary

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SENSOR AND PLATFORM

MAIZE CROP PHENOTYPING FOR DISEASE RESISTANCE USING UAV MULTISPECTRAL DATA

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ABSTRACT

Cost-effective and data-driven crop variety throughput phenotyping is critical for increasing yield in the face of climate change. Plant breeding programmes' success depend on development of high yielding crop varieties that are resistant to various biotic and abiotic threats. Rising temperatures and unpredictable rainfall patterns provides a conducive environment for the development of crop diseases. Maize is one of the main staple food crops in SSA, grown on a total of about 27 million ha according to FAO data. Adapting maize production to future climates depends not only on our ability to precisely predict future climate scenarios, but also on the development of robust adaptation strategies that address the challenges associated with climate change. These adaptation strategies include, but are not limited to, improved germplasm with resistance to diseases, and tolerance to heat and drought (Mutanga et al. 2017). In this regard, variety selection efficiency relies on accurate field-based phenotyping, which measures the relative genetic potential as influenced by the target production environment and expressed in terms of grain yield, biomass, and tolerance to abiotic and biotic stresses (Araus and Cairns 2014; White et al. 2012). With the proliferation of climate change driven plant diseases, the advent of Unmanned Aerial Systems has provided an opportunity to provide detailed and accurate crop phenotyping information.

This study explored the potential of UAVs multispectral data sets in improving the efficiency of crop phenotyping in maize (*Zea mays* L.) varietal response to the maize streak virus (MSV) disease. The study was conducted at Rattray Arnold Research Station (RARS) in Zimbabwe. The trial was planted on 23 November 2018 and the vegetative stage of the crop was in December 2018 and January 2019. A weather station was erected at the site to record all the required meteorological data. We evaluated three replicates of Twenty-five maize varieties grown in an experimental field trial under artificial MSV inoculation. Three established check varieties that represent resistant, moderate and susceptible sensitivity to MSV were selected. Fertilizer was applied at a rate of 450 kg ha⁻¹ basal (13:26:13 – N: P: K) at planting with top dressing of 450kg ha⁻¹ ammonium nitrate (34.5% N), split into (225kg ha⁻¹) at early vegetative and the second half (225kg ha⁻¹) at

booting (pre-flowering) stage. Weed removal was conducted through hand pulling and herbicides application.

Scoring for the severity of MSV infection on a scale of 1 to 9 was done at mid-vegetative, flowering and mid-grain filling stages. Scale of 1 represented zero to very low susceptibility symptoms while 9 represented severe symptoms. The drone imagery was acquired using a Parrot Sequoia Multispectral camera mounted on eBee SQ UAV (Swiss Geo Consortium Sensefly, Cheseaux-Lausanne, Switzerland). The Parrot sequoia sensor is made up of 5 cameras, with 4 discreet bands: Green (530 – 570nm), Red (640 – 680nm), Red-edge (730 – 740nm) and NIR (770 – 810nm). An additional panchromatic band covering the red, green, and blue (RGB) is included. The UAV-derived multispectral reflectance data in the visible-NIR region were acquired at the three different phenological stages at an altitude of 42.5 m and a spatial resolution of 8 cm. Using Pix4Dmapper, the imagery was stitched and then input into QGIS to extract reflectance data. The bands for each variety were transformed into six indices, namely, the normalized difference vegetation index (NDVI), green normalized difference vegetation index (GNDVI), Rededge NDVI (NDVirededge), Simple Ratio (SR), green Chlorophyll Index (CIgreen) and Rededge Chlorophyll Index (CIrededge).

Significant relationships were obtained between the indices and MSV scores with correlation coefficients ranging from 0.74-0.84. We further used the Random Forest (RF) algorithm to evaluate the utility of UAV-derived data in classifying varieties into resistant, moderately resistant and susceptible categories. The RF algorithm is robust and has some in-built functionalities that can be used to optimize variables, thus suitable in this case where one of the objectives was to rank the most important indices for phenotyping (Chemura et al. 2017; Pal 2005).

The optimized RF yielded overall classification accuracy of 77.3% (Kappa = 0.64) while the unoptimised RF yielded 68.2% (Kappa = 0.51) accuracy. The Mid-vegetative phenological stage was the optimal period for accurate varietal phenotyping and discrimination while the GNDVI, CIgreen, CIrededge and the Red band were the most important indices selected for improved classification. Out of 30 variables used in the RF algorithm, only seven (including 5 VIs) were selected as optimal in classifying the different levels of infection levels. The selected bands and indices at vegetative stage were: CIgreen, GNDVI, CIred-edge, SR and NDVI, Red and Green

This study showed the importance of UAV-derived imagery in plant phenotyping, an encouraging result given the difficulties experienced in manual plat breeding phenotyping, which involves laborious screening of a large number varieties to select the most suitable ones for advancement and commercialization. The temporal analytical flavor adopted in this study provides an impetus to accurate phenotyping by taking advantages of the

phenological information contained in different varieties in response to MSV infection. The result is critical for improved data provision at high spatial and temporal resolutions for plant breeding programmes, which will assist in the mitigation and adaptation to climate change impacts.

Keywords: *Maize Streak Virus, Random Forest, Phenology, Unmanned aerial Vehicles*

DEVELOPMENT OF INTEGRATED SRA-BASED DATA VISUALIZATION PLATFORM FOR THE PREDICTION AND RESPONSE OF FLOODS AND DROUGHTS

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ABSTRACT

The recent acceleration of climate change increases natural disasters such as floods, droughts and the frequency of torrential rains. Thus, it is expected that disaster response and water resources management will become increasingly difficult. Therefore, in this study, the integrated SRA-based data visualization platform for the prediction and response of floods and droughts thereto was established to continuously and intuitively visualize the observation information and flood disaster information acquired by land observation sensors and SRA (Satellite, Radar, AWS), etc. by using spatial information construction technology and computer graphics technology so as to deliver the information to users. The platform consists of a high-precision hydrological radar-based precipitation monitoring and scenario-based multidimensional urban flood prediction simulation system, a satellite-based drought monitoring system that can detect drought changes and a monitoring system for estimation of the current water balance in ungauged watersheds. It supports decision-making in the event of a disaster and is equipped with functions that can quickly deliver a vast amount of information. This integrated platform for providing real-time floods and droughts information and for the comprehensive utilization of observation data is deemed to be able to function as a universal system designed for the prediction of flood disasters and the provision of water-related information.

Keywords: *Floods, Drought Monitoring, SRA (Satellite, Radar, AWS), Visual Information Platform, Decision Support System*

TURNTABLE-BASED AND ARTIFICIAL TEXTURE AIDED PHOTOGRAMMETRIC 3D RECONSTRUCTION AND SPECIFICATION MEASUREMENT OF SHUTTLECOCK

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ABSTRACT

In the course of 3D object reconstruction, it is likely to experience incomplete reconstruction for those low-textured objects using photogrammetric means. Badminton is one of exciting sports, yet the 3D reconstruction of shuttlecock has never been easy due to its highly homogenous tone and symmetric shape, making it perfect to be our low-texture target. Under the low-cost consideration, a digital camera, projector, and turntable are used to capture images. By using the turntable and artificial tie points, the number of consumed projectors could be as less as one, and the full 360° coverage of image acquisition can be obtained. The artificial tie points arrange and join all partial point clouds into a complete set in Agisoft Photoscan platform, while the projected artificial textures support adequate richness of features for dense image matching. Besides, the scale control through precise distance measurements implements the 3D reconstruction task in a much easier and straightforward manner. The results of point cloud show that the completeness and geometrical accuracy of point clouds meet the required quality. However, the error of check scale is about 1.4 times of GSD, i.e. 0.14 mm suggests that further improvements are needed. Last but not least, 3D point clouds of shuttlecock made by the proposed method can provide efficiently and conveniently analytical data for specification measurement, such as roundness and lengths, and perform quality inspection for the process of shuttlecocks production.

Keywords: photogrammetry, low-textured area, artificial texture, turntable, roundness

ASSESSING INTER-SENSOR ALIGNMENT OF DIWATA-2'S HIGH PRECISION TELESCOPE

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ABSTRACT

Diwata-2's High-Precision Telescope (HPT) is a multispectral optoelectronic payload, functioning in four bands namely, Red (600 nm to 700 nm), Green (500 nm to 630 nm), Blue (340 nm to 500 nm), and near-infrared or NIR (700 nm to 1000 nm). The HPT also boasts a spatial resolution of 4.7 m ground sensing distance (GSD). Due to its multispectral nature and high resolution, the HPT is suitable for damage assessment as well as detecting landscape changes post-disaster. Accurate stacking of the images across bands assures the resulting remote measurements are as precise as possible. However, due to manufacturing errors, strong vibrations during launch, as well as thermoelastic effects while in orbit, the sensors would tend to misalign with respect to each other. These misalignments may badly affect some of the necessary preprocessing steps such as layer stacking and direct georeferencing, which in turn affect the calculation of the final remote sensing products. It then becomes necessary to assess the alignment between charge-coupled device (CCD) sensors of each band in order to perform proper compensations during remote sensing product calculations. In this paper, the homography matrix for each of the HPT CCDs was calculated. Each homography matrix represents the misalignment of each CCD, in terms of rotation and translation, along the x, y, and z axes. In all calculations, the Blue CCD is set as the reference due to its position with respect to the optical axis of the imaging optics. The homography matrix was obtained from common points between images collected using the scale-invariant feature transform (SIFT) algorithm. Testing the calculated matrix against the parameters established by Hartley and Zisserman (2004) shows the occurrence of an affine transformation. The tests also show shearing on x and y, which further confirms the transformation. The calculated average misalignment for the Green CCD along x is 112 μm , variance of 1.11 μm , while the average misalignment along y is 86 μm , variance of 0.74 μm . Meanwhile, the average misalignment for the Red CCD is 11 μm , variance of 0.76 μm , along x, and 217 μm , variance of 0.74 μm , along y. Other observations such as CCD rotation and aspect ratio difference were also noted.

Keywords: computer vision, remote sensing, optoelectronic payload

HIGHER GEOMETRIC ACCURACY USING GPS DERIVED GROUND CONTROL POINTS FOR LULC ANALYSIS

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ABSTRACT

Georeferencing in remote sensing imagery provides an integrated monitoring of the land use land cover (LULC) changes of urban growth. Geometric accuracy in georeferencing can be increased using Global Positioning System (GPS) derived ground control points (GCPs). Providing higher geometric accuracy is essential in LULC analysis especially in dense area in rapid urbanization. The geometric accuracy relies largely on accurate rectification of the remotely sensed data to produces classified thematic change maps. The study used data from Landsat TM, ETM+ and OLI TIRS. The rectification process involves two main references which are the GPS derived GCPs and the topographic map derived GCPs. GPS derived GCPs are acquired through ground measurement using Android 10.36.0 WGS84 capability smartphone. The topographic map is acquired from the Department of Survey and Mapping Malaysia with 1:50,000 scale, 25-meter contour line and rectified skew orthomorphic grid projection. The study found that the GPS-derived GCPs were accurately higher with the root mean square error (RMSe) shows higher accuracy for its source points and corrections points.

Keywords: *Geometric accuracy, Global Positioning System, ground control points, root mean square error*

SMAP AND SENTINEL-1 DATA ASSIMILATION TO IMPROVE SUGARCANE GROWTH MONITORING

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ABSTRACT

Soil moisture dramatically affects crop growth and agricultural productivity. There are many instruments to measure soil moisture but just a few to measure the large area. The SMAP satellite is NASA's first mission designed to measure soil moisture worldwide. This research aims to study the potential of soil moisture data from the SMAP satellite and the averages backscatter of VH and VV polarisation from the Sentinel-1 satellite to compare the time-series trend of a one-hundred sugarcane plot. The time-series data is between August 2020 and July 2021. We extract soil moisture data using the L2 SM_SP: Soil Moisture (Sentinel Radar, Radiometer) data of SMAP with one-kilometre resolution and VH and VV averages backscatter polarisation of the synthetic aperture radar (SAR) system of the Sentinel-1 satellite. The fact revealed that soil moisture changes correspond to rainfall and other factors such as sunlight and irrigation. In the SAR pre-processing, we average the backscatter value of polarisation data with/without terrain correction to determine its difference in data preparation which we found slightly different. Then the soil moisture data and the averages backscatter of VH and VV polarisation were used to monitor the time-series trend of the sugarcane plot. It found that both data were positively correlated to significantly monitor sugarcane's growth at $r = 0.435$ and $r = 0.443$, respectively. When analysing the relationship in each sugarcane plot area, without outliers, that is, deviations from other values so much so that it caused the suspicion that a different mechanism caused it. The significance level is approximately $r = 0.800$, which is a high correlation level. We conclude that the soil moisture data had potential and could support the monitoring of sugarcane growth and the average backscatter of SAR polarisation data enabling planning and management of the sugarcane industry.

Keywords: SMAP, Soil moisture, Sentinel-1, Polarisation

FEATURE SELECTION OF EEG SIGNALS FOR EMOTIONAL STATE CLASSIFICATION IN MACHINE LEARNING

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ABSTRACT

Emotional health is very important to build our life. It is equally as important as our physical health. Dealing with our emotions is a difficult task because we can't see them. To analysis emotional state is also the interested field of the researcher. We can test the brain wave to analysis the emotion using electro-encephalography (EEG) signals. There are many kinds of emotions. We propose to classify the human brain wave for happy, disgust, surprise, anger, sad and fear. To classify six types of human emotion needs data annotation, feature extraction, feature selection and classification methods by analyzing electroencephalography (EEG) signals. We propose the embedded feature selection methods to select the least number of features in order to increase accuracy and decrease the cost of data classification. In this propose model used the combination of the Lasso and Ridge Regulation methods to reduce the freedom of the model. The input dataset are from the Database for Emotion Analysis using Physiological Signals (DEAP). In this model propose the high accuracy by comparing with the previous method.

Keywords: *electro-encephalography (EEG), feature selection, embedded feature selection methods, Lasso and Ridge Regulation methods.*

APPLICATION COMPARISON OF 3D TERRESTRIAL LASER SCANNING BETWEEN TERRAIN AND NON - TERRAIN OBJECTS

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ABSTRACT

3D terrestrial laser scanning technology is a revolution in the field data collection for various three-dimensional applications. It is used very effectively in the establishment of Digital Terrain Model (DTM), terrain changing assessment, as well as the non-terrain objects, especially tangible and intangible cultural heritage. The aim of the article is to compare the similarities and differences between the use of 3D terrestrial laser scanning technology in the terrain applications and the cultural heritage conservation. Several aspects were compared in details such as technical equipment, processes, and the actual products in the case study (Bac Ninh province, Vietnam). The results show that each field when using this technology has the advantages and disadvantages. The research will be very useful for scientists and technicians in different studies. They may combine the benefits of both fields in the future for the best outputs.

Keywords: *Terrestrial laser scanning, Terrain, Non – Terrain, Bac Ninh*

UNMANNED AERIAL SYSTEMS FOR IMPROVING AGRICULTURE PRODUCTIVITY: CASE STUDY OF COFFEE PLANTATION MAPPING AND MONITORING IN VIETNAM

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ABSTRACT

Unmanned Aerial Systems (UAS) have become increasingly popular in recent years for agricultural applications in support of effective farm management and improved agricultural productivity. This paper aims at demonstrating the use of UAS for detail mapping and monitoring of plant health in Vietnam's coffee plantations in Lam Dong province, Vietnam. With low-altitude and flexible flight operations, a WingtraOne VTOL UAV equipped with a RGB camera and a MicaSense multispectral sensor was used to collect high spatial resolution and quality images under varying terrain and climate conditions in four flight missions during the 2020-2021 coffee season. Using Pix4Dmapper or Agisoft Metashape photogrammetric processing, high spatial and temporal resolution UAV-image products, including RGB and multispectral orthomosaics, DSMs, point clouds and various vegetation index (VI) maps, were generated for accurate smallholder farm mapping, species differentiation, tree recognition and counting and crop health monitoring. The paper also discusses the cost and technical benefits of the conducted UAV mapping as compared to conventional coffee farm monitoring methods.

Keywords: *Unmanned Aerial Systems, Photogrammetry, Multispectral Sensor, Coffee Plantation Mapping*

DATA ACQUISITION TECHNIQUES ON EXISTING HISTORICAL BUILDING BASED ON BUILDING INFORMATION MODELING (BIM) USING CLOSE-RANGE METHOD IN BALI

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ABSTRACT

The need for space is getting higher due to the increasing population growth thus it can expand its construction and the need for space for tourism which is functioned as a guest house and restaurant. Penglipuran Bali traditional village is designated as a tourism village that has historical buildings hence the transfer of functions of these needs is inevitable. In addition, currently, the need for BIM modeling and inventory digital data to provide designs (as-built drawings) for existing historic buildings requires a laser scanning device. It is very expensive and the process is rather long. 3D modeling of historic buildings requires precise data acquisition and processing to be of good quality. BIM can be created from laser scanning results or in the form of a point cloud. The next method offered uses a close-range method with a Digital Single-Lens Reflex (DSLR) that is integrated with an Unmanned Aerial Vehicle (Drone) in forming a 3D model. Every DSLR stand with Tripod has at least 9 photos with different heights and the sides are shifted about 20-25 cm to get 60% coverage. This method uses the concept of normal and convergent (15°) photos. The results of the point cloud integration of historical buildings can be used as a reference in BIM modeling with the addition of local wisdom semantic information and can also be used as a new method of data acquisition to implement 3D Cadastre in Indonesia while maintaining quality and low cost. Data acquisition has an RMSE of less than one centimeter (<1cm).

Keywords: Drone, DSLR, Penglipuran Village, Close-Range, BIM

CALIBRATION AND VALIDATION OF AN AIRBORNE HYPERSPECTRAL SCANNING IMAGER FOR AGRICULTURAL MISSIONS

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ABSTRACT

Hyperspectral remote sensing has been in wide use for agricultural monitoring. Its high spectral resolution enables better characterization of crops and other vegetation. Airborne scanning scientific cameras present an advantage of having a readily deployable instrument that can get zero cloud cover and high spatial resolution over the targets for applications such as monitoring or detecting changes right after calamities. With these merits, we designed and assembled a hyperspectral scanning camera called “Hypie” from commercial off-the-shelf (COTS) components. This paper reports the laboratory radiometric calibration done with the sensor in order to recover the spectral information and convert the digital numbers into radiance units. An outdoor experiment is done to capture vegetation spectra and sun irradiance. Three (3) sets of calibration constants are calculated and are validated against a commercial spectrometer. The maximum absolute error and root mean square error values computed range from 0.599 to 1.470×10^{-4} W/m²-sr-nm and from 0.775 to 1.689×10^{-4} W/m²-sr-nm respectively.

Keywords: *pushbroom, scanning, hyperspectral, calibration, validation*

PAYLOAD CHARACTERIZATION OF AN AIRBORNE PUSH-BROOM HYPERSPECTRAL IMAGER

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ABSTRACT

An airborne hyperspectral imaging sensor can capture data containing 2D spatial information and spectrum in the third dimension. A push-broom hyperspectral imaging system can obtain the 3D information by capturing the dispersed spectral components from a single line slit of spatial information, then scanning perpendicular to the slit to obtain the complete 2D spatial information. This study aims to characterize different properties of the in-house developed airborne push-broom hyperspectral imaging sensor with commercial off-the-shelf (COTS) components. The payload system has undergone sensor characterization by determining and calculating the dark current bias, linearity, photon transfer curve, and flat-field of the detector. Moreover, the image quality is further examined by measuring the payload system's modulation transfer function (MTF). Lastly, the effect of the imaging spectrometer on spectral, spatial, and intensity components was investigated using simulations and actual tests of the payload prototypes with 50 and 80-micrometer slits.

Keywords: *push-broom, hyperspectral, characterization*

INSPECTIONS OF HYDRAULIC AND SLOPE STABILITY STRUCTURES WITH UAV-BASED HIGH DEFINITION THERMAL CAMERA

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ABSTRACT

Due to the global climate change in recent years, Taiwan often suffered from short-delayed and heavy participation. It may lead to the occurrence of regional disasters or expansion of already-existed disaster areas. Inspections to hydraulic and slope stabilization structures have been carried out. However, those inspections were often restricted by on-site environmental factors which make it difficult to reach. Furthermore, some of the structural damages cannot be observed with visible light images. Therefore, this project aims to apply UAV with high-resolution visible light and thermal-sensing camera to inspect the structural deterioration and overcoming the environmental limitations. This project mainly studies the hydraulic structures located at Nantou mountainous area. Thermal images were used as the fundamental evidence and proven by the visible light orthophotos and digital surface model (DSM). The key objectives are to establish the Standard Operation Procedures (SOP) of UAV inspections, evaluate the reliability of UAV for inspections of hydraulic structures and prove the hydraulic structural damages by the UAV-based high definition visible light and thermal-sensing camera.

Keywords: UAV, Thermal-sensing camera, hydraulic structure, crack inspection

A SAR ATR METHOD USING WVV DESCRIPTOR OF A SUBSET OF SCATTERING CENTERS

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ABSTRACT

Automatic target recognition with SAR image (SAR ATR) is crucial for military and civilian applications. SAR image can be obtained in most weather types, day-and-night, and high resolution. In response, researchers have developed feature-based classification methods for ATR with scattering center (SC) extracted from SAR image, which provides a physically relevant description of the target. However, classification in realistic scenarios is still difficult as the number and distribution of SCs could sensitively change according to various operating conditions such as target, sensor, and environment. The key challenge lies in one-to-one correspondence of the point pattern matching between the test and the corresponding template. For practical SAR ATR applications, collecting datasets in various conditions is also another challenge as it is expensive and involves several complex processes. It is useful to replace the templates for train with simulated SAR images created by electromagnetic prediction software using a computer-aided design (e.g CAD) model of the target in that case. However, there are significantly distributional differences between measured data and synthetic data because of the difference in the used CAD model and real model or the type of simulator, which causes poor recognition rates under standard operating conditions (SOC). Therefore, it is necessary to develop a robust ATR method to classify targets under extended operating conditions (EOC) as the real world even when tested by measured data and trained by synthetic data. One promising way to overcome these challenges is to reconstruct the SCs by using the world view vector (WVV) descriptor, which contains a set of 360 vectors represented by the angular coordinate. The WVV-based feature reconstruction with point location and amplitude could consider the structure similarity as well as the point similarity for the two SC sets.

In this paper, we propose an improved WVV-based ATR method using a subset of the SCs, instead of using all SCs. The flowchart is divided into 3 steps, a subset of SCs selection, WVV-based reconstruction, and matching score computation. Once the SC sets of the test and template are extracted, a subset of SCs within the statistically calculated radius is only selected and then reconstructed by the WVV descriptor. The WVV is created by

computation of the polar radius and the polar angle of the rest points after establishing a polar coordinate system with origin at each point. The polar angles are then resampled at intervals of 1° and the polar radii are interpolated linearly. Finally, the SC sets are reconstructed into the WVV set as the same number of the SC sets. The similarities between the test and template are evaluated based on the WVV sets and the amplitudes. Regarding the similarity as the weight of the bipartite graph matching, we find the optimal matching between the two SC sets. Afterwards, the matching score is determined to recognize the target by measuring the WVV-based similarity and then combining several weights related to the matched/unmatched number of SCs and selected/unselected number of SCs.

To evaluate the classification performance of our method, experiments are conducted on MSTAR and SAMPLE datasets under the standard operation condition (SOC) and various extended operation conditions (EOC) including noise corruption and partial occlusion. As a dataset for experiments, Moving and Stationary Target Acquisition and Recognition (MSTAR) has been widely used in the past two decades which consists of a collection of one-foot resolution SAR images collected at all azimuth angles. Meanwhile, synthetic and Measured Paired and Labeled Experiment (SAMPLE) is a dataset recently released by AFRL, which consists of measured and simulated SAR images using CAD models of 10-class MSTAR targets. Unfortunately, only some parts of the SAMPLE dataset collected at 10° to 80° azimuth angles are publicly open. The proposed method was first evaluated under SOC on the 10 classes of targets for overall classification accuracy. When the testing data are defined as the MSTAR dataset from each class collected at 15 depression angle and the training data are collected at 17 depression angle, the recognition rate is about 95%. Secondly, experiments are conducted under EOCs, noise corruption, and partial occlusion. When the SCs are randomly removed according to the percentage of missed points, the performance maintains at a high level of over 80% until the percentage is smaller than 65%. When the test data is occluded from randomly four different directions, the performance still maintains at a high level over 80% until the occlusion level of 30%. In the end, an experiment is conducted with SAMPLE dataset for exploration how effectively our method could be used in a real scenario on training synthetic images. The recognition rate is in the range of 85% to 90% depending on the template's depression angle. Compared with several state-of-the-art SAR ATR methods, our results show the feasibility and robustness when using the simulated image as template and the real SAR image as test data

We have provided an improved WVV-based ATR method using a subset of the SCs. The previous method using all SCs has robust ATR capability, insensitive to translation, random perturbation, and random addition and deletion of SCs. However, if some parts of the test and template

SC sets were different, the WVV-based similarity was very low, and the classification result was wrong as the set of 360 vectors is sensitively changed according to the distribution of SCs. In the real world, the occlusion of target by external environment like artificial or natural objects could always happen. Therefore, we developed the method that is less susceptible to partial differences between the two SC sets by selecting a subset of SCs and considering several weights related to the unmatched number of SCs and unselected number of SCs which couldn't be applied to the WVV-based similarity. For evaluation of our proposed method, we conducted several experiments under SOC and EOC. When using measured data as test and template, our performances in experiments are similar or a little higher than other SAR ATR methods. However, even when the template consists of only synthetic data, the ability to classify targets is very excellent. Therefore, we expect that the proposed method would be useful in a practical SAR ATR system with simulated images as the template DB. Future works can be conducted beyond the experiments presented here with more synthetic SAR images.

Keywords: SAR ATR; World View Vector (WVV); Scattering center (SC); SAMPLE

SEA SURFACE KA-BAND DOPPLER SCATTEROMETRY AT HIGH WIND SPEED: A FIELD EXPERIMENT

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ABSTRACT

Measuring sea surface winds and currents from space may become possible using a Doppler scatterometer. Dedicated missions are planned in the Ka-band to improve the data resolution and accuracy. However, the knowledge of the Ka-band backscattering from the real sea surface is still poor. Particularly, the behavior of the Ka-band backscattered signal is less known for high wind conditions ($>20\text{m/s}$). The Ka-band crosssection, in contrast to the lower frequency Ku/X/C/L-bands, is more sensitive to small-scale particles, e.g. droplets separated from wave crests at high winds. In this message, we report the results of a tower-based field experiment conducted using a continuous wave dual-co-polarized Ka-band radar during strong, up to 33 m/s, offshore wind events. In addition to the radar, this strong offshore katabatic wind event, about 12 hours long, was also recorded by supplementary wave, wind, and current sensors. At the wave fetch about 1 km, the maximum wavelength was about 10 m. At such extremely young wind-sea conditions, an apparent droplet generation was observed during wind gusts. The radar measurements were performed at 10, 20, and 45-degree incidence angles mostly at cross-wind and up-wind look geometry. Based on these measurements, we refine the previously developed Ka-band geophysical model function for high wind conditions. The droplet cloud radar signatures are apparent in the Doppler spectrum tails, but their overall contribution is rather weak. Thanks to this fact, the standard modulation transfer function (MTF) approach works well to evaluate the wave-induced Doppler velocity contribution and thus estimate the sea surface current. These results can be useful for the interpretation of tropical cyclone observation using Doppler radar techniques.

Keywords: *radar, scatterometer, Ka-band, ocean, Doppler*

AN APPROACH FOR OPTIMIZING HYDROLOGICAL PARAMETERS AT RIVER BASIN SCALE USING OPEN SENSOR NETWORKS

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ABSTRACT

Manual and uneven distribution of hydro-meteorological stations, offline data, high cost of modeling software and state-owned stations' data, lack of trust in technology, and lack of expert knowledge, are the barriers that exist in most developing countries, which evade inclusion of hydrological modeling approaches for water resources management. As a solution for this, an open sensor network has been deployed in the Deduru Oya river basin of Sri Lanka to utilize open big data in the effective management of water resources. In absence of pre-determined parameter values for the river basin, the sub-catchment level parameter values for both wet and dry periods and daily and hourly time-steps have been estimated through inverse modeling approach, by way of fitting model simulations to observations. The model has been customized to utilize the estimated data of the weather generator to prevent the underutilization of open data in the stage of model stabilization.

Keywords: *Parameter optimization, Warm-up period, Open sensor networks, 4ONSE, Deduru Oya basin*

RADIOMETRIC CONSISTENCY INTERCOMPARISON OF GF-5, ZY-1-02D AND LANDSAT 8

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ABSTRACT

In recent years, Chinese hyperspectral satellites represented by Gaofen-5 (GF-5) and Ziyuan-1-02D (ZY-1-02D) have been launched, which can provide abundant data sources for quantitative remote sensing applications. However, the existing hyperspectral data has narrow swaths and long revisit period. To help address large-scale and fast-changing environmental problems, it is often necessary to combine multi-source data for environment monitoring. At this time, stable and reliable radiometric quality and high consistency of multi-source data radiometric is necessary, which has become a prerequisite for the quantitative application of multi-source remote sensing. Radiometric consistency inspection based on remote sensing data has strong scalability and is less restricted by time and place. In this article, we use the column average and the overall image average to calculate the relative radiometric accuracy of the visible shortwave infrared hyperspectral cameras AHSI (the Advanced Hyperspectral Imager) carried by the GF-5 and ZY-1-02D. Due to the difference in the spectral response function of different sensors, this article has carried out band conversion on the GF-5 and ZY-1-02D data, to match the routinecalibrated Landsat 8 bands with a similar spatial resolution of 30m, and then cross-validate the radiometric consistency of these two hyperspectral sensors' apparent reflectance with the Landsat 8 data. The results show that the relative radiometric differences of GF-5 data are within 15%, and the differences of ZY-1-02D data are within 10%. Compared with the data from the 2nd to 7th bands of Landsat 8 in the adjacent time, the bias of the apparent reflectance of the GF-5 and ZY-1-02D images is within 0.015, and the root mean square error (RMSE) is less than 0.05.

Keywords: GF-5 AHSI, ZY-1-02D AHSI, Hyperspectral remote sensing, Radiometric performance

ESTIMATION OF TREE HEIGHT UNDER TRANSMISSION SYSTEM USING INTERFEROMETRIC SAR (INSAR)

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ABSTRACT

One of the most important hazard sources for powerlines is an electric shortage induced by too close canopy branches. In this research, we are estimating trees heights around the power transmission system in Thailand using polarimetric interferometric synthetic aperture radar (PolInSAR). The results of this research should facilitate hazards management and mitigation for power transmission lines by employing the regularly acquired spaceborne SAR images. Estimating tree heights using spaceborne Pol-InSAR is very challenging due to several issues. First, the very small vertical wavenumber makes the system very sensitive to any phase change or phase noise, second, the repeat pass system is inertly affected by temporal decorrelation which can be very significant for forest regions due to tree movements with wind or by simply growing. In this research, we study tree heights in parts of Thailand using two Full-Pol ALOS PALSAR-2 Lband images and employing the Random Volume over Ground (RVoG) module, which assumes the canopy part as a layer of randomly distributed particles characterized by an exponential decay of the transmitted radar power. RVoG models the relation between the complex coherence and the radar scattering center using $[\gamma = e^{j\varphi_0} \gamma_{1v} + \mu]$, where φ_0 is the ground phase and μ is the ground contribution. The pure volume coherence $[\gamma_v = p_1 2(e^{-\sigma p_2} - 1) / (p_1 + p_2)]$ is modeled by relating tree heights (h) to decay rate (σ) and vertical wavenumber (kz) using $p_1 = 2\sigma \cos \theta$ and $p_2 = p_1 + jkz$. This model employs the relation between the radar signal polarimetry and the location of the corresponding scattering center to estimate the height of the highest scattering center assuming to be the top of the canopy layer. We used two L-band SAR images acquired on 18th April 2016 and 13th June 2016 to estimate the complex coherence of our study area using different polarimetry e.g. HH, HV, VV, HH-VV.. etc.

However, in our study regions, we found the coherence values are very low due to temporal decorrelation. This prevented estimating the ground phase and canopy (pure volume) complex coherence by fitting a line in the complex plane. Therefore, we assumed the pure volume coherence to be the HV coherence, and the ground coherence to be the HH coherence. Then, we subtracted the ground phase from the canopy phase by complex conjugate the HV and HH complex coherences. The resulting phase is a representation of the canopy height, however, we found that it is affected by a ramp bias, therefore, we modeled and removed a surface of the first degree from the final phase to reduce the ramp effect. To estimate the final canopy height, we calculated the vertical wavenumber and incident angle for our study area and created a lookup table relating complex coherence to tree heights ($h\nu$) and decay rate (σ). By comparing the final results with LiDAR data, we found several issues preventing accurate canopy height estimation in our study region. First of all, the very low coherence values prevented dense spatial estimation as we use a coherence threshold of 0.25. Second, the rapid change in dielectric constant due to the heavy cloud cover and the rain season reduced the accuracy significantly. Third, the rough topography with slopes ranging from 5o to 70o affected the performance of the RVoG model. The steep slopes cause different canopy heights and ground radar responses to be mixed within a single pixel which makes identifying the actual canopy height very challenging. An additional source of error is the agriculture fields around the power transmission lines which are permitted for selected crops. The crops change the radar responses between acquisitions significantly due to, growing, irrigation, and harvesting. We believe that agriculture is the main source for phase decorrelation in our study regions. To evaluate the final results, we isolated the pixels with an error of less than 2 meters, and we found that these pixels have low slopes rate and low temporal decorrelation. We found that estimating canopy height with high accuracy mainly depends on the nature of the study area in addition to the observing system characteristics. We believe that using repeat pass spaceborne L-band SAR images can be used to estimate canopy heights but with high caution to the sources of phase decorrelation. We recommend modeling ground slopes and carefully select the SAR images to be observed within the dry season to reduce the dialectic constant effect, especially in tropical regions. We believe that tandem satellite observations are the best solution to eliminate temporal phase decorrelation and provide regular canopy height monitoring.

Keywords: *Pol-InSAR; Canopy Height; RVoG; Thailand*

ALGORITHM AND IMAGE PROCESSING

EXTRACTING ROCK INFORMATION BASED ON INTEGRATED CONVOLUTIONAL NEURAL NETWORK AND IMAGE PROCESSING TECHNOLOGY

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ABSTRACT

The lithology identification and the extraction of oil-bearing information on rock surface are the most critical works in exploring minerals, oil and gas resources. An automatic classification method of integrated convolutional neural network was proposed to identify the lithology of rocks. Comprehensive image-processing techniques are used to extract the oil-bearing information on the rock surface. Firstly, five convolutional neural network models, including AlexNet, VGG16, Inception_V3, Xception and ResNet50, were trained with the enhanced rock sample set to obtain five different classification models. An integrated model was further established by using the majority voting method; Secondly, the rock area in the image, which was taken in a dark box illuminated by fluorescent light, was extracted by the comprehensive image-processing techniques, such as linear stretching, Canny edge detection, and image expansion, and verification was made with the area of interest extracted by ENVI; Finally, the ratio of oil-bearing area to the area of the rock was calculated by the image masking and HSV transformation processes. The classification results show that the verification accuracy of a single model (Inception_V3) is 98.87%, while the verification accuracy of the integrated model (Xception, VGG16, Inception_V3) is 99.29%, which is better than single model; In addition, the deviation of the rock profile obtained by the comprehensive image-processing techniques fall within 1% compared with the area of interest drawn by ENVI; The percentage of the pixel number of oil-bearing derived from the results processed by the image mask and HSV transformation processes to the total pixel number of the rock area is 2.85%. Compared with the traditional observation procedure, the workflow used in the paper can save time greatly to extract the oil-bearing information.

Keywords: *Lithology Identification; Oil Content Extraction; Convolutional Neural Network; Model Integration; Comprehensive Image-Processing Techniques*

GROUND OBJECT CLASSIFICATION ALGORITHM BASED ON ZHUHAI-1 SATELLITE HYPERSPETRAL IMAGE

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ABSTRACT

With the increasing resolution of satellite and aerial remote sensing images, much more useful spectral and spatial information can be obtained from hyperspectral images than before. This paper proposed a feature classification method based on machine learning and an integration model to classify ground objects in Zhuhai-1 OHS hyperspectral satellite images precisely and robustly. Firstly, principal component analysis was used to reduce the dimension of the data. Secondly, the classification model was established by the combination of undersampling, binary classification model and multi classification model. Then, random forest, AdaBoost and neural network classification algorithms were used to train the training data. Finally, based on the idea of voting method, the classification models were integrated into a new classification model, and comparisons were made between the classification of these single algorithms and the integration model. The principal component analysis on the hyperspectral images shows that the first two bands of these images almost contain 95% information. Therefore, the classification on the first two bands not only can maintain the accuracy, but also can reduce the amount of data for image classification processing and saving classification time effectively. Among the three single classification algorithms, the best one is the random forest classification model with an accuracy of 0.656 and a kappa value of 0.472. While the integration model can give a better classification result than the three-single classification algorithms, with an accuracy of 0.660 and the kappa value of 0.481, the integration model is in fact can improve the accuracy of the classification on Zhuhai-1 satellite hyperspectral images.

Keywords: Model Integration; Random Forests; Adaboost; Neural Networks

A NOVEL METHOD FOR MEASUREMENT OF ORIENTATION OF ROCK JOINTS FROM POINT CLOUD BY FACET AMALGAMATION APPROACH

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ABSTRACT

The Geotechnical Engineering Office (GEO) of Civil Engineering and Development Department (CEDD) of the Government of the Hong Kong Special Administrative Region has been employing various remote sensing methods to enhance the engineering geological input in supporting geotechnical studies. For slope mapping, the use of conventional manual mapping method to measure joint orientations (i.e. dip angles and dip directions) has been found to be expensive, time-consuming and environmentally unfriendly. In addition, there may be constraints to access to remote sites and mapping of rock slope on site may pose safety hazards to the field personnel. To improve effectiveness and efficiency, many studies have been carried out to reduce the amount of field work by remote sensing techniques, and the focus was mainly on computer-aid generation of individual joint planes from point cloud captured either by laser scanning or photogrammetry. In view that such an approach often requires good understandings of the conditions of rock joints such as variations in orientations in different parts of a joint planes due to waviness and unevenness. To this end, delineation of joint plane requires setting of parameters by a trial and error approach which is not technically desirable. To overcome this problem, we have developed a new approach which is entirely different from the aforementioned computer-aid approach. Instead of attempting to form joint planes from point cloud, we first used point cloud to generate a 3-D triangular mesh to model the slope face. By measuring the dips and dip directions of all triangles (facets) of the mesh, a stereoplot of all facets was generated. Statistically, the majority of facets should be able to represent the overall orientations of all measurable discontinuities on the slope, and the facets due to waviness and unevenness in random directions should be in minority. To this end, by amalgamation of the orientations of facets, the major joint sets of the slope could be analysed. An assessment of different algorithms using K-d Tree, Fast Marching and this new approach have been performed. The results show that this novel method is more effective and efficient in identifying rock joints as compared to other algorithms with less requirements and more tolerance in parameter setting. This new approach has been proven to be an easy-to-use and user-friendly method which can greatly facilitate rock slope stability analysis.

Keywords: *Rock Slopes, Joint Planes, Point Cloud, Facets, Dips, Dip Directions, Stereoplot*

AN ANALYSIS ON THE OPTIMAL SEGMENTATION OF VHR SATELLITE RGB IMAGES

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ABSTRACT

With the development of satellites in the form of high-resolution and constellation satellites, it is necessary to mosaic and analyze dozens of images due to the narrower swath of high-resolution satellites compared to that of medium- or low-resolution satellites. As such, various studies using mosaic images are needed, and since these mosaic images have distorted spectral characteristics, there have been many restrictions on their use. Therefore, in this study, an analysis on the segmentation using only RGB bands was conducted to utilize the images with distorted spectral characteristics for segmentation and even classification.

According to the segmentation results, the optimal segmentation scale was 75 for the mosaic images of Korean Peninsula, and the combination of RGB and Vegetation index seems the most appropriately segment the image especially for the boundary of bare ground and buildings. However, this study is optimized for mosaic images of Korean Peninsula, and it is necessary to compare and analyze the research results using other images and the results applied to other regions. Therefore, further research using those segmentation results should be made to validate and promote the use of mosaic images.

Keywords: KOMPSAT, Satellite Images, Segmentation, RGB

MODELLING SOIL ORGANIC CARBON STOCKS UNDER COMMERCIAL FORESTRY IN KWAZULU-NATAL SOUTH AFRICA USING TOPO-CLIMATE VARIABLES

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ABSTRACT

Commercial forests (CFs) are expanding globally, offering great potential for absorbing carbon and mitigating climate change. Compared to natural forests (NFs), CFs landscapes are largely ignored in soil organic carbon (SOC) mapping and climate change mitigation. Specifically, the relationship between the controlling factors that include topo-climate variables and the distribution of SOC is still poorly understood. Consequently, this study sought to map SOC stock variability within CFs using topo-climatic variables and geospatial strategies. Eighty one soil samples and 31 topo-climate predictors were simulated for SOC. A backward elimination method and the Maximum Entropy (Maxent) algorithm were used for optimum variable selection (11 variables) and regression, respectively. Results showed good accuracies for both training (area under the curve = 0.906) and test (area under the curve = 0.885) datasets, and provide an effective framework for SOC modelling within CFs; valuable for climate change mitigation.

Keywords: Commercial forests; Soil Organic Carbon; Topo-climate; Maxent

ATMOSPHERIC CORRECTION FOR INLAND WATERS USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

The retrieval of water remote-sensing reflectance is an important and fundamental step for water quality monitoring using satellite remote sensing techniques. The atmospheric effects are generally significant and complex, which make atmospheric corrections (ACs) difficult to accurately derive the remote-sensing reflectance. The radiative transfer model is considered a promising method in atmospheric correction. Nevertheless, the approach requires calculating a set of parameters using complicated models and formulas, including aerosol model, atmospheric conditions, and sensor geometric information. This leads to time-consuming and sometimes produces negative water remote sensing reflectance. With a revisit cycle of 16-day, free available, and a high resolution of 30 meters, Landsat 8 OLI imagery is widely utilized for water quality monitoring in inland waters. However, the sensor receives surface reflectance and atmospheric effects, including scattering caused by Rayleigh and aerosol and absorption caused by gas and aerosol. This study proposed an atmospheric correction method based on artificial neural networks for inland waters to retrieve the water remote sensing reflectance (Rrs) using Landsat 8 OLI imagery. The input data required for the neural network model consists of a training dataset and a testing dataset. The number of data for training is 262580 samples, and 71 samples for testing. The training dataset includes eight TOA spectral reflectance (from band 1 to band 9 except the Panchromatic band), three geometric angles data, that is, sensor zenith angle (VZA), sun zenith angle (SZA), and relative azimuth angle (RAA), and aerosol data (AOT). The iCOR Rrses are used as the labels of the training dataset. The *in-situ* Rrs data which was measured in the field campaigns in Vietnam in different lakes and on different Landsat 8 acquisition days using spectra radiometer are separated into two groups: one for training the neural network model and the remaining data is for testing the model. The top of atmospheric (TOA) reflectance can be converted from digital number (DNs) using metadata file attached in Landsat 8 collection 1 Level 1 product, while the geometric angles are provided in Landsat 8 collection 2 Level 1 product, and the aerosol

data (AOT) is attached in Landsat 8 level 2 product. The iCOR Rrs is the Rrs data retrieved by using image correction method (iCOR), which is assessed as one of the best radiative transfer models for atmospheric correction for inland water bodies. Our proposed model includes three 3-dimensional convolution layers to extract the TOA spectral feature, five fully connected layers to predict the Rrs, and one output layer. Besides, the model also contains one target layer where the iCOR Rrs and *in-situ* Rrs working as label data. The output Rrs is in five bands in the visible and near-infrared region. The Keras Tuner function was used for model tuning to obtain the optimal hyperparameters, including the number of hidden layers, the number of neurons for each layer, the dropout rate for each layer, the learning rate, and the best epoch. The proposed AC model was then retrained with the optimal hyperparameters. The retrieved Rrs results were then validated with *in-situ* measurements and compared with existing atmospheric correction methods (including dark object subtraction (DOS), quick atmospheric correction (QUAC), atmospheric correction for OLI lite (ACOLITE), fast line-of-sight atmospheric analysis of spectral hypercubes (FLAASH), Landsat 8 surface reflectance code (LaSRC), and Image correction for atmospheric effects (iCOR). The testing data were classified into four trophic classes (including oligotrophic, mesotrophic, eutrophic, and hypereutrophic). The testing results show that the retrieved Rrs values closely match with *in-situ* measurements in all five bands in the visible and near-infrared region. The result also reveals that the proposed AC model can avoid producing negative remote-sensing reflectance. Comparing to the six AC methods, the proposed AC model shows the best performance in all trophic levels; while the iCOR processor is more appropriate for eutrophic water, the ACOLITE and LaSRC can be used, but they often failed in the NIR region. In all trophic levels, the DOS and QUAC methods seem unsuitable for atmospheric correction in inland lakes because they produce uncertainties by only removing the haze effect in the atmosphere. The proposed AC model was further tested on lake Laguna, Philippines, and lake Barra Bonita, Brazil, located in the tropical region, bringing reliable results. The proposed method can address the negative remote sensing reflectance issue existing in some traditional atmospheric correction methods. This method is efficient and easy to use when the network is well trained. Therefore, the proposed AC model has the potential for further remote sensing applications in water quality monitoring. However, the proposed model could not estimate Rrs reasonably in hypereutrophic water in algae bloom conditions. Thus, the proposed model is recommended for atmospheric correction in water bodies that have the Chl-a concentration in the range (1.6, 395) mg/m³ or Secchi disk depth (SD) in the range (0.2, 5.1) meter.

Keywords: Atmospheric correction, inland waters, artificial neural networks, Landsat 8 OLI imagery

**SPECKLE FILTERING AND PHYSICAL SCATTERING
DECOMPOSITION FOR ALOS-2 PALSAR-2
POLARIMETRIC MOSAIC**

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ABSTRACT

This paper presents the speckle filtering and physical scattering decomposition for the ALOS-2 PALSAR-2 fully polarimetric mosaic. The processing steps include 1) multi-looking, 2) speckle filtering, 3) geocoding, 4) mosaicking, and 5) model-based polarimetric decomposition. Another variant of iterative bilateral filter, called gravitational filter, was assessed for polarimetric speckle filtering. Benchmarking against the refined Lee filter and the boxcar filter, the experimental results on the ALOS-2 PALSAR-2 polarimetric data confirmed the effectiveness of the gravitational filter in speckle reduction and image feature retention. Prior to the mosaicking, the geodetic coordinates of selected control points, which were given based on the Geodetic Reference System 1980, were first converted into the Universal Transverse Mercator map coordinates. Subsequently, the ALOS-2 PALSAR-2 specklefiltered data were geocoded by using second-order polynomial equation and least squares method. For the polarimetric scattering decomposition, an iterative multistage four-component decomposition was applied to the ALOS-2 PALSAR-2 polarimetric mosaic. From the decomposition result, a large amount of negative power pixels over vegetated areas were reduced. The total number of the remaining negative power pixels was only 0.006%.

Keywords: *ALOS-2 PALSAR-2, Geocoding, Mosaicking, Speckle Filtering, Physical Scattering Decomposition*

OBJECT-BASED CLASSIFICATION USING MASK R-CNN AND CNN FROM VERY HIGH-RESOLUTION IMAGERY

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ABSTRACT

With the development of modern technology, the resolution of remote sensing imagery increasing rapidly. As the resolution of remote sensing imagery increases, it becomes more difficult to classify urban land use and cover types and recognize complex patterns in urban areas using traditional pixel-based methods. Therefore, we combined Object-based Image Analysis and Deep Learning, to accurately classify very high-resolution imagery of urban areas in this study. Object-based Image Analysis is used as the main classifier, while Deep Learning algorithms, Mask R-CNN and CNN, are used as feature extractors. In this study, very high-resolution images were used to classify three urban scenes in Ulaanbaatar, Mongolia. The first scene was used as the training site, whereas the second and the third scenes were used as test sites. As a result, the final classification with ten classes of selected scenes in Ulaanbaatar was created. The overall accuracy of classification result was above 90% in each scene, including 92.69% in the training site, 91.76% in the first test site, and 93.04% in the second test site. Our result shows the combination of Object-based Image Analysis and Deep Learning increases accuracy of classification from very high-resolution imagery of urban areas.

Keywords: *Object-based Image Analysis, Deep learning, Mask R-CNN, CNN*

IDENTIFICATION OF PERSISTENT INFRARED EMITTERS IN ASIA WITH VIIRS NIGHTFIRE DATA: 2012-2020

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ABSTRACT

The Visible Infrared Imaging Radiometer Suite (VIIRS) collects nightly global data in near infrared (NIR), shortwave infrared (SWIR) and midwave infrared (MWIR) spectral bands, providing a unique capability to observe and characterize infrared emitters at night. The VIIRS nightfire (VNF) algorithm identifies infrared (IR) emitters in multiple spectral bands and calculates temperature, source area and radiant heat via Planck curve fitting. VNF data are produced nightly and extend from 2012 to present. The most common infrared emitter across Asia is biomass burning. Industrial IR emitters are hidden amongst the vast numbers of biomass burning detections. Here we present a survey of persistent IR emitters in Asia. Having a catalog of known IR emitter sites make it possible to monitor the sites for use in economic forecasting and greenhouse gas emission inventories.

Keywords: *VIIRS, Nightfire, Infrared Emitters, Flares, Shortwave Infrared*

RELATING THE SPATIAL RESOLUTION AND SENSOR DEGRADATION OF DIWATA-2'S HIGH PRECISION TELESCOPE USING EDGE DETECTION

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ABSTRACT

Diwata-2 is a 56 kg microsatellite launched by the Philippines for earth observation last 2018. It is equipped with High Precision Telescope (HPT) which has four charge-coupled devices in the visible region (red, blue, and green), and in the near-infrared region. It also has a ground sampling distance of 4.7m at nadir. Due to its high spatial resolution, the HPT can be used for land cover change detection and disaster damage assessment. Having good image quality produced by the payload assures the usability of its product. However, the microsatellite has been in operation for almost three years and is constantly exposed to harsh space environments, which can result in sensor degradation. In order to maintain the image quality of the payload, it is necessary to observe the effects of degradation and apply proper adjustments and corrections. In this paper, occurrence of spatial degradation was investigated by using edge detection. This method was done by, first, clipping a part of an image with a distinguishable edge and homogenous sides. Examples of these are the roof of a building or road edges. Then, the mean pixel value of each row was computed from the clipped image and the pixel closest to the mean value per row was extracted. The edge was then delineated by connecting each extracted pixel location using linear regression. To compute the spatial resolution from the edge, pixel values perpendicular to it were extracted to produce an edge spread function. Then, the derivative of the edge spread function was computed to create a line spread function. To smoothen the curve, normalization and gaussian fitting was applied. The resulting function's full width at half max would indicate the image's spatial resolution. This represents the number of pixels the sensor needs to discern an object in an image. To further understand and differentiate the variations in spatial resolution, the pointing angle and the sun position relative to the satellite during image acquisitions were also considered.

Keywords: Remote Sensing, Sensor Degradation, Edge Detection, Spatial Resolution

BI-TEMPORAL RADIOMETRIC NORMALIZATION OF LANDSAT 8 IMAGES USING PSEUDO-INVARIANT FEATURES

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ABSTRACT

Relative radiometric normalization (RRN) is one of the radiometric corrections for satellite imagery besides absolute radiometric normalization (ARN). In contrast to the absolute method that corrects various components such as atmospheric condition, earth-sun distance, illumination and viewing angle of satellite to find true reflectance, relative method does not find true reflectance but do the transformation of digital number to fit with reference image digital number or try to find common scale of digital number both of reference and target images instead. Several studies have conducted relative radiometric normalization to solve radiometric inconsistency issues by using pseudo-invariant features (PIFs). PIFs are reference objects that has an insignificant or near stable reflectance value change over time. This study is aimed to evaluate radiometric normalization result for Landsat 8 surface reflectance product that utilized Google Earth Engine platform for the computations. Normalization in this paper applied Multivariate Alteration Detection for PIFs selections. The selection of PIFs is based on data distribution of MAD result, the threshold values for selection are 10%, 15%, 20% and 25% of data distribution. Finally, the normalization used selected PIFs as sample data for calculate the slope and aspect of linear regression. On this study show the normalization result have the highest Pearson correlation value on 10% PIFs blue band which achieve 97.6% then the lowest Pearson correlation on 25% PIFs SWIR1 band which achieve 91.4%. The results suggest that developed approach have a potential solution to deal with inconsistency issues.

Keywords: *Relative Radiometric Normalization, Pifs, Multivariate Alteration Detection, Google Earth Engine*

A REVIEW OF LAND CHANGE MODELLING TECHNIQUES USING REMOTE SENSING AND GIS

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ABSTRACT

Land Use and/or Land Cover Change (LULCC) is characterized as dynamic, widespread, and accelerating process. Due to the significance of such changes, modeling changes in land cover is a high priority area for research thus, monitoring and analyzing LULCC has become one of the most critical studied issues. In effect, maps and datasets which quantify biophysical variables, including LULC, are essential for understanding and modeling complex interactions and impacts between the natural and human environments, from regional to global scales. Furthermore, multi-temporal analyses of LULC provide important insights into long-term trends which serve to identify drivers and determinants of change and prediction of future changes. Remote sensing (RS) is continuously providing valuable data for the earth's surface since 1972, while the power of the Geographic Information System (GIS) in modeling the change provides the suitable platform for handling the digital spatial data necessary for characterizing and predicting these changes and associated impacts. This review deals with the most frequent, up to date methods for modelling the LULCC such as data types, pre-processing of RS data and time-series imagery, and analysing the LULCC using conventional as well as the most developed and cutting-edge algorithms and techniques. The generic flow of the LULCC modeling, challenges, and limitations faced by the researchers over the past five decades were presented and discussed. Indeed, in regions where there is a lack of sufficiently detailed cartographic information, land change modelling using geospatial technologies can be pivotal in providing a basis for planning, management, and conservation initiatives.

Keywords: *Change Detection; Lulc; Time-Series*

MODEL-BASED POINT CLOUD RECONSTRUCTION OF EXCAVATION SITE FOR BURIED PIPE MANAGEMENT

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ABSTRACT

Construction space modeling is required for automated operation of construction vehicles, construction management, and safety management. Construction sites are constantly changing during drilling work. Thus, a base map of the construction site should be updated using point clouds acquired through several steps in construction work. Particularly, multiple buried objects such as underground pipes should be measured in construction work because buried objects are difficult to measure with 3D scanners after such work is complete. Moreover, it is better to visualize buried objects with software products such as virtual reality and augmented reality to avoid accidental destruction because of excavation work using construction vehicles such as backhoes. Therefore, 3D measurement and modeling of buried objects are significant in construction work. In this study, we proposed a rapid 3D measurement and modeling of underground objects in construction work. First, we estimate the central axis of point clouds for the 3D modeling of buried pipes. Second, the 3D pipe model was fit to acquired point clouds. Buried pipes can be represented as known geometry models because of products provided based on industrial standards. Thus, the 3D model fitting approach was applied using a pipe model prepared in advance. Then, after 3D model fitting, the depths of buried pipes from ground surfaces were calculated using the estimated axis and point clouds of ground surfaces. We conducted an experiment on 3D measurement based on point cloud acquisition with SfM/MVS and 3D laser scanner during electric line pipe installation work. We also experimented on the 3D modeling of pipes using point clouds acquired with a handheld camera and 3D laser scanner to reconstruct 3D shapes and positions of pipes at a construction site.

Keywords: BIM, SfM-MVS, Point clouds, 3D Modeling, Model Fitting

POINT CLOUD RECONSTRUCTION OF TEXTURE LESS REGIONS WITH TOPOLOGY CONSTRAINTS BETWEEN CORRESPONDING POINTS

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ABSTRACT

Point clouds are generated with structure from motion/multi-view stereo (SfM/MVS) or laser scanning for building information modeling (BIM). Although the SfM/MVS can generate dense point clouds, it is not easy to reconstruct point clouds in texture-less regions because the SfM/MVS is based on feature point-based image matching. Thus, we propose a methodology to generate point clouds of all pixels in texture-less regions with the topology constraints among corresponding images. In this study, we use the back projection of point clouds to understand the topology of the corresponding points to improve the performance of corresponding points estimation and mismatching rejection with the epipolar constraints. We conducted an experiment on the 3D modeling of a metal bridge. Through our experiment, we confirmed that our methodology can reconstruct point clouds, even if targeted images contain texture-less regions.

Keywords: *Structure from Motion; Multi View Stereo; Epipolar constraints; BIM*

VEHICLE DETECTION FROM UAV REMOTE SENSING IMAGES USING DEEP LEARNING

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ABSTRACT

With the development of the city, the number of vehicles in the city is constantly increasing, a large number of vehicles not only increase traffic congestion, but also contribute to the frequent occurrence of traffic accidents, and the public recreational space in the residential area also becomes more and more crowded because of the increase of vehicles. For this problem, the temporal and spatial resolution of satellite remote sensing data are difficult to meet the requirements of urban vehicle information monitoring, while the installation of a large number of fixed cameras is costly and there are many monitoring blind spots. The remote sensing monitoring by UAV can meet this demand with low cost. In this paper, we use UAV to take low-altitude photographs of some stations, highways, neighborhoods in Shanghai and parking lots in Inner Mongolia Autonomous Region to obtain aerial remote sensing images with centimeter-level resolution. In order to obtain higher quality research data, different flight parameters are set during the flight photography process, taking into account the characteristics of the study area and flight management policies. To increase the robustness of the model, different levels of image enhancement are done on the samples before training. Then single target extraction of vehicles in UAV images is performed using the Unet convolutional neural network technique of deep learning. The model training parameters are continuously adjusted during the training process to get the best training results and obtain 99% ultra-high accuracy. Through controlled experiments, it can be seen that the recognition effect of deep learning on vehicles is much better than that of traditional machine learning methods. This experiment shows that the method of this paper is effective and real-time, and can provide a valuable technical means for urban traffic and community management.

Keywords: Deep learning; UAV; Remote Sensing; Vehicle identification; Urban management

DEEP LEARNING FOR SEMANTIC SEGMENTATION OF CORAL IMAGES IN UNDERWATER PHOTOGRAMMETRY

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ABSTRACT

Coral reefs are undergoing rapid changes as a result of increasing ocean temperatures, acidification, eutrophication, and chemical pollution. Regular monitoring activities are important for assessing the influence of unfavorable factors on corals and tracking subsequent recovery or decline. Monitoring by field surveys provides accurate data but at highly localized scales and so is not cost-effective for coral reef scale monitoring at frequent time intervals. Satellite and UAV remote sensing are alternative and complementary approaches, while remote sensing on coral reefs from satellites and drones cannot provide the level of detail and accuracy required. In order to get 3D accuracies in the order of a few mm we have to apply underwater photogrammetry, with images at fairly large scale. Deep learning-based underwater photogrammetry provides a comprehensive solution for large-scale and precise monitoring. It can quickly acquire a large range of underwater coral reef images. These images are passed through a self-calibrating bundle adjustment to generate an accurate 3D object model. The identification of the different corals and their distinction from dead corals and other objects is achieved through advanced image preprocessing and coral annotation technologies. Finally, through a semantic segmentation method based on deep learning, the population number and distribution of different corals in the study area can be obtained. In our research, the experimental data is a seabed coral image set of Moorea Island. By adopting a reasonable data set division and preprocessing method effective edge information is retained and the problems of lack of coral image data and low contrast of coral borders are overcome. This paper applies three state-of-the-art convolutional neural networks (Unet, SegNet, and Deeplab V3+) to the semantic segmentation of corals, compares their performance, and proposes a new improved method. Finally, in order to quantitatively describe the performance of the semantic neural network in this experiment, this paper uses the neural network model evaluation index of mean intersection over union (mIoU) ratio and pixel accuracy (PA). The proposed trained network can accurately distinguish living from dead corals, which could reflect the health of the corals in the area of interest.

Keywords: *Coral images; semantic segmentation; Convolutional Neural Network (CNN); deep learning, underwater photogrammetry*

A CONVNET-BASED MARINE ANIMALS AUTOMATIC DETECTION AND REMOVAL SYSTEM IN UNDERWATER PHOTOGRAMMETRY

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ABSTRACT

In recent years, with the advancement of marine resources and environment research, the ecological functions of reef-building coral reef ecosystems distributed in warm shallow waters of the ocean are being continuously discovered and valued by people. Because it is closely related to global climate warming and the development of marine resources, the demand for its dynamic and normalized monitoring is increasingly urgent. In order to achieve efficient, accurate, and automated large-scale coral surveys, traditional water surface photogrammetry and remote sensing technologies (satellite remote sensing, drone remote sensing, and surface ship remote sensing) cannot meet the requirements. Underwater photogrammetry technology must be used to achieve this goal. Millions of coral images acquired by underwater ROV/AUS/UUV every year, but in many images, marine animals such as fish or turtles appear to block coral on the seabed in a large area. This situation is very similar to traditional close-range photogrammetry or nap-of-the-object photogrammetry. Therefore, in order to reduce the interference of moving objects on the observation objects, these moving objects must be handled properly. Therefore, how to efficiently check occluded images and eliminate invalid images has become a difficult task at present, and traditional manual recognition and processing cannot handle the ever-increasing massive data processing.

In view of the difficulty, an underwater image sieving and processing scheme is proposed, the key technology of which is the object detection model and the salient object detection model. For underwater images, it is necessary to determine the type and number of the objects at first, so the underwater object detection model is used to extract all the marine animals in the images, such as fish and turtles. Aiming at the characteristics of underwater vision, on the basis of preprocessing, an improved algorithm based on YOLO is used to achieve efficient and accurate underwater object detection. According to the type and number output from object detection, the area of the image occluded by marine animals can be quickly estimated, and then the image is initially sieved based on the estimation result. Specifically, it is necessary to remove images which are covered by a large area of

occlusions or contain too many occlusions. If the number of marine animals and the occluded area in the image is small, and other parts contain important information, the occluded area of the image will be cropped first. The salient object detection model is then used to segment its accurate boundary, and the occluded object will be erased, so as to provide better data for the subsequent underwater photogrammetry automatic interpretation tasks. To accurately eliminate the occlusion, it is necessary to extract the precise boundary of the object as we told before. While the existing models usually pay more attention to the accuracy of the subject and ignore the importance of boundaries, a novel salient object detection model with multi-level feature fusion and emphasis on boundaries is proposed in this paper. It consists of a prediction network and a refinement network. The prediction network is a supervised Encoder-Decoder network which uses U-Net architecture, and it can output initial saliency map by combining high-level and low-level image features. The refinement network refines the saliency map via learning the residuals between the initial saliency map and the ground truth. The training loss function is a hybrid loss, which consists of binary cross-entropy loss and structural similarity loss. The former loss weights the foreground and background pixels equally so that it can evaluate the precision of predicted result from the whole. And the latter assigns higher weights to the boundary thus it helps to gain saliency maps with more accurate edges. By using the hybrid loss, the loss of the predicted saliency map can be measured from different levels, thereby the region of the salient object is accurately predicted while the fine structure is precisely segmented. Considering the lack of high-resolution underwater image dataset, a new underwater object detection dataset is constructed by this paper, which includes a fish detection dataset and an underwater salient object detection dataset.

The results of the experiment on the dataset show that our scheme can effectively sieve and process underwater images, as shown in Fig.1. The underwater object detection model can recognize the marine animals quickly and accurately, thus sieving the underwater image preliminarily, eliminating the images containing too many occlusions and cropping the occlusion from the remaining valid images. On this basis, the salient object detection model can identify the precise position and boundary of the object in the occluded area. And then the occlusions are erased, so that mismatches will be avoided in the photogrammetric process. It can be seen in Fig.1 that image containing quite many fish is eliminated while the image with only a few fish is preserved and the fish is erased. Furthermore, in this workflow, the object detection is fast and the salient object detection may take relative more time as it deals with boundaries. The statistical data shows that the efficiency of this method can meet the needs of real-time processing, so it can help to reduce workload. In conclusion, the proposed underwater image sieving and processing scheme uses convolutional neural network to accurately locate the

position of marine animals and segment them, and perform the required processing based on the analysis of the occlusion circumstances to reduce the influence of occlusions to the utmost. Its characteristics of high efficiency, accuracy and rapidness can bring quality assurance and high precision to underwater photogrammetry.

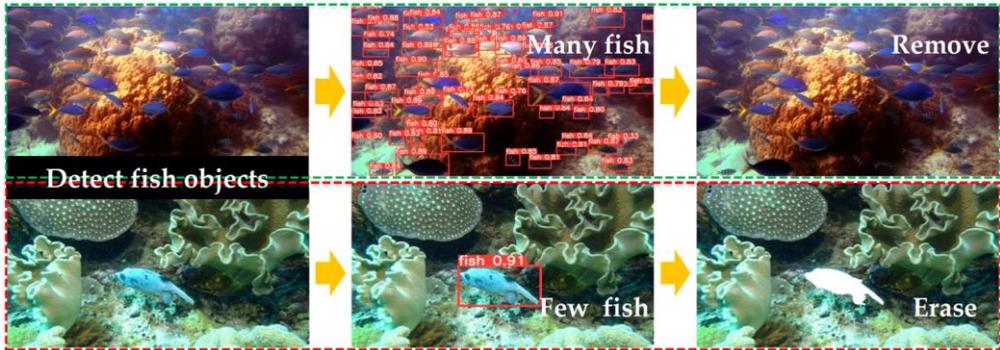


Fig.1. The process flow and effect of the method proposed in this article

Keywords: *Coral Images; Object Detection; Salient Object Detection; Underwater Photogrammetry*

STUDY OF TERRESTRIAL LASER SCANNING INTENSITY DATA FOR THE BOSSCHA OBSERVATORY BUILDING'S MATERIAL CLASSIFICATION

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ABSTRACT

In this study, the intensity value was derived from the results of data acquisition using TLS, which were then registered to determine which scanworlds overlapped as a criterion for selecting the intensity value sample. The obtained intensity values are influenced by geometrical factors and the material composition of the object. Because the intensity value is used to identify and classify the various materials that comprise an object, it is necessary to conduct research on the intensity value because it can support in detecting structural damage to buildings or in asset management. The identification process was carried out in this study using the windows scan method. The classification process relates to the intensity value that each material acquires, which is determined during the identification process. Materials with similar or identical intensity values will be classified together. The study's findings indicated that an intensity value within a specific classification range indicated the presence of material on the research object in the form of concrete walls, wooden doors, wooden windows, and glass lamps.

Keywords: *Terrestrial Laser Scanner, Point Cloud, Intensity, Bosscha Observatory*

DETECTION METHOD OF CONVALLARIA KEISKEI USING CNN AND FUZZY C-MEANS

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ABSTRACT

Unmanned aerial vehicles (UAVs) are being applied in various disciplines, such as agriculture, surveying, and logistics. Farmland crop growth has been monitored using UAVs. *Convallaria keiskei*, a plant species indigenous to Japan, was on the verge of extinction. *Convallaria keiskei* was protected and managed manually. Applying image processing and machine learning automates *Convallaria keiskei* classification, helps estimate the increase in efficient colony numbers, and reduces the detection cost. In a previous study, we proposed a flower number estimation method by combining image processing and a convolutional neural network (CNN). However, several regions were misidentified as flowering regions, and the subject numbers were reduced. Therefore, we herein propose a novel detection method that combines image processing, CNN, and fuzzy c-means. The F-measure was used as an evaluation index, which increased in twelve of thirteen images. While the previous method misidentified flowerless regions in an image as flowering regions, the proposed method did not. The proposed method lowered the misidentification as it ignored the regions that appeared similar to flowering regions, exhibiting reduced misidentification of *Convallaria keiskei* flowering regions than the previous method.

Keywords: Remote Sensing, UAV, Neural Network

EVALUATION OF ATMOSPHERIC CORRECTION METHODS FOR SENTINEL-2 IMAGERY IN THE SPECTRAL IDENTIFICATION OF POPLAR (*POPULUS DELTOIDES* BARTR.) SPECIES

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ABSTRACT

Spectral libraries can be used for the analysis of the spectral properties of tree species, as well as for the detection and mapping of tree species through remotely sensed data. This study aims to statistically analyze the performance of atmospheric correction methods in calibrating ground spectral measurements with the Sentinel-2 imagery. In this context, field spectral measurements of *Populus deltoides* Bartr. species cultivated in Akyazı district of Sakarya province, Turkey obtained with the ASD (Analytical Spectral Devices) FieldSpec-3 high resolution (HiRes) spectroradiometer (350nm-2500nm) were used as the main data source. In order to evaluate the effects of atmospheric correction methods in identifying poplar species, ENVI QUAC and Sen2Cor processor were applied to Level-1C product of Sentinel-2 data. Moreover, atmospherically corrected Sentinel-2A imagery was also utilized for the comparison of the reflectance values of poplar trees. Furthermore, five widely used spectral vegetation indices (i.e., NDVI-1, NDVI-2, GRNDVI, CVI, and CLgreen) were estimated for comparison of field measured reflectance spectral data and atmospherically corrected Sentinel-2 data. Linear regression (LR) model and normalized Euclidean distance were utilized to estimate the similarity level between field spectra obtained for poplar trees and the spectral signatures from atmospherically corrected Sentinel-2A products, ENVI QUAC and Sen2Cor processor. The LR results showed that highest R² values were estimated as 0.996 and 0.997 for Sen2Cor processor and Sentinel-2A image, respectively. Moreover, calculated normalized Euclidean distance results verified the findings that atmospherically corrected imagery better represents the spectral signature of the poplar trees. The results of this study revealed that atmospherically corrected Sentinel-2 image exhibits great potential for integration in spectral resampling of field spectra measurements of poplar species.

Keywords: *Asd Field Spectra, Poplar, Reflectance, Sentinel-2, Spectral Library*

EXTRACTION OF VERY-HIGH RESOLUTION TOPOGRAPHY FROM TRI-STEREO KOMPSAT-3 IMAGERY THROUGH REFINED GEOMETRIC MODELING

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ABSTRACT

This study presents a methodology on how to extract topographical features from tri-stereo satellite imagery using a Refined Rational Function Model (RFM) and build a Digital Elevation Model (DEM). KOMPSAT-3 tri-stereo images captured on Carabao Island in the Philippines were used on this study.

The RFM refinement from tri-stereo imagery is based on the GeoEye-1 reference image and SRTM 30m DSM where Ground Control Points (GCP) and Tie-Points (TP) are calculated. Prior to refinement, the raw Level 10 KOMPSAT-3 images show overlapping offset of around 26 to 30 meters. After the refinement, the resulting orthorectified panchromatic KOMPSAT-3 tri-stereo images show improved georeferencing accuracy of 3 to 5 meters based on a single point of reference.

The resulting Digital Surface Model (DSM) was able to achieve a ground resolution of 1.4 meters. The quality of tri-stereo DSM is assessed with respect to ALOS 30m DSM by calculating the correlation coefficients and elevation differences for all pixels in the study area. Histogram analysis revealed a mean of -0.63 meters and standard deviation of 4.05 meters. The linear regression and Pearson correlation coefficients were both 0.99. In general, the ALOS 30m DSM has slightly higher measurements than the tri-stereo DSM but are highly correlated with each other.

This study demonstrated that optical satellite imagery can be used to extract topographic features and monitor geomorphic processes such as landslides, generate flood routing models and other derivative applications.

Keywords: *Tri-stereo Image, Digital Elevation Model, Digital Surface Model, Rational Function Model, Photogrammetry, Geometric Modeling, Topography Extraction*

LIDAR SCAN MATCHING WITH PPP-RTK FOR 3D FARM MAPPING

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ABSTRACT

In various advanced agriculture activities called smart agriculture, we focus on three-dimensional measurements for farm mapping and machine control. We also focus on precise point positioning real-time kinematic systems, such as Global Navigation Satellite System (GNSS) positioning with submeter-level augmentation services (SLAS), centimeter-level augmentation services (CLAS), and multi-GNSS advanced demonstration tool for orbit and clock analysis (MADOCA) to improve the efficiency of precise positioning using the Quasi-Zenith Satellite System. In our study, we selected a farm as an experiment area to acquire point clouds and position data of cultivation works before sowing soybeans. We used a low-price light detection and ranging device with a multifrequency GNSS. Through our experiment, we evaluated the positioning performance of SLAS, CLAS, and MADOCA for point cloud acquisition. Moreover, we confirmed that our methodology can reconstruct point clouds from a tractor.

Keywords: *Scan Matching, Multilayer Lidar, PPP-RTK, Mobile Mapping, Smart Agriculture*

PIXEL BASED LAND COVER CHANGE DETECTION ANALYSIS AND PREDICTION USING REMOTE SENSING AND GIS TECHNIQUES A CASE STUDY OF MANDALAY CITY, MYANMAR

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ABSTRACT

In this paper, Land cover change detection, change type, and prediction are investigated by using Remote Sensing and Geographic Information Systems (GIS) in Mandalay city, Myanmar over a period of 20 years. The land cover changes by using maximum likelihood algorithm and support vector machine algorithm for land cover change classified with four classes including Water, Buildup, Vegetation, and Bare land from the year (2000-2020). The Mandalay city was lost 16.12% of water, 60.1% of its vegetation land, and 67.87% of its bare land. Significant distant amounts of these losses have been absorbed by the expanding urbanized areas, which have gained 70.27% of the land. And then calculate the overall accuracy assessment of the classified land cover maps was analyzed by estimating the kappa value and overall accuracy. Finally, predictions of land cover change detection for 2030 show that the water, vegetation, and bare land to decrease by an additional 21.70%, 10.76%, and 9.30% respectively. The highest gain in 2030 is predicted for urbanized areas at 5.54%. This study can provide suggestions and a basis for urban development planning in Mandalay City, Myanmar.

Keywords: Land Cover, Change Detection, Prediction

APPLICABLE MEAN-SHIFT FILTERING PARAMETERS FOR MAPPING OF WEED IN CASSAVA FIELDS BASED ON UAV IMAGES

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ABSTRACT

Recently, a very high spatial resolution image for precision agriculture can be collected from sensors mounted on the Unmanned Aerial Vehicle (UAV), which is less time-consuming, has accurate control, high performance, and low operation cost. As the high spatial resolution, the object in this image contains many pixels that vary differently in the pixel value. Image classification results of using raw pixel values may be affected by the heterogeneous properties of objects. Mean-shift filtering is a process to smooth the different fine pixels into the homogeneous region and remove noise from plenty of small areas on the image. The appropriate parameters are crucial to filter this process. This study explores the applicable mean-shift filtering parameters, spatial size, and color value to improve the classification accuracy of weeds and cassavas. The RGB image from the UAV was used as an input dataset for the mean-shift process. Consequently, the filtered images were classified by the Support Vector Machine (SVM), presenting the weeds and cassavas map. The experimental result shows that using Mean-shift filtering can increase classification accuracy up to 4.22% from pixel-based classification by varying different sets of parameters. The classification accuracies are 78.38% - 82.60%. It shows that the mean-shift filtering with the appropriate parameters can be employed to improve the classification accuracy.

Keywords: *High-Resolution Image, Weed Classification, Cassava Field, Mean-Shift Filtering, Support Vector Machine (SVM)*

SURFACE REFLECTANCE CORRECTION USING CONSTRAINED HARMONIZATION FOR OPTICAL SATELLITE IMAGERY

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ABSTRACT

Surface reflectance derived from optical satellite images is a fundamental and important material for remote sensing applications. The advanced atmospheric corrections have achieved great progress in the removal of atmospheric effects by using complicated physical-based models. However, the process of image-by-image atmospheric correction may cause bias errors for multitemporal images, which produce temporal inconsistencies and discontinuities over the surface reflectance of invariant ground objects. In this study, a surface reflectance correction is proposed for multispectral and multitemporal satellite images. The surface reflectance correction is determined by using pseudoinvariant features instead of an entire image, and the correction is based on a harmonization technique with temporal-consistency and spectral-consistency constraints. With the constraints, the spectral signatures in multispectral images can be maintained, while the surface reflectance biases in multitemporal images can be removed during the image harmonization. In the method, the pseudoinvariant features are determined by using iterative reweighted multitemporal and multivariate alteration detection, called IRMMAD, which is an extension of IRMAD. The multispectral and multitemporal surface reflectance bias removal is formulated as an optimization problem, and a least-squares linear system is solved for optimal harmonization. Qualitative and quantitative analyses on six atmospheric corrections (AC) models multitemporal images have been conducted, and the methods are evaluated using the measurements of spectral and temporal consistencies. The experimental results show that the surface reflectance biases can be significantly removed while the spectral signatures can be preserved. In addition, the proposed method outperforms related harmonization methods in terms of consistency measurements.

Keywords: *Surface Reflectance, Constrained Image Harmonization, Spectral Consistency, Temporal Consistency*

EMBEDDING WATERMARK ON DIGITAL AERIAL PHOTO IN GEOTIFF FORMAT USING DISCRETE WAVELET TRANSFORM AND DISCRETE COSINE TRANSFORM

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ABSTRACT

Digital watermarking is a technology for granting copyright to digital products. As a marker in digital products, a watermark is one way that can be inserted as additional information on the image, and the inserted information can be invisible, difficult to delete or change. Simulation using python with one image host aerial photo three bands (red, green and blue) 16-bit GeoTiff format with coordinates, image size 4742x4742 pixels with the top left coordinates 106.791 East Long 6.68694 South Latitude and the resolution is 0.01666 seconds for longitude and 0.01666 seconds for latitude. And an image of the one band 8-bit png format of BIG logo watermark in black (0) and white (255) with a size of 50x50 pixels. In this study, six simulations of watermark embedding were carried out by Replacing the maximum values of 255, 50, 25, 10, 5 and 1. The method used to embed watermark images is Discrete Wavelet Transform (DWT) combined with Discrete Cosine Transform (DCT). Watermarked image quality was measured using Peak Signal to Noise Ratio (PSNR), Structural Similarity Index (SSIM), Mean Square Error (MSE) and Visual Information Fidelity (VIF). The optimal watermark image number is at number 25 with a PSNR value of 80.3192, RMSE of 0.3438, VIF of 0.9930, and SSIM of 1.0000. The value of watermark one, which is inserted into the host image, makes the watermark image unrecognizable but has the largest PSNR (81.5050) compared to the others, while RMSE (0.3000) has the smallest value.

Keywords: Copyright, Watermark, Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT)

WEED IDENTIFICATION USING VEGETATION INDICES AND MULTISPECTRAL UAV IMAGING

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ABSTRACT

Weeds are undesirable plants in a field that compete with desirable plants. This competition results in a significant reduction in the expected yield. Depending on the nature of weeds, different chemical herbicides are used to avoid this reduction in the yield. However, excessive use of chemical herbicides can be hazardous for the environment. Therefore, effective site-specific use of the herbicides is desirable to minimize the negative impacts on the environment. Multiple existing studies have proposed methods to identify weed concentration regions from the field images. These studies are primarily focused on the identification of weeds at early phenological stages. However, as far as we know, there is no study to identify the weeds at later phenological stages for the maize field as high similarity in the weeds and the crop makes it difficult to distinguish them. Therefore, this study proposes a novel pipeline to identify and mask weed concentration regions in the images, collected through UAV at the later phenological stage. The image dataset is collected on three different days and at three different altitudes. The proposed pipeline uses U-Net for precise and fast semantic segmentation in the image. Moreover, instead of generating ground truth images manually or from software, we used two vegetation indices GNDVI and NDRE images as ground truth images. GNDVI-based pipeline successfully identified weeds with a 0.81 IOU score whereas NDRE could achieve only a 0.75 IOU score.

Keywords: Precision Agriculture, UAV, Weed Identification, U-NET

3D OBJECT DETECTION FROM MOBILE LIDAR POINT CLOUD WITH DEEP LEARNING

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ABSTRACT

The usage area of LiDAR technology, which can be detected from the aerial, terrestrial and mobile, is expanding day by day. Especially for mapping and autonomous vehicles, mobile LiDAR offers very useful data. Mobile point clouds are a type of data obtained using laser scanners mounted on a moving vehicle. An accurate sense of space and precise positioning are crucial requirements for reliable navigation and safe driving of autonomous vehicles in complex dynamic environments. Recently, deep learning approaches have been preferred for the evaluation and information extraction of complex mobile LiDAR data. Although successful results have been obtained for camera-based solutions with deep learning, it may not be fast enough in inference paths due to convolution operations. There are improved methods for real-time performance in object detection. Single-shot detectors, like YOLO, are some of the best in this regard. In this study, moving or stationary vehicles, people and cyclists on the point cloud have been detected by deep learning. Vehicles, pedestrians and cyclists were detected with YOLO3D-YOLOv3 and YOLO3D-YOLOv4, which are the developed version of the YOLO algorithm applied to 2D images for 3D point clouds. KITTI benchmark dataset was used in this study. The point cloud is projected onto a grid mesh with a resolution of 0.1 m per pixel in the form of a bird's eye view. The range of a LiDAR patch is 30.4 meters to right and 30.4 meters to the left, and 60.8 meters forward. Input shape of 608x608 per channel is obtained by using this range with the resolution of 0.1 m per pixel. Average mean precision (mAP) results in this study were obtained within the mAP lower limit of 0.5 IoU for each object class. The mAP was obtained as 83.04%. with YOLO3D-YOLOv4 and 81.50% with YOLO3D-YOLOv3.

Keywords: Deep Learning, Object Detection, Point Cloud, YOLO, Mobile LiDAR

CLASSIFICATION FOR URBAN SPRAWL ANALYSIS OF MUMBAI METROPOLITAN REGION (MMR)

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ABSTRACT

The rapid Urban growth in metro cities has introduced serious environmental challenges in many megacities hindering the goals of sustainable development which includes natural resource management, maintenance of infrastructure facilities, sanitation etc. and it is a cause of concern for Urban and town planners for efficient Urban Planning. The Land Use and Land cover (LULC) Classification is important for Urban growth analysis.

The Mumbai Metropolitan region (MMR) in Maharashtra, India comprising of 9 districts has seen such Haphazard and explosive growth especially in past 3 decades. The population of Mumbai has more than doubled since 1991, when the census showed that there were approximately 12.5 million people living in the area. Population growth from 12.5 million to 23.5 million in 2021 is seen.

This has led to cities expanding towards periphery and rural neighborhood causing urban sprawl. This study focuses on finding the LULC for the MMR for last three decades so that it may help the Urban Planners to understand the growth. With the Spatial and Temporal analysis an attempt has been made to understand the changing dynamics of LULC in Mumbai Metropolitan region. This change was found using Maximum Likelihood Classifier. Further for modelling and prediction CA Markov model was used.

Results show the change in land from 2000 to 2020 and mainly sprawling outward. Modelling using CA-Markov pointed out that urban growth to increase by 2030. The notable observation of our study is that urban growth would have an infill growth in the city completely and then starts sprawling outward and emphasizes need for policy planners and urban managers to provide immediate interventions for infrastructure development necessary for sustainable growth of Indian urban agglomerations.

Keywords: Remote Sensing, LULC, Urban Sprawl, CA-Markov Model

IMAGE MOSAICING FOR UAV-BASED PUSHBROOM HYPERSPECTRAL IMAGING

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Abstract

Hyperspectral imaging has many applications in agricultural and environmental remote sensing. There are many metrics that can be derived from spectral data such as vegetation indices which can detect the presence of stress and disease. A push-broom imaging system captures via line-scanning, and is capable of a higher spectral resolution than a snapshot camera which can only operate on limited spectral band counts. Combining this with the low-cost and flexible deployment of unmanned aerial vehicles (UAV) can yield on-demand data of high spatial and spectral resolution. The challenge lies in mosaicing the push-broom images. Since each image line-scan has only one spatial axis, using area and feature based image mosaicing algorithms is ineffective. We designed a push-broom hyperspectral imaging system from commercial-off-the-shelf (COTS) components intended for UAV flight captures. This paper details the image mosaicing approach that utilizes the data from Global Positioning System (GPS) and inertial measurement unit (IMU) sensors. The algorithm is homography-based and uses the position and attitude of the UAV and camera to compute the relative positions of the target and image planes, and projects the line-scans in a single mosaic. Test flights were performed using a DJI Matrice 600 Pro to determine the accuracy of the mosaics in preserving known measurements and features.

Keywords: Pushbroom, Image Stitching, Image Mosaicing

A WEB-BASED APPLICATION UTILIZING CONVOLUTIONAL NEURAL NETWORK (CNN) METHOD FOR DETECTING RICE PLANT DISEASES IN BUTUAN CITY, PHILIPPINES

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ABSTRACT

Currently, applications or tools for recognizing rice leaf diseases are one of the desires of farmers for the sustainability of rice planting and productions as rice plant diseases are one of the major challenges of farmers. Several bacterial, viral, or fungal diseases affect the rice plants causing reduction of rice productions. In the realm of rice plant disease recognition, there are several methods studied in the research community. In this study, the proponents developed a CNN-based model for recognizing common rice leaf diseases – Bacterial Leaf Blight, Bacterial Leaf Streak, and Rice Brown Spot. The CNN-based model is trained to recognize the three common rice leaf diseases using a database of rice plants with disease images. The developed model achieves a training accuracy of 93.67% and a validation accuracy of 91.25%. The developed model was integrated in a web application and reached an accuracy of 99.95% when tested on a set of independent rice plant disease images. In addition, several experiments using another set of images on the developed model in the web application for detecting rice plant diseases have been conducted and the developed model achieved recognition rates of 99.91%, 99.97%, and 99.94% for Bacterial Leaf Blight, Bacterial Leaf Streak, and Rice Brown Spot, respectively.

Keywords: *CNN-based model, Deep Learning, Bacterial Leaf Streak, Bacterial Leaf Blight, Rice Brown Spot*

DEEP LEARNING-BASED UAV AERIAL TRIANGULATION WITHOUT IMAGE CONTROL POINTS

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ABSTRACT

The emerging drone aerial survey has the advantages of low cost, high efficiency, and flexible use. However, UAVs are often equipped with cheap POS systems and non-measurement cameras, and their flight attitudes are easily affected. How to realize the large-scale mapping of UAV image-free control supported by POS faces many technical problems. The most basic and important core technology is how to accurately realize the absolute orientation of images through advanced aerial triangulation technology. In traditional aerial triangulation, image matching algorithms are constrained to varying degrees by preset prior knowledge. In recent years, deep learning has developed rapidly in the field of photogrammetric computer vision. It has surpassed the performance of traditional handcrafted features in many aspects. It has shown stronger stability in image-based navigation and positioning tasks, especially it has better resistance to unfavorable factors such as blur, illumination changes, and geometric distortion. Based on the introduction of the key technologies of aerial triangulation without image control points, this paper proposes a new drone image registration method based on deep learning image features to solve the problem of high mismatch rate in traditional methods. It adopts SuperPoint as the feature detector, uses the superior generalization performance of CNN to extract precise feature points from the UAV image, thereby achieving high-precision aerial triangulation. Experimental results show that under the same pre-processing and post-processing conditions, compared with the traditional method based on the SIFT algorithm, this method achieves suitable precision more efficiently, which can meet the requirements of UAV aerial triangulation without image control points in large-scale surveys.

Keywords: *Aerial Triangulation; Unmanned Aerial Vehicle; Convolutional Neural Network; Image Matching*

ESTIMATING FIRE TEMPERATURE WITH SHORT-WAVE INFRARED BANDS OF HIGH RESOLUTION SATELLITES

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ABSTRACT

This paper describes a novel technique of detecting daytime fires and estimating fire temperature and fire fractional area using the short-wave infrared (SWIR) bands of high resolution satellites such as Sentinel-2, Landsat-9 and WorldView-3. It is a great challenge to detect daytime fires due to the influence of solar reflected radiance. In our algorithm, the surface reflectance is modeled by a linear combination of a small number of reflectance basis functions. The algorithm could then retrieve the sub-pixel fire temperature, fire area, together with the surface reflectance of the background. This technique would enable detection and characterization of small fires in the tropics, where fires are typically small and not as intense as those in the temperate region.

Keywords: Fire, Modeling, Thermal Imaging, Basis Functions, Sentinel-2

AN ALGORITHM FOR THE DIRECT ESTIMATION OF NDVI WITH LANDSAT TOA REFLECTANCE

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ABSTRACT

Vegetation index can effectively describe the coverage, distribution and growth of vegetation. As a simple and sensitive vegetation index, normalized difference vegetation index (NDVI) is widely used in crop yield estimation, surface classification and vegetation extraction. However, due to the influence of atmospheric conditions and other factors, the atmospheric correction results in some areas are uncertain and even difficult to obtain accurate atmospheric variables (e.g., aerosol optical depth), resulting in the inability to estimate NDVI from surface reflectance. This paper introduces an algorithm to directly estimate NDVI with Landsat top of atmosphere (TOA) reflectance. The algorithm builds a segmented regression model of TOA reflectance and surface NDVI, obtains the model coefficients under different geometric conditions, and generates a look-up table to store regression coefficients. Through this algorithm, the instantaneous NDVI can be obtained directly from the TOA reflectance, which not only provides a way to obtain the surface NDVI for the areas where the atmospheric correction is difficult or the atmospheric correction results are not accurate, but also can be used to produce high-resolution surface NDVI products with spatiotemporal continuity. In order to verify the accuracy and reliability of our algorithm, we use the Landsat 8 TOA reflectance data of Hunan area in China to calculate the surface NDVI, and use another surface NDVI products obtained by atmospheric correction and band operation to verify the accuracy of the estimation results, count the relevant accuracy indicators, and make a comparative analysis. The statistical results show that the accuracy of NDVI estimated by this method is good, and the overall results are reliable.

Keywords: *Oli, Vegetation Index, Brdf, Segmented Model*

ESTIMATION OF HOT MUDFLOW CURRENT USING LONG TERM DINSAR

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ABSTRACT

Several techniques have proposed to observe long-term land deformation using phase information of synthetic aperture radar (SAR), for example, InSAR, DInSAR, PS-InSAR, SBAS using spaceborne SAR images. But every mission of spaceborne SAR has an orbit duty period less than ten years and other problems of discontinuity or blank period of observation using the similar specification of sensors. Hence land deformation with an observed time of more than ten years is not available to be monitored continuously using a single mission. This research proposed a method called Bridging Consecutive DInSAR (BC-DInSAR) to connect Consecutive DInSAR. These methods were employed to investigate land deformation and the impact caused by hot mudflow accident at Regency of Sidoarjo, Indonesia, where this disaster happened on 29 May 2006 and is flowing until now. The differential GPS data since 2006 was employed to validate the analysis result of BC-DInSAR, which obtained 0.46 m RMS error.

Keywords: Synthetic Aperture Radar, Consecutive, DInSAR, Law of conservation of material, Multi Sensor

GEOGRAPHIC INFORMATION SYSTEMS (GIS) AND WEB GIS

GIS BASED ACCESSIBILITY RESEARCH OF THE COMMUNITY PHARMACY SERVICES IN DISTRICTS WITH HIGH NUMBER OF COVID-19 CASES DURING PANDEMIC IN ISTANBUL

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ABSTRACT

Pharmacies are one of the basic components of health services in settlement centers. Providing pharmacy services to the community efficiently can be achieved with the sufficient number of available pharmacies precisely distributed within the settlement areas. Especially in extraordinary times as the Covid-19 Pandemic, the adequate and accessible service of pharmacies contributes surveillance by reducing the potential contacts. In this study, two districts with high number of COVID-19 cases in İstanbul, Bağcılar and Esenler districts, were examined using geographic information technology. In this context, the number of pharmacies in the study area and their spatial distribution were examined and a neighborhood-based service adequacy assessment was provided. In addition, pharmacies with fast pedestrian access were determined by evaluating the defined service area of each pharmacy together with demographic data. Policies for effective pandemic management that can be applied in regions with limited or no service access within international standards were discussed. The main findings of the study are that although there are sufficient number of pharmacies for the living population in both districts where unplanned urbanization is dominant, the population without pedestrian access within the standards is remarkable due to the imbalances in the spatial distribution of the existing pharmacies in the study area. It is important to establish temporary service points in these regions during the pandemic so that this problem, which is especially appeared in neighborhoods with high population density far from the district center, does not adversely affect the pandemic management. After the pandemic, studies should be planned to improve the existing unequal service distribution by considering the service demand and service usage habits of the people of the region.

Keywords: *Availability, service area, pandemic, pharmacy*

EXPLORING URBAN LAND USE CHANGE USING GIS INTEGRATED GEOSTATISTICAL ANALYSIS REFERENCE TO COLOMBO URBAN FRINGE, SRILANKA

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ABSTRACT

Colombo is the Capital city of Sri Lanka. Its urban expansion gradually moves towards its urban fringe. In the period of time, the fringe area also expands to outward rural areas. Its ultimate result is converting fertilized agriculture land into urban land uses. Identification of this changing process and factors effecting to these changes are important for future land use planning. Present planning is not considering this situation and it is a clear research gap existed in the urban analysis in Sri Lanka. Therefore, this study aimed to analyze the existing land use changing pattern in the Colombo urban fringe and affected driving factors. GIS based statistical analysis was used to explore this changing pattern. Paper maps, digital maps, lidar images, satellite images and Google maps were used as data of this study. The land use change was analyzed using cross tabulation using the change detection method embedded in ArcGIS 10.3. Using those data, an urban change map and different criterion maps were identified based on factors affecting to land use change. The data sample was determined based on the simple random sampling method. Relationship between land use change and affecting factors were calculated using logistic regression. The outcome of the analysis shows how the land use in the Colombo fringe area has been converted over three decades using land use maps and it highlighted the gradual increase of the built-up land with decrease of green land. In addition, results explore land value, population density and proximity factors were mostly affected to this conversion pattern. Identification and quantification of this pattern is very useful for future planning activities in the Colombo urban fringe. The analysis can be applied to whole urban fringe area and its results contributes to develop knowledge planning framework for development plan exercises in Sri Lanka.

Keywords: *Urban Land Use, Factors Affecting Land Use Change, Land Use Change Detection, Urban Fringe, Logistic Regression*

DEMONSTRATIONAL EXPERIMENT FOR THE EARLY DETECTION METHOD OF WANDERING DEMENTIA PATIENTS BY USING GNSS

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ABSTRACT

Early stage of the research was reported in ACRS2020. This report is advanced research results continuing from last year. Japan has a continuously increasing population of elderly people aging 65 years old and older. At the same time, the number of dementia patients has been increasing. Therefore, the number of missing people among dementia patients has been holding a high record. A lot of reports and information about accidents and troubles in relation to dementia patient has been reported. The patient's family has big problems that the patient may cause an accident and trouble. In the research, we proposed the early detection method of wandering dementia patients by using GNSS logger and smartphone. First step in the research, obtaining their behavior route using GNSS logger and smartphone beforehand, it conducted behavioral analysis based on saved data. Those results are utilized for identification of the main purpose of wandering and a discovery in case of disappearance. Demonstrational experiment has been conducted with the cooperation of elderly people. Examinees are elderly people without dementia. Lending some equipment for examinees and they used it in their daily lives. As a result, it was able to record their behavior pattern. Also, analyzing recorded data, we considered whether it is possible to use that when dementia worsen, saved data can possibly be utilized and split up behavioral route; it could serve as a health index. Also, we have been doing the same experiment with the cooperation of younger people.

Keywords: *GNSS Logger, Smartphone Application, GIS*

COVID-19 GEO-SPATIAL BIG DATA ANALYSIS OF POPULATION MORTALITY FOR COUNTRIES SITUATED AT LATITUDES BETWEEN 64°N AND 35°S

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ABSTRACT

The outbreak of the Covid-19 emerged from Wuhan, Hubei province of China, spread geo-spatially in more than 210 countries causing more than 96.7 million people of the global population infected and 2.06 million deaths (as on 20th January 2021) from 25.416 million people infected and 0.851 million deaths (as on 30th August 2020), which is still spreading in geospatiotemporal way to the new geographical locations. There are marked variations in the spectrum of daily new cases of covid-19 between different countries. People do not receive sufficient sunlight to retain adequate vitamin D levels during winter in countries situated at the latitude beyond 35°N. Vitamin D is important in preventing the cytokine storm and subsequent acute respiratory distress syndrome that is commonly the cause of mortality. The global spreading of covid-19 caused marked variations in population mortality between different countries situated at different latitudes, which suggest establishing the correlation between latitude and the severity of the covid-19 outbreak. In this paper, geo-spatial big data analysis has been carried out for determining the impact of latitude and the role of vitamin-D on population mortality for 52 countries situated between the latitude 64°N and 35°S, based on population mortality data from 15th April 2020 to 30th June 2021, which shows relatively lower population mortality in countries that lie below the latitude 38°N. This paper explains the variability factor of population mortality from 3rd May 2020 to 30th January 2021 with respect to population mortality on 15th April 2020 for determining the severity of the covid-19, which shows the significant severity of the covid-19 outbreak in the country such as South Africa, Colombia, Russia, Kuwait, India, Mexico and Ukraine during 30th September 2020 to 30th January 2021 and sudden rise of variability factor for Romania, Serbia, Slovenia, Austria and Poland.

Keywords: *Vitamin-D, Marked Variation, Severity of the outbreak, Variability of opulation Mortality*

GEO-SPATIAL BIG DATA ANALYSIS OF COVID-19 FOR SOUTHEAST ASIAN COUNTRIES SITUATED AT LATITUDE BELOW 38°N

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ABSTRACT

The outbreak of the Covid-19 originated from Wuhan City, quickly spread across China and beyond following human mobility patterns covering more than 210 countries of the globe, and World Health Organization (WHO) declared the outbreak a pandemic on 11 March 2020. The outbreak of Covid-19 spread geo-spatial and spatiotemporal way in countries situated at latitude between 64°N and 35°S, causing more than 182.969 million (182,969,081) people of the global population infected and 3.963 million (3,963,102) deaths (as on 30 June 2021). The spatial spreading of covid-19 spectrum due to large-scale migrations were reported in the southeast Asian region, with the first case in Thailand on 13 January 2020, which is followed by South Korea on 20 January 2020, and Vietnam and Taiwan on 22 January 2020 prior to reach Hong Kong and Singapore on 23 January 2020. Malaysia reported the first covid-19 case on 25 January 2020, which further spread to Philippines on 30 January 2020 prior to reach Indian Sub-continent on 31 January 2020. There are marked variations in the spectrum of daily new Covid-19 cases and population mortality between different countries in the Southeast Asian region such as India, South Korea, Taiwan, Vietnam, Singapore, Thailand, Malaysia, Indonesia, Philippines, Hong-Kong, and Myanmar. In this paper, spatial big data predictive analysis have been carried out based 5-days moving averages of new covid-19 cases from 19 February 2020 to 30 June 2021, which shows multiple surge of covid-19 spectrum in the southeast Asian region. This paper further describes the impact of latitude on population mortality for determining the severity of the outbreak based on population mortality data of 28 countries situated at latitude below 64°N from 15 April 2020 to 20 January 2021, whereas relatively lower population mortality observed for the countries situated at latitude below 38°N.

Keywords: *Covid-19 Spectrum, Big Data Predictive Analysis, Population Mortality, Multiple Surges*

ANALYSIS OF KEYHOLE TOMB-LIKE TOPOGRAPHY OF ORONO-SHIMA ISLAND—ORIGINS OF THE ANCIENT TOMB SYSTEM IN JAPAN?

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ABSTRACT

Orono-shima Island is a remote Island in the Tsushima Strait, it is 4.3km around. Since ancient times, it has been a landmark when crossing from the Korean Peninsula to Japanese archipelago via Tsushima Island and Iki Island. However, large-scale ruins and burial mounds are not known on Orono-shima Island until now. During my four years on the island, the author walked all over the island for terrain survey. As a result, the author discovered a topography like keyhole tomb which is a characteristic Japanese burial mound, on the northern cape of the island. It could be up to 150m in size, one of the largest around Kyusyu Island. There is no burial mound comparable to this on a remote island in Japan. Therefore, we created a 3D image using a drone photograph of this terrain and we compared the results with another keyhole tomb. In addition, we analyzed the image of infrared radiation of Orono-shima Island took by Landsat8. In conclusion, it was speculated that this topography was the prototype of the oldest type of keyhole cairn tomb in Japan. The topography of the northern part of Orono-shima could be regaining the missing link between the cairn on the Korean Peninsula of the first century and the oldest type of keyhole cairn tomb in Japan of the third century. By the way, the keyhole tombs were a grave system of the ancestor of the emperor family, and the emperor family is the oldest royal family in the world which inherits the Japanese myth. Therefore, if the topography of the northern part of Orono-shima Island was the founder type of keyhole tomb, Orono-shima Island might be Onogoro-shima Island that was the first land to appear in Japanese mythology.

Keywords: *Archaeology, Topography, Regional geography, Geographic information system, Remote sensing*

**LAND SUITABILITY ASSESSMENT FOR
POULTRY FARMS IN DAVAO CITY
USING GEOGRAPHIC INFORMATION SYSTEM (GIS)
AND FUZZY ANALYTIC HIERARCHY PROCESS (FAHP)**

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ABSTRACT

The study was conducted to map out the suitable location for poultry farming in Davao City. Fuzzy Analytic Hierarchy Process (AHP) and Geographic Information System (GIS) were used to generate the suitability map. Triangular fuzzy number (TFN) was used in calculation of weight values which addressed the uncertainty of the experts' opinion. Experts participated were from Davao City Agriculturist department and Veterinarians office, NGO, and poultry farm industry. There were six factors considered namely elevation, land cover, landslide prone, river and road network, and soil type with weight values of 11%, 41%, 7%, 20%, 14% and 7%, respectively. The maps were reclassified into four classifications (high, moderate, marginal and not suitable). The classifications were represented by numerical values 1 to 4 with 1 as the highly suitable and 4 as not suitable classification. There were 28 highly suitable barangays in Davao City, Southern Philippines for poultry farming. Some recommendations for future research were to consider more factors, and replicate the methods using a different study area

Keywords: *Chicken, Landslide prone, Waterways, Zoning*

SPATIAL ANALYSIS FOR FREE-RANGE DUCKS: A STUDY AREA OF PATHUM THANI PROVINCE, THAILAND

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ABSTRACT

Free-range ducks is an agricultural activity which conduct mostly in paddy area. The left-over rice grains are important source of ducks' food. However, the declination of paddy area due to the expansion of urban has highly affected the free-range ducks farming. Pathum Thani province has high capability in rice producing for all year round due to the effective irrigation system and the suitable land quality. Therefore, free-range ducks farms are mostly found in Pathum Thani and other central regions provinces e.g. Ayuthaya, Supan Buri. The objectives of this research were 1) to the suitable paddy fields for free-range ducks farms in Pathum Thani and 2) to assess the risks which could threaten the free-range ducks activity. The Analytic. Hierarchy Process (AHP) and GIS were used for assessing the suitable land for free-range ducks activity. Three main important factors namely 1) the size of the rice paddy area, 2) water source distance and 3) distance from the community. The research results showed the most suitable area for free-range ducks was found only 4% of the paddy area, moderately suitable paddy was 72.21%, and the less-suitable rice field was 23%. The risk factors and impacts on free-range ducks activity can be divided into 3 aspects, namely, human and social issues, consisting of (1) urban expansion problems affecting rice paddies and water sources, (2) insecurity from thieves. Environmental issues consisted of (1) the use of chemicals in rice farming; (2) the risk of epidemic outbreaks. Economic issue, prices and the marketing processes.

Keywords: *AHP, free-range duck, GIS, paddy field, Pathum Thani*

REMOTE SENSING AND GIS WEB-BASED SYSTEM FOR PROTECTION AND RESTORATION OF MANGROVE (E-PESISIR) IN MALAYSIAN'S COASTLINE

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ABSTRACT

The mangrove ecosystem has been disrupted and destroyed as a result of development in the surrounding area. It is facing critical decline and degradation worldwide, at a rate of 1 to 2% per year. The loss of mangroves leads to the loss of valuable ecosystem services as well as significant protection for communities vulnerable to sea-level rise and disaster events. Considering these problems, the Malaysian government has implemented programs to plant mangroves in coastal areas. This paper therefore, presents the design and development of a webGIS system that enables users such as Forestry Department of Peninsular Malaysia (FDPM) to assess the success of mangrove ecosystem rehabilitation and restoration. e-Pesisir is developed using PHP, JavaScript, HTML and CSS languages along with various ArcGIS Enterprise tools such as Portal, Server and Web AppBuilder. Web AppBuilder for ArcGIS is used to build the GUI (graphical user interface), Portal for ArcGIS and Server act as middleware and Oracle RDMS is used as the backend database. The system is designed to support two types of data models: raster and vector data models. The analytical results show that the system is capable of providing accurate information in an efficient manner. It is also an alternative management tool that can be combined with other techniques, such as field monitoring, to improve mangrove ecosystem protection and restoration. In conclusion, this paper presents and highlights the advantages and benefits of the system that provides better support for related agencies in finding smart ways to restore and manage mangrove ecosystems in the Malaysian coastline. The operation of the e-Pesisir application since 2016 has improved conventional methods of mangrove ecosystem protection and restoration, and even helps stakeholders to plan more effectively and efficiently in the long term.

Keywords: *Remote Sensing, e-Pesisir, WebGIS, Mangrove, Coastline*

MYMARHALAH: A SMART NAVIGATION MOBILE APPLICATION FOR MUSAFIR IN MALAYSIA USING GIS AND RELATED TECHNOLOGIES

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ABSTRACT

Smartphone penetration in Malaysia has exceeded 88% as share of the population and is projected to continue to increase over the coming years. Rapid technological advances open up opportunities to develop Geographical Information System (GIS) based mobile applications using embedded features inherent in mobile devices as well as application framework components and APIs. The evolution in Global Positioning System (GPS) technology has improved the accessibility and navigation accuracy in mobile applications. Islam has set some specific rukhsah (concession) concepts that can be applied by musafir (muslim travellers) including prayers of jama' and qasar (combine and shorten) if the journey exceeds two (2) marhalah which has been decided as 81km by Malaysian Islamic Authority. Currently there aren't any well-defined application available to assist them in fulfilling their obligation in Malaysia. myMarhalah is a mobile GIS application developed to facilitate musafir with their journey by displaying navigation routes, calculating travelled distances, identifying permissible leniency for prayers, locating nearby mosques, showing prayer times and listing the answers for frequently asked questions on related issues. The application uses open source native cross platform development that supports agile software development life cycle (SDLC) and allows DevOps to develop full native application for iOS and android simultaneously. This saves a lot of time in maintenance and upgrades. Equipped with artificial intelligence and machine learning technologies, myMarhalah provides multiple route options to users and dynamically changes active navigation based on user's decision. Integration with mosque location allows users to navigate to the mosque of their choice in the middle of the journey to perform prayer and navigate back

to the final destination seamlessly. The application also adopted big data technology in its search and query functions for better user experience (UX). With the absence of distinct application for musafir in Malaysia, myMarhalah is the first one-stop mobile GIS application that provides convenient solution for them to implement the concession concept in their journey. It is also in line with the Malaysian Government's Digitalisation Strategy to improve public service delivery using emerging technologies.

Keywords: *Geographical Information System (GIS), Mobile Application, Artificial Intelligence, Machine Learning Technique*

THIN PLATE SPLINE IN DETERMINING 500 YEARS MORPHOLOGY EVOLUTION OF HISTORICAL CITY OF MELAKA

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ABSTRACT

Morphological urban studies have often been discussed in geographical literature, especially regarding geographical-historical settlement studies. Old maps are crucial for comparing spatial relationships of past phenomena and their evolution over time and permitting qualitative and quantitative analysis. However, most of the old maps were hand-drawn, unscaled and recorded by traveller or historian lead. Therefore, the spatial information of the old maps needs to extract and analysed. This paper will demonstrate old maps to study urban morphology in Melaka with the scientific geo-referenced approach by using thin-plate spline projection. Thin plate spline is a global elastic transformation that maintains the assigned map coordinates of all control point locations but applies smoothly varying transformations between control points. This transformation is capable of geo-referenced low quality or less-precise historical maps. Multiple old maps from different years are used; 1515,1830,1960 to integrate with SPOT satellite images from 1993, 2005 and 2015. The results show that the Thin Plate Spline technique is accurate and able to coefficients once-and-for-all. Simultaneously, the GIS software with relevant geo-referencing techniques can provide accurate spatial geo-information to study historical morphology. Moreover, the geo-referenced historical maps open up new opportunities for a broad spectrum of historical analysis extracted from flat maps.

Keywords: *Thin plate spline, GIS, urban morphology, historical city, old maps*

COMPARATIVE ASSESSMENT OF RURAL DEVELOPMENT PROGRAMMES IN PANCHAYATS OF HIMACHAL PRADESH USING GEO-INFORMATICS

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ABSTRACT

The spirit of India lives in villages and only by changing the face of rural areas, there will be better future for the State and nation as a whole. The Rural Development Department is engaged in changing the face of rural Himachal through its many fold development schemes, working in a participatory manner with the rural folks. Whereas the natural resources of a region are the divine assets which significantly contribute to development of that region, the infrastructure is treated as an engine of growth and provides a basic framework for economic and social progress. The Physical infrastructure strengthens the economy, boosts investment, attracts prospective entrepreneurs and helps alleviation of poverty and reduces unemployment incidence. The social infrastructure like drinking water supply, sanitation, education, health etc. helps in improving quality of life of rural inhabitants. The Rural Development Department is responsible for implementing various national and state level schemes/programmes aimed at improving economic and social status of rural inhabitants by development of socio-economic infrastructure in rural India. The panchayats are fundamental and grass root level units in rural India. Despite sustained efforts, regional disparities are observed in implementation of rural development programmes. The advanced spatial information technologies provide effective and meaningful tools for examination/evaluation of the rural development made under Centre and state sponsored schemes. To harness benefits of Space Technology and Geo-informatics for mapping assets developed under various rural development schemes, a study was attempted for Comparative assessment of implementation of rural development programmes in Pujarali, Chamyanana and Malyanna panchayats of Himachal Pradesh. The panchayat resources information system was designed for the identification and mapping of the local resources spatially and understanding the problems and potentialities of each resource. It provides the basic details in GIS format and will serve as a base for planning as well as comparison of the development activities in rural areas.

Keywords: *Panchayat, spatial, GIS, remote sensing*

SITE SUITABILITY ANALYSIS FOR A NUCLEAR POWER PLANT USING GIS AND AHP TECHNIQUE - SRI LANKA

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ABSTRACT

Day by day, necessities of mankind are being increasing and people find new ways to make their lives more convenient. As a basic need, electricity plays a vital role in the society like other needs and it resulted an energy crisis in the present world. Therefore, it is essential to find viable alternatives for this energy crisis. Though, electricity has been generated according to the demand, still Sri Lanka is facing supply shortage which cannot be fulfilled with the prevailing power generation methods. Therefore, the concept of a 'New Power Plans' has been aroused to find solutions to the ever-increasing energy crisis. These power plans should be a good solution to minimize the emission of greenhouse gases and climate changes. One solution is to build a nuclear power plant in Sri Lanka. To build a nuclear power plant, any country has to fulfil some essential requirements. Some of these requirements are spatial in nature and others are social and economic requirements. For the spatial requirement analysis, GIS based environment is the most effective method. One of the spatial analysis, site selection plays a major and critical role. Thus, this study focuses on the applicability of GIS for selecting a suitable site for a nuclear power plant in Sri Lanka. This study was undertaken using two analysis techniques; AHP (Analytical Hierarchy process) and GIS. From the literature review, the study area was limited to the North part of Sri Lanka and secondary data and literature review were helpful for getting understanding about the social and economic requirements for proper site selection. The study reveals that the most suitable area for establishing a nuclear power plant is Kilinochchi district coastal area.

Keywords: *Spatial data analysis, nuclear power plant, Analytical Hierarchical Process, GIS*

APPLICATION OF WEB-BASED MODEL IN LAND POOLING: A CASE STUDY OF SYANGJA, GUTHIM

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ABSTRACT

Nepal is a developing country with more than 70% of people engaged in agriculture contributing approximately 31% to GDP. Agriculture is not so easy in Nepal due to uneven topography and sloppy land that causes problems in using modern farming techniques that has left Nepal a way far behind in agricultural development. Land pooling is a suitable way of developing agricultural land. Due to land pooling, the traditional means of agriculture can be replaced by modern tools and methods. The problems like irrigation, access to roads, less production, unscientific habit of cultivation, etc. can be easily overcome by this technique. This report gives an overview of how the land pooling techniques can be effectively applied in resolving the problems of Ganeshpur village, Syangja District and how the information can be displayed via a web-based model.

The primary & secondary data essential for the project were collected from the field survey & Survey Department respectively and that information were utilized to plan the plot doing various analyses following all the guidelines required for land fragmentation. The final result along with the parcel & parcel owner information will be displayed on a web-based platform. Web based models help in understanding and creating a common platform for visualizing, sharing data, information about the parcels. The dissemination of information is done through web mainly using Leaflet and Django. The location and attribute information of any plot can be obtained with one click in the system. There will be a login system to access the admin view on the web. The admin has an ability to add, update or delete the data of the system according to the need of time. The user can surf our land pooling web application without logging into the system. They have the privilege to view different shapefiles and raster files of parcel and plots in different base layers. This system also facilitates as a medium to connect farmer with the user by giving an ability to add a product of respective plot. Since land pooling is a major project of nation, it is the most necessary project for both government as well as private organizations for planning, updating and visualizing the plot of certain area.

Keywords: *Web-GIS, Leaflet, Django, Survey Department*

SPATIAL ANALYSIS ON THE URBAN CHANGES OF TANINTHARYI TOWN IN MYANMAR

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ABSTRACT

This paper observes the urban changes of Tanintharyi Town in Taninthayi Region, Myanmar. Tanintharyi is one of the ancient cities where urban development is gradually invading the old city. So, the urban changes drive on the tangible and non-tangible environments. The objectives are to study physical environment changes, to examine the socio-economic activities changes, and finally to analyze the risk conditions of cultural heritage sites of Tanintharyi ancient city. The main data is obtained from the downloading of the satellite imageries (2012 and 2020) for the comparison of urban development changes. Data from field survey and open interviews with residents and authorized persons are collected to approach the destination for spatial and temporal changes of the physical environmental changes, socio-economic activities changes, and the present condition of cultural heritage sites with the aid of the Remote Sensing and Geographic Information Systems (RS& GIS) technology. The results show the spatial urban changes of the physical and socio-economic changes and the gradual decrease of the cultural heritage environment for the period 2012 and 2020.

Keywords: *Tanintharyi town, cultural heritage, physical environment changes, socio-economic activities changes, spatial urban changes*

GIS-BASED ASSESSMENT OF COASTAL TOURISM VULNERABILITY TO CLIMATE CHANGE – CASE STUDY IN DANANG CITY, VIETNAM

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ABSTRACT

Da Nang City is a coastal City in the Central Vietnam which is considered as a sensitive area to climate change and its consequences. This City is also one of the famous tourist destinations in the Coastal Central of Vietnam. This study tends to figure out the impacts of climate change on the sustainable tourism development for Danang City under the vulnerable context. The main objective of the project is to determine the vulnerability of climate change on the tourism development of Da Nang City based on a comprehensive assessment of three factors: exposure to hazards, local sensitivity and adaptive capacity. The method of using satellite image data (remote sensing) and Geographic Information System (GIS) combining field survey data is main approach in this research. Integrating remote sensing and GIS methods to assess the impact of natural disasters (floods, droughts, salinization, etc.) is considered as an effective method with advantages of quick and accurate updating according to temporal and spatial changes of natural disasters. The climate change vulnerability index (CVI) integrated with the AHP hierarchical analysis method (Saaty, 2008) has been implemented in this study to determine the tourism vulnerability for the study area. As the results, Ngu Hanh Son and Son Tra district have been pointed out as the highest vulnerable areas to the city tourism. The study also proposes a number of adaptive solutions for areas under highly vulnerable level to climate change.

Keywords: *Climate change, tourism vulnerability, GIS database, Danang City, Analytical Hierarchy Process*

SPATIAL ANALYSIS ON THE PATTERNS AND REASONS OF MIGRATION IN A SATELLITE TOWN, YANGON REGION

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ABSTRACT

Migration in geography usually refers to the movement of humans from one place to another. There is no non-migrated region in the world. Every region has migration more or less. Why do people migrate? It has many reasons. Reasons are different and controlled by various variables. The aim of the paper is to study the socio-economic conditions of migrant people. Objective of the paper is to find out the reasons for migration in an urban area of satellite town near the capital city. To study the aim and objective of the research, field survey was conducted in 2019 in Thanlyin Town, located on the other side of Yangon City and divided by Bago River. Thanlyin Town has 17 wards. Ten wards are taken as the sample. Proximity analysis is used to discover the importance of location and the proximity relationship with migration. The output information is shown by map and graphical presentation. Point distance is calculated to look at the reasons. The correlation results of point distance are between +0.22 and +0.44. These results show that migration is not the distance reason alone. Partial data are between +0.4 and +0.6. These two factors prove that migration is based on social, economic and geographic features of the area.

Keywords: Migration, socio-economic conditions, satellite town, proximity, partial correlation

HOTEL LOCATIONS IN A TOURISM DESTINATION: A SPATIAL ANALYSIS APPROACH

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ABSTRACT

Previous studies have shown that there is a relationship between infrastructure development and the location of tourism sites in a destination. Among them is the construction of accommodation facilities, such as hotels, motels, and guest houses. This condition shows that business developers and the tourism community need to explore various information to develop strategies. The purpose of this study was to explore information about the characteristics of the hotel location and tourism sites. This study used a Geographical Information System (GIS) to compile the spatial and attribute data, to comprehensively visualize the phenomena studied. The spatial data used in this study are hotel location data and tourism sites, along with its attribute data. The area covered in this study is the Special Region of Yogyakarta, which is one of the main tourist destinations in Indonesia. Spatial data and its complementary attributes are collected from various sources, pre-processed, and managed for further analysis. Average Nearest-Neighbour (ANN) and Kernel Density Estimation (KDE) were conducted to analyze the proximity between locations. The spatial interaction between hotels and tourism sites is identified by using an overlay technique between the density map of the distribution of hotels and the density map of the distribution of tourism sites. According to the spatial analysis of the ANN and the KDE, there is a tendency to cluster. The overlay of two KDE maps also shows spatial interactions. There are specific patterns between the categories of accommodation facilities and the categories of tourism sites. The information gained from this study can be used to better understand the current spatial characteristics of accommodation facilities as input in determining business development strategies.

Keywords: *Hotel, Facility Location, Tourism Sites, Spatial Analysis.*

ANALYSIS OF TOURIST BEHAVIOR AND INTEREST BY GEOTAGGED PHOTOS

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ABSTRACT

Recently, to avoid excessive concentration at tourism spots, the dispersal of tourists has become important. The dispersal of tourists to an alternative tourism spot that has similar tourist attractions to popular tourism spots can be one of the ways to mitigate overcrowding. Understanding tourists' behavior and interest is helpful in solving this problem. Moreover, it is easy today for users to generate and share data that reflects their interests. This research aims to clarify tourists' behavior with respect to their interests and find a method suitable for data classification. To this end, a spatiotemporal distribution of geotagged photos collected from an online photo-sharing service was utilized. Specifically, photo owners were divided into tourists and residents, with the focus on the spatiotemporal information of photos, and only the former were used for analysis. Labels and their reliability scores were applied to photos using Google Cloud Vision application programming interface; the labels were summarized in a label-appearance table. In this research, two methods were applied to the table. One used the R package ClustOfVar and hierarchical clustering, and the other used a topic model based on Latent Dirichlet Allocation. Hotspots, which were found by P-DBSCAN (one of applications of DBSCAN: density-based spatial clustering of applications with noise) were classified according to photo classification. Hotspots and tourists were classified on the basis of two types of photo classification: ClustOfVar and the topic model. The results show the type of tourism spots, including the popularity of spots, historical spots, and natural spots. Moreover, three tourist types can be identified: tourists who take photos mainly at popular tourism spots, tourists who take photos mainly at less popular spots, and those who take photos of various types of spot.

Keywords: *geographic information system, tourism, geotagged photos, clustering, topic model*

SYSTEMATIC REVIEW ON DIGITAL TOOL APPROACHES FOR COMPREHENSIVE URBAN WASTE MONITORING

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ABSTRACT

Recently Scientists found that more than 1,000 rivers distribute 80% of plastic waste. They also found that most of that waste is carried by small rivers that flow through densely populated urban areas, bringing urban waste is one of the critical threats to urban area sustainability. The process of monitoring by using Digital tool approaches is the efficient way to handle these issues. The capability of fast, accurate, and comprehensive output can be embedded in this system. This article provides a systematic review to see a comprehensive review of digital tool approaches in monitoring urban waste in urban areas. An indication of the urban waste issue alongside the ramification of the analysis is discussed. The collection of articles, manuscript, thesis, and other publication types on remote sensing, Geographical Information system (GIS) and crowdsourcing usage are compiled. At the same time, the diverse applications worldwide using digital tools are described. The finding shows that the approaches of digital tools can be maximized, especially on remote sensing and GIS approaches. Finally concluded the proof of the capability of digital tools in ensuring future earth sustainability and resiliency.

Keywords: *Remote sensing, GIS, Plastic waste and urban waste*

MORAN'S I SPATIAL AUTOCORRELATION OF COVID-19 INFECTION RATES: IS THERE SUCH IN BUTUAN CITY?

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ABSTRACT

Understanding the spatial autocorrelation of COVID-19 can aid in scientific decision-making in suppressing this infectious disease. This study calculated the cumulative incidence rate of barangays in Butuan City affected by the outbreak of the COVID-19 pandemic from April 15, 2020 to February 28, 2021. This research used Global statistics, i.e., Global Moran's I and Getis-Ord General G, to investigate if spatial autocorrelation occurs in the study region. This study also examines clustering by distance using incremental spatial autocorrelation and multidistance spatial cluster analysis. The analysis of the hot spot/cold spot and Anselin Local Moran's I were then used to locate high- and low-risk areas of the COVID-19 pandemic. Barangays with a 90 – 95% confidence interval were identified as significant. Moreover, cluster and outlier analysis demonstrated that ten Barangays exhibit HH-cluster and appear to be high-risk clusters.

Keywords: *COVID-19, Global Spatial Autocorrelation, Incremental Spatial Autocorrelation, Multi-Distance Clustering, Local Spatial Autocorrelation*

GEO-SPATIAL BIG DATA ANALYSIS OF COVID-19 SPECTRUM ENVELOPE OF FIRST AND SECOND WAVE OF THE OUTBREAK IN THE SOUTHEAST ASIAN REGION

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ABSTRACT

The outbreak of Covid-19 emerged from Wuhan, China during December 2019 and spread geo-spatially in more than 200 countries causing more than 182.969 million people of the global population infected and 3.963 million deaths (as on 30 June 2021), which is still spreading in geo-spatiotemporal way with multiple peaks of Covid-19 spectrum. This has seriously threatened the human health and life of the people posing the challenges to control the severity due to multiple peaks of Covid-19 spectrum observed during the pandemic period. The spatial spreading of covid-19 spectrum due to large-scale migration from Hubei province of China caused the outbreak in the Southeast Asian region covering the latitude between 38°N to 6°S. The Southeast Asian countries observed first and second wave of covid-19 spectrum with different spectrum envelope, which caused severe population mortality depending upon the spectrum pattern of the outbreak. This spreading of the spectrum caused marked variations in population mortality between different countries depending upon Covid-19 spectrum envelope characteristics with its spectrum peak height and width, existing healthcare infrastructure and its supply chain management of healthcare delivery systems of the country, which stressed the need for Covid-19 spectrum analysis of the first and second wave, and population mortality to develop predictive spectrum models of the third wave to determine the severity and population mortality. In this paper, big-data predictive spectrum models of mortality have been developed based on the analysis of Covid-19 spectrum of the Southeast Asian region using spectrum envelope characteristics and population mortality data from 15 April 2020 to 30 June 2021, for predicting severity of third wave of Covid-19 outbreak, for countries that lie at the latitude beyond 38°N, which can be used by decision makers to design the lockdown measures and geo-spatial supply chain management of healthcare delivery system.

Keywords: Covid-19, Geo-Spatial Big Data Analysis, Population Mortality, Spectrum Envelope

MInDSEt: A GEOSPATIALLY ENABLED INTEGRATED DATA SHARING ENVIRONMENT FOR MINDANAO, PHILIPPINES

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ABSTRACT

MInDSEt, or the Mindanao Integrated Data Sharing Environment, is an online geospatial data and information sharing facility/geospatial data infrastructure established in Caraga State University, Philippines. MInDSEt was developed using Geoserver for data storage and OGC services, and Geonode for data cataloguing and visualization. It was originally developed as data sharing facility of the stakeholders of the Geo-SAFER Mindanao, an R&D program which focused on generating detailed flood hazard maps of flood-prone river basins and watersheds in Mindanao, Philippines through numerical simulations using LiDAR-derived elevation datasets. Initially, MInDSEt was aimed to cater the needs for LiDAR-derived datasets (DTM, DSM) and flood hazard information (e.g., maps and GIS files) for Mindanao, as well as a venue to data sharing of its stakeholders that includes Geo-SAFER Mindanao implementing educational institutions and Local Government Units. Recently, MInDSEt's functionality was expanded to allow registered organizations and users to store and share any kind of geospatial data and information. One of the features of MInDSEt is its capability to categorize stored datasets as restricted (i.e., a specific organization or member of that organization can only access the data/information), controlled (i.e., data/information can be accessed by an organization or user after approval of data request), or public (i.e., anyone, even unregistered users can access the data). MInDSEt is also capable of handling externally stored data/information, wherein only the links to the external data/information are stored instead of the data/information files. This capability is advantageous to accommodate a greater amount of data/information with minimal effect to the facility's data storage. Through MInDSEt, it is envisioned that geospatial datasets and information of Mindanao and for Mindanao will be come easily accessible by anyone.

Keywords: *MInDSEt, Geo-SAFER Mindanao, Data Sharing Infrastructure, Geonode, Geoserver*

USING MAXENT IN FINDING SUITABLE LOCATIONS FOR ESTABLISHING FALCATA TREE PLANTATIONS IN CARAGA REGION, MINDANAO, PHILIPPINES

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ABSTRACT

The Caraga Region in Mindanao, Philippines, is considered a significant contributor in log production, specifically due to Falcata (*Paraserianthes falcataria*) plantations. Over 80% of the country's Falcata log production came from Caraga Region in 2019. Among the challenges faced by the tree-growers is finding a suitable location for the establishment of new plantations. We used MaxEnt, a machine learning Species Distribution Modeling (SDM) based on Maximum Entropy principles, for this study's Falcata plantation suitability modeling and mapping. This approach used 2,125 Falcata location points distributed in the region, biophysical factors (i.e., Elevation, Slope, Aspect, and the like), and bioclimatic factors (i.e., Annual Mean Temperature, Isothermality, and Annual Precipitation, among others). The model was found to have acceptable model performance based on the average training and test Area Under the Curve (AUC) values of 0.76 and 0.73. A 1 km x 1 km Falcata suitability map was generated using the model. The map shows that 12% of the region has high suitability, while 23% and 30% have moderate and low suitabilities. On the other hand, 35% of the region was not suitable for Falcata plantation establishment.

Keywords: *Falcata, Suitability Mapping, MaxEnt, Maximum Entropy, Caraga Region, Mindanao, Philippines*

EXPLORING THE SPATIAL LINKAGES BETWEEN TOURIST ATTRACTION LOCATION WITH SURROUNDING FACILITIES IN BANDUNG CITY, INDONESIA

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ABSTRACT

Bandung is one of the holiday destination cities in Indonesia. The city of Bandung is located in the Bandung Basin area, surrounded by mountains. However, the location of the arrival gate for domestic and foreign tourists is still centered in the city of Bandung, both for airports, train stations, and travel agencies. This provides many opportunities to develop various tourist areas. Previous studies showed that there is a relationship between the location of tourism sites and supporting facilities. This study aims to explore the spatial linkages between tourist attraction locations with surrounding facilities in Bandung City, Indonesia. The spatial data were edited and visualized using the Geographic Information System (GIS). PostgreSQL managed the spatial database management systems as well as utilizing various query functions for spatial data in the PostGIS extension. This study also used Python programming language to automate the SQL query execution in connection to PostgreSQL using the Psycopg2 library. Co-location pattern mining is used to analyze spatial behavior between the tourism site and its supporting facility in Bandung City, namely leisure facilities, accommodation, food services facilities, shopping facilities, and transportation facilities. There are sets of facilities in a spatial neighborhood that have a co-location pattern, also known as co-location rules. The computational results show a strong co-location pattern between spatial data sets, which consist of accommodation, food services facilities, leisure facilities, and shopping facilities. Related to the object of this research, tourist attractions also have a co-location rule, as a set with accommodation, food services facilities, and leisure facilities. This co-existence of tourism features in the spatial neighborhood can be used as a consideration for government and business developers to develop and improve both tourism destinations and facilities to attract more tourists, as known that the tourism sector is a new economic source in Indonesia.

Keywords: *Tourism, Facility Location, Spatial Analysis, Geographical Information System*

THE SPATIAL AND SOCIAL PATTERNING OF HEALTH CARE FACILITIES IN GREATER JAKARTA, INDONESIA

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ABSTRACT

The distribution of health facility location has a direct impact on the community; inaccessible health care facility is more likely to increase the risk of morbidity and mortality for some cases, while also provoking public discontent. The local governments and health facility providers need to understand the spatial characteristics of the distribution of health facilities related to the social and demographic conditions of the community. This study aims to explore information about the spatial and social patterning of the health care facility located in Greater Jakarta, Indonesia. Spatial analysis using the Geographically Weighted Regression (GWR) method was conducted to detect the relationship between the distribution of health facility locations and the social and demographic characteristics of the community. Geographical Information System is used as the main approach to compile, edit, visualize, and process spatial and attribute data. Geographically Weighted Regression proved that the current distribution of health facility locations has a significant relationship with the population. Furthermore, the population data is generated into spatial weights for the spatial autocorrelation analysis, using the local indicator of spatial association (LISA) to identify the spatial clustering of healthcare facility locations. Spatial autocorrelation analysis calculates the Moran's I index which identifies areas that are significantly clustered or outliers. The outliers within the studied area show a high number of the population with a low number of health care facilities, or some areas with a relatively high number of health care facilities with a low population. This finding identified improvement needed to gain the equal distribution of health care facilities based on the population distribution to increase public access to health care and reduce inequities. This knowledge is important to develop effective location-based strategies to determine the health facility location, to improve the overall health care system, which will directly improve public health.

Keywords: *Facility location, Spatial analysis, Geographical Information System, Geographically Weighted Regression (GWR), Local Indicator of Spatial Association (LISA)*

DETERMINATION OF HIGH-RISK MUNICIPALITY OF COVID-19 CASE IN AGUSAN DEL SUR, MINDANAO, PHILIPPINES USING GIS APPROACH

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ABSTRACT

The greatest battle that Filipinos face today was the fight of Corona Virus Disease or the SARS-CoV2. COVID-19 pandemic is life-threatening in terms of our public health. Many lives were killed, and some are survived this pandemic brought that. The typical living of Filipinos was turned into a catastrophic form of living because the enemy was unseen. The economic and public health sector was put to balances to ensure the general welfare of the public. Government efforts in battling this disease were extremely advantageous because public safety is of paramount importance at all. We come out with this study to mitigate, respond, and prioritize those areas with its riskiest for the mass. This study aims to determine and visualize the high-risk municipalities of Agusan del Sur using the method of min-max normalization and the percentile ranking by quartiles. Percentile Ranking is used to determine the range of classified as low, moderate, high, and very high. In determining the overall risk in the Province of Agusan del Sur, we used the Analytical Hierarchy Process, a multi-criteria decision-making platform. We chose the experts of this field to respond in the AHP Form. Pairwise comparison is being used in this study to determine each risk factor indicator; all of their ratings will be used in processing weighted overlay analysis in Arc GIS which is one of the major activities of this study. The study can aid the local government plan, and direct mitigation plans to suppress and preclude the COVID-19 pandemic. The result shows that the Municipality of Prosperidad was the very high-risk Municipality of Agusan del Sur of COVID-19. On the other hand, Bayugan, San Francisco, Talacogon, and Trento were placed at high risk. In contrast, Esperanza, San Luis, Lapaz, Rosario, Bunawan, Santa Josefa and Sibagat, Veruela, Loreto were placed under the category of moderate and low respectively.

Keywords: COVID-19, Pairwise Comparison, Analytical Hierarchy Process, Percentile Ranking, Risk Assessment

**DETERMINATION OF THE POTENTIAL HEADS
FOR HYDROPOWER PLANTS USING GEO-SPATIAL
TECHNOLOGY: A CASE STUDY OF THE 8 MAJOR RIVER
BASINS OF MINDANAO, PHILIPPINES**

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ABSTRACT

Mindanao in the south is the second largest island in the Philippines and consumes 13% of the national electricity output. With few Renewable Energy (RE) resources developed in the region so far, hydropower with an abundant resource still provides 80% of its total electricity requirement. The Department of Energy (DoE) projects that hydropower is expected to be still a major source of RE thus adding areas of potential sources is still needed even in micro-scale uses. Efforts to make it economic, flexible and damaging to the environment is a major factor its construction is still favored in the region. In every hydropower development, one parameter that helps to determine available hydraulic power inherent in the system is the available elevation head. In this study, the focus will be on the measurement of available head of the 8 Major River Basin in Mindanao. The available head is defined as the vertical distance where the water should be allowed the maximum vertical displacement and the shortest path to travel. The maximum vertical displacement accounts for the high water head. Large water head accounts for higher power potential. Hydropower projects (HPP) can be classified in many ways: by size (large, medium, small and micro-scale); by purpose (single or multi-purpose); and by the way incoming river flows are regulated to generate energy. The intention of this study is to locate potential elevation head processed from SAR data further developed in Geographic Information System (GIS) environment. With the use of the GIS, it can be used to form a core of practical methodology that will result in more resilient in less time and can be used by decision-making bodies to assess the impacts of various scenarios. Further this can be used to review, cost and benefits of decisions to be made in assessing HPPs. It offers means of an initial assessment for accessing and interpreting information for the purpose of decision making.

Keywords: *Hydro potential, Mindanao, Renewable Energy, GIS, Geospatial Technology*

UTILIZING GIS TECHNIQUES FOR STUDYING SPATIAL DISTRIBUTION PATTERNS OF GREEN LOGISTICS ACTIVITIES UNDER PANDEMIC SITUATION: A CASE STUDY IN THAILAND

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ABSTRACT

This paper aims to use Geographical Information System (GIS) techniques for studying spatial distribution patterns of green logistics activities at tourist attractions to current COVID-19 situation in Muang Nakhonratchasima district, Thailand. Forty Nine purpose based questionnaires were collected online between 1 April – 31 July 2021. This data was spatially analyzed using high/Low clustering Getis-Ord General G in ArcGIS program. The overall score of 8 green logistics activities in 12 tourist attractions in Muang Nakhonratchasima district is 1.89, which is at a low level. However, almost all tourist places have a high level of green awareness with the exception of Phanomwan Castle (low level). The result reveals that the green logistics activities pattern was neither a clustered or dispersed pattern, which also refers to as a normative distribution pattern in such 12 tourist attractions of Muang Nakhonratchasima district. Both public and private organizations has realized to reverse logistics using a barcode, electric email, and information online for facing the current COVID-19 situation. Consequently, the obtained results will be suggested for TAT Nakhonratchasima and the office of Nakhonratchasima City Municipality further.

Keywords: *GIS Techniques, Spatial Distribution Patterns, Green Logistics Activities, Tourist Attractions, COVID-19 Situation*

GUIDELINES FOR CREATING WEB GIS APPLICATION FOR TREES' MAP ON ARCGIS SERVER AND OPEN SOURCE GIS SOLUTION: THE CASE OF NONGRAWEING AREA, THAILAND

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ABSTRACT

The aim of this study is to guide web-GIS development for presenting tree maps in forest area at Nongraweing sub-district where is important place for learning locally natural resources of Rajamangala University of Technology Isan. This study suggested two approaches: 1) developing GIS web on ArcGIS server and 2) developing GIS web on Geoserver. As a result, both approaches return the same number of features, attributes and metadata for the test datasets, and download time and file size of given datasets. However, the most significant differences occurred in the operation *GetCapabilities* and *Getfeatures*. In the first operation, file size is generated by Geoserver regarding the geometry type and the request described. The second operation is similar with minor variations but the Web Feature Service (WFS) files created by ArcGIS server are larger than those created by Geoserver. Moreover, those requests were done by a python script so we need to take a second look on the common consumer side with the Desktop GIS. For nongraweing area, this area is not so big so trees' data is not large too. We suggest that should use developing GIS web on ArcGIS server because it is easy for using and not complex for learning.

Keywords: *Web GIS application, Tree map, ArcGIS server, open source GIS solution, Web Map Service*

GIS MODELLING FOR CHECKING BOUNDARY OF LAND PARCEL IN THAILAND

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ABSTRACT

This study aims to help Department of Lands (DOL) for checking boundaries of land parcel in form of digitized GIS data from satellite and aerial imagery. The study area was focused on Kham Sakae Saeng district where establishes in Nakhon Ratchasima (NK) province of Thailand. For method, ArcGIS ModelBuilder application was used for modeling GIS tools. Firstly, we planned the workflow from the concerned DOL officers that was divided into three groups: editor tool, reshape tool and topology tool. Then, the used GIS tools in each group were represented in form of diagram on ArcGIS ModelBuilder including running and validating model. In three diagrams of ArcGIS ModelBuilder, using reshape tool and topology tool have the high accuracy that 92.02% and 81.07% respectively. Using editor tool has the lowest accuracy (60%). This study suggests increasing of accuracy that should have to expand the details of the sequent process of caused tool. For this approach, the ArcGIS ModelBuilder tool is advantageous for automating the process; this also allows easy updates on data and analyses of checking shape of land parcel boundary. This automated checking is a flexible, time-saving, and cost-effective tool for screening large areas.

Keywords: *ArcGIS ModelBuilder, GIS techniques, Land parcel, Geospatial data*

CLOUD COMPUTING, BIG DATA AND AI IN REMOTE SENSING

CENTROID-UNET: DETECTING CENTROIDS IN AERIAL IMAGES

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ABSTRACT

In many applications of aerial/satellite image analysis (remote sensing), the generation of exact shapes of objects is a cumbersome task. In most remote sensing applications such as counting objects requires only location estimation of objects. Hence, locating object centroids in aerial/satellite images is an easy solution for tasks where the object's exact shape is not necessary. Thus, this study focuses on assessing the feasibility of using deep neural networks for locating object centroids in satellite images. Name of our model is Centroid-UNet. The Centroid-Unet model is based on classic U-Net semantic segmentation architecture. We modified and adapted the U-Net semantic segmentation architecture into a centroid detection model preserving the simplicity of the original model. Furthermore, we have tested and evaluated our model with two case studies involving aerial/satellite images. Those two case studies are building centroid detection case study and coconut tree centroid detection case study. Our evaluation results have reached comparably good accuracy compared to other methods, and also offer simplicity. The code and models developed under this study are also available in the Centroid-UNet GitHub repository: <https://github.com/gicait/centroid-unet>.

Keywords: *Deep-Learning, Satellite-Imagery, Centroids, Building-Footprint, Tree-Canopy*

RESULTS OF APPLYING STANDARDIZED METHODS OF HYDROGRAPHIC DATA FOR STATIONS 74162 - SON TAY - VIET NAM

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ABSTRACT

Climate change has recently caused severe impacts. Particularly, flood has destroyed crops, houses, roads, ... resulting in highly vulnerable situations of the local people. Forecasting water level on Red River is an important task for flood warning. Currently, forecasting science along with the development of information technology, artificial intelligence and remote sensing has opened a new research direction. Water level data at river stations in Red river - Viet Nam are collected by automatic monitoring with frequency of collection depending on the time of year. These data need to be cleaned to eliminate outliers, missing values; standardized form of time series ... In our research, the authors will indicate the current status of water level data collected at the station 74162 - Son Tay. Our hybrid models are built and tested using big datasets from hydrological stations, namely, 74162 - Son Tay – Hanoi (both with collected data from 2011 to 2019). These are actual data, provided by the National Center for Hydrometeorological Forecasting. Based on the current status of this data set, experimental methods of Data processing to replace missing values with the method of interpolation and normalization of data in time series form shall be carried out with time spaced 3 hours apart. The experimental results show the effectiveness of the new approach in that the combined model deep learning of Artificial Intelligence. When there is complete data, ensuring the completeness and reliability will be the decisive factor to the accuracy of the prediction and forecast models.

Keywords: *Artificial Intelligence, Missing values, Outliers, Time series, Water level*

MOTION DETECTION AND TRACKING IN CONSTRUCTION SPACE USING TEMPORAL POINT CLOUDS

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ABSTRACT

Conventional ICT construction vehicles have been developed to improve productivity. However, the conventional ICT construction vehicles have several technical issues in cooperated operations with workers. Therefore, we focus on a methodology to keep the safety in cooperated operations with workers and construction vehicles at a construction site. Our proposed methodology is based on 3D sensing from a construction. In 3D sensing, temporal point clouds are acquired for moving object tracking. Moreover, we develop an exterior-typed 3D measurement unit with low-price RTK-GNSS and LiDAR to provide lower-price ICT construction vehicles. In this research, we experimented excavation works using a backhoe at a simulated construction space. Through the experiment, we confirmed that our methodology can detect and track the bucket and workers using temporal point clouds acquired from a backhoe in drilling works.

Keywords: *Point Cloud, Object Recognition, Object Tracking, Object Classification, Construction Vehicle*

SHIP DETECTION AND CLASSIFICATION FOR KOMPSAT OPTICAL IMAGES USING DEEP LEARNING

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ABSTRACT

Many studies have been conducted to apply deep learning-based technology to high-resolution satellite image analysis, and the key is how to efficiently apply models appropriate to our own problem. Our mission is to find and classify ships in KOMPSAT (Korea Multi-Purpose SATellite) optical images which include KOMPAT-2 (GSD 1 m), KOMPSAT-3 (GSD 70 cm), and KOMPSAT-3A (GSD 55 cm). The same model was used for the different satellite images with different GSDs by unifying the resolution in the preprocessing step. This also makes it possible to use public datasets from other optical satellites such as xView and DOTA for ship detection. Our deep-learning based analysis consists of three steps: detection, pose estimation, and type classification. Pose estimation means measuring the heading and the size of the ship. State-of-art object detection models usually don't produce oriented bounding boxes. This is why we separate pose estimation from the detection. We used AIS data manually registered to satellite images to create the ground truth of ship types. So the training data is prepared from different information sources by different methods for each model, and that's another reason to divide the analysis into three steps. In this study, we used the FasterRCNN + ResNeSt model for detection, and the ResNeSt model for both pose estimation and classification. It has performed well enough to achieve our initial goal, and the method seems to be efficient to adopt state-of-art models for further performance enhancement.

Keywords: *Machine Learning, Object Detection, Pose Estimation, AIS, And High-Resolution Satellite Image*

APPLIED ARTIFICIAL NEURAL NETWORK IN THE SPATIAL PREDICTION OF LANDSLIDE HAZARDS CASE STUDY IN THE RED RIVER BASIN, VIETNAM

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ABSTRACT

Landslide hazards frequently occur in the upper part of Red River Basin Vietnam causes of and many losses of lives. The main objective of this paper is to evaluate and classify of risk levels of landslides maps base on the important factors causing landslides. Several causative landslide factors such as rainfall, relief amplitude, slop, land cover, soil type, aspect, fault density, drainage density and lithology have been considered. The result presents an account the actual locations landslides that occurred over a period of 18 years in the study area in Lao Cai Province in Red River basin. Landslide susceptibility were estimated under different Geo-Environmental conditions. In this study, Bayesian Regularized Neural Network (BRNN) was applied, results of the model are evaluated, compared and matched to locations where new landslides occurred. The result of the study enabled the validation landslide susceptibility models and significance to the local geo-environmental conditions. The area under the curve (AUC) for the statistical index model was 0.91 for the BRNN model.

Keywords: *Regularized Neural Network, Red River basin, Lao Cai-Vietnam*

URBAN LAND COVER CLASSIFICATION WITH VERY HIGH RESOLUTION SATELLITE IMAGERY BY MACHINE LEARNING

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ABSTRACT

In this paper we used a machine learning method for urban land cover classification using WorldView-2 imagery with 8 multispectral bands at 2-m resolution and a 0.5-m panchromatic band. The WorldView-2 imagery was acquired on 26 Jan 2020 covering a region of interest (ROI) in Singapore. After radiometric correction and spectral-preserving pan-sharpening, the pan-sharpened multispectral reflectance was used for classification. Eight classes (Tree, Grass, Cloud, Water, Building, Bare soil, Shadow and Road/Paved) were defined. A thousand samples, each with 11 spectral features were extracted from the imagery. The features were 8 spectral bands from the pan-sharpened multispectral image plus 3 spectral indices. Eighty percent of the samples were used to train a Convolutional Neural Network (CNN) model with depth 5 and kernel size 5 x 5 pixels. The remaining 20% were used for validation and an accuracy of 92.1% was achieved. The trained CNN was applied to classify the whole ROI and the result was compared to a ground truth map. Two regions were selected for accuracy assessment. One was dominated with man-made objects (Buildings and Road/Paved), the other mainly contains natural objects (Tree, Grass, Water and Bare soil). The overall accuracy was 94%. This high accuracy strongly suggests that the machine learning method is a good approach for urban land cover classification using very high resolution satellite imagery.

Keywords: Land Cover Classification, Machine Learning, Convolutional Neural Network, Urban Remote Sensing, Very High Resolution

AGRICULTURAL LAND MONITORING ON AMAZON WEB SERVICE

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ABSTRACT

The paper demonstrates developing a remote sensing cloud processing platform from the Sentinel-2 dataset (S2) and SMAP supporting the ASEAN agriculture management system. Every month, S2 from the S3 bucket is download to a Varuna Land Monitoring (VLM) platform (on Amazon EC2). Then the pre-processing such as vegetation index (NDVI: Normalized Vegetation Index and NDMI: Normalized Different Moisture Index), cloud masking (using Scene Classification (SC) image), fill-gap (using the mathematical model) are executed for each grid tile over the 98 tiles of the Thailand region (for this initial stage of VLM to the entire ASEAN region further). Each acquisition image is collected and composited into a monthly dataset using the maximum value composite (MVC) method. MVC is a suitable method for plant growth monitoring that is the major purpose of the VLM platform. Then TM reference image is transformed into a geographic coordinate system. The pixels of each tile are rearranged to fill the gap of each twisted image frame due to the projection transformation process. This process is necessary for the data dissemination platform to cover a large area. The VLM dataset publishes in the OGC web services using GeoServer by ImageMosaic datastore type on the tile caching technology using the GWC S3 BlobStore plugin (expanding the storage throughout S3 bucket technology). Finally, the vegetation indices will publish to geospatial end-user (agricultural researcher community) through WMTS (Web Map Tile Service) protocol. The computing algorithm of the steps is explained and discussed in this paper's sections for the recommendations of the next improvement. Finally, the recommendation is explained in the conclusion of this paper.

Keywords: Amazon Web Service, Sentinel-2, Agricultural Land Monitoring Platform

BUILDING SEGMENTATION FROM VHR AERIAL IMAGERY USING DEEPLABV3+ ARCHITECTURE

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ABSTRACT

Up-to-date building footprint maps are of high demand for geographical applications such as sustainable urban planning and management, smart city applications, urban sprawl monitoring, population estimation and disaster management. Unplanned growth and settlement cause many problems such as deterioration of ecological balance, increase in damage from natural disasters, destruction of fertile lands, and drought. Analysis and monitoring of urban growth is an important issue for urban planning, environmental management, and sustainable development in areas of rapid urbanization. Recent advancements on remote sensing and artificial intelligence technologies provide great opportunities to obtain rapid, reliable and accurate building footprint maps. Very high-resolution satellite images and aerial images are rich data sources of spatial information for obtaining building footprints with automated approaches for cities with a variety of building types. Convolutional neural networks (CNN) have recently been used to successfully recover building footprints from satellite images. However, building segmentation from high resolution data is still a challenging task due to complex backgrounds and heterogeneous data structure. To overcome these problems, deep learning (DL) techniques became useful approaches. Different DL models have been proposed for building segmentation such as U-Net with VGG11 encoder pre-trained on ImageNet, Conditional Random Fields (CRF) with FCN, end-to-end self-cascaded network approach and generative adversarial networks (GAN). Additionally, there are existing open datasets for building segmentation issues such as Massachusetts building, ISPRS Vaihingen and Potsdam, Inria and WHU dataset. In this study, we aimed to investigate the performance of the DeepLabv3+ architecture for building segmentation. The hyper parameters of the architecture have been tested and selected empirically to obtain accurate results. The Wuhan University (WHU) Aerial Building Dataset with a spatial resolution of 0.075 to 0.3 m is used for training and testing. The dataset is split as 80%, 10% and 10% for train, validation and test, respectively. Input images are cropped to 512 x 512 pixels. The accuracy assessment results on the test dataset show that mean intersection over union (IoU) reached 98.23%. The obtained results show that DeepLabv3+ architecture is highly capable for building segmentation from very high resolution aerial imagery.

Keywords: Building Extraction; Deep Learning; High Resolution Aerial Images; Deeplabv3+; WHU Dataset

QUANTITATIVE ANALYSIS OF RELATIONSHIPS AMONG BUILDING DENSITY, HEIGHT, LAND SURFACE TEMPERATURE, AND POPULATION DENSITY IN TOKYO

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Abstract

With the accelerated development of urbanization and rapid population growth, the pattern of urban buildings is changing. As an important component of urban structure, buildings have complex relationships with the surface thermal environment and human habitation. In this study, we selected the area around Shinjuku, Tokyo as the study area. The datasets used in this study were airborne thermal infrared image, airborne LiDAR data, building footprint data, and population census data. The relationships among building density, the height of roughness elements (mean height), mean land surface temperature (LST), and population density were quantified at the grid scale using correlation analysis. The results showed that: (i) The correlation ($p < 0.001$) with mean LST was most strong for building density ($r = 0.6718$), followed by population density ($r = 0.6050$) and mean height ($r = -0.3814$). (ii) Building density was positively correlated with population density ($r = 0.4949$, $p < 0.001$). The research hopes to provide a reference for further seeking the coordinated and balanced development of environmentally sustainable and energy-efficient cities.

Keywords: *Urban Buildings; Thermal Environment; Airborne Thermal Infrared Image; Airborne Lidar; Correlation Analysis*

**INSTANTANEOUS ERYTHEMAL UV-B RETRIEVAL
WITH MODERATE RESOLUTION IMAGING
SPECTRORADIOMETER (MODIS)
BASED ON MACHINE LEARNING METHODS**

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ABSTRACT

Erythemal UV-B has a significant impact on human health and the global ecosystem. Therefore, its monitoring has attracted great attention among researchers in recent years. However, traditional satellite-derived UV-B retrieval products have a low spatial resolution, and algorithms to generate these products rely on experience modeling and parameters provided by other satellite products. This paper attempts to use machine learning methods to retrieve all-sky kilometer-level erythemal UV-B from moderate resolution imaging spectroradiometer (MODIS) data with its multispectral information. Specifically, we design a framework that combines fully connected neural network (FCNN) and random forest (RF) to capture the complex relationship between MODIS TOA and erythemal UV-B. In addition, we establish a dataset based on 7 Surface Radiation Budget Network (SURFRAD) stations between 2007 and 2016, including MODIS TOA reflectance, solar zenith angle (SZA), view zenith angle (VZA), MODIS surface reflectance, altitude, and ozone observations. We conduct extensive experiments on the SURFRAD data set, demonstrating that the FCNN+RF performs significantly better than state-of-the-art machine learning methods such as SVR, RF, and FCNN.

Keywords: *Random Forest; Support Vector Regression; Fully Connected Neural Network*

DISASTER MONITORING AND PREVENTION

IMPORTANCE OF SPACE TECHNOLOGY FOR MONITORING AND MANAGEMENT FOREST FIRES (CASE STUDY: SYRIAN COASTAL FORESTS)

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ABSTRACT

Fires is the most important disturbance agent in global vegetation worldwide, affecting between 3 to 4 million square kilometers, annually. Secondary effects of fire include sudden onset disasters such as landslides, mudslides, rock falls, and flashfloods. Creeping disasters triggered by fire include post-fire soil erosion, ecosystem degradation, and reduced carrying capacity for human populations and their livelihood.

Space borne remote sensing technologies has enabled to map and monitor vegetation resources in varying scale and time. These Technologies have improved the capability to identify fire activities at local, regional and global scales by using visible and infrared sensors on existing platforms for detecting temperature anomalies, active fires, and smoke plumes. Geosynchronous satellites such as GOES and polar orbiting sensors such as the NOAA, AVHRR have been used successfully to establish calendars of vegetation state (fire hazard) and fire activities. Other satellites with longer temporal sampling intervals, but with higher resolution, Such as Landsat 8, Ikonos, Quick bird, Geo-eye, sentinel and SPOT, Indian, Russian Chinese satellites and space borne radar sensors, deliver accurate maps of active fires, vegetation state and areas affected by fire.

Providing an effective response to wild land fires by our vision requires four stages of analysis and assessment:

- 1- Determining fire potential risk
- 2- Detecting fire starts
- 3- Monitoring active fires
- 4- Conducting post-fire degradation assessment

The technological advancement in space remote sensing has been widely experimented in last years to obtain the desired information.

In result: the Maryland dataset indicates that nearly 20% of Syria's forests have been lost since 2000. During the summer of 2020 and especially from July to October, Hundreds of wildfire incidents have been reported in Syria. By interpretation of space data at October 2020a grand total of

approximately 30,000 hectares of agricultural and forested land across NW Syria is estimated to have been burned during the wildfire incidents in the period September 1st to October 15th, 2020. Forest fires Assessment that took place in Syrian coastal area and Lebanon from late August (27) till 17 October 2020 using Sentinel satellite, has been indicated that the affected areas in Lebanon were around 1652 Hectares. The NBR and the Δ NBR indices were applied on sentinel images dated 23 August, 27 September, 7 and 17 October 2020. The severity of damage varied between Moderate to low, ModerateHigh and High.

In Conclusion: Space remote sensing technologies gives accurate results for monitoring, management and assessment forest fires impacts.

Keywords: *Disasters, satellites, soil erosion, assessment, Images*

DEVELOPMENT OF A METHOD FOR EXTRACTING DISASTER AREAS AROUND INFRASTRUCTURES USING MULTI-TEMPORAL SAR IMAGES

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ABSTRACT

In recent years, torrential rains caused by global warming have become more serious and frequent, causing extensive damage to various infrastructures. In order to reduce the damage, preventive maintenance is desirable. In contrast, surveying localized ground surface changes by hand is difficult. Therefore, effective and efficient implementation of national land monitoring is required. Nowadays, the use of Synthetic Aperture Radar (SAR) imagery is expected to provide a comprehensive view of the earth's surface, independent of weather conditions and time of day. Differential interferometric SAR (DInSAR) technique has been widely known as wide range of land subsidence measurement method. In particular, Persistent Scatterers Interferometry (PSI) can accurately measure wide range of land subsidence by using multi-temporal SAR images. Based on the accurately estimated ground displacement velocity, we can detect small ground displacement behavior before a disaster occurs, which may be useful for disaster management. In this paper, PSInSAR analysis was conducted around the Takeo Junction (JCT) in western Japan, where a large landslide occurred in the past due to a heavy rainfall disaster and the road surface was uplifted significantly. After that, we conducted a basic study on the development of a method for detecting signs of disaster based on ground displacement velocity. As a result, we can detect the behavior of the ground pushing up the road surface before a landslide occurs. This result suggests the possibility of using satellite SAR imagery to detect signs of a disaster.

Keywords: *Synthetic Aperture Radar (SAR), PSI, heavy rainfall disaster, detection of disaster areas*

GROUND DISPLACEMENT AFTER MW6.7 EARTHQUAKE IN LAKE KHÖVSGÖL OF MONGOLIA DETERMINED SENTINEL-1B SATELLITE DATA

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ABSTRACT

Conventional field-based monitoring or large-scale monitoring is a costly and time-consuming process that requires many days, people and equipment in different field weather conditions. According to the remote sensing-based satellite data, which is the main advanced technology of modern science, it is economical and stable without requiring brigade manpower and special equipment, regardless of time and space location, without visiting the area for research and analysis. There are two main methods of traditional measurement and radar remote sensing to study ground deformation and displacement such as subsidence, uplift, and horizontal and vertical displacement. This study's purpose is to monitor for ground deformation and displacement before after the earthquake using a kind of SAR satellite of remote sensing-based on Differential Interferometric Synthetic Aperture Radar technology recently happened earthquakes in Mongolia. In this research has selected as the study area for happened earthquake epicenter magnitude 6.7 north centered of Khövsgöl Lake 26 km distanced from western south of Turt soum local time when at the 05:30 am 12th of Jan, 2021. As a result of the study, when mapping the scatters of ground displacement impacted after earthquake epicenter depth of Khövsgöl lake around was defined surface subsidence -22 cm where on two-part section ground with between 7.2 km distance, located until about 15km from steep to the west the lakeside.

Keywords: *Sentinel 1B, Earthquake, Ground displacement, Deformation, Interferometric, SAR*

GIS-AIDED PERFORMANCE SIMULATION OF GIGAQUIT DAM: A COMPARATIVE ANALYSIS OF HYPOTHETICAL FLOODING

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ABSTRACT

This study aimed to simulate hypothetical flooding in Gigaquit, Surigao del Norte, to assess how the dam affects the intensity of flooding events through series of simulations under six extreme rainfall scenarios. In this study, the 2D HEC-RAS model integrated with geographic information system (GIS) application has been employed. The flood simulation was conducted using the unsteady flow module of the HEC-RAS model. On the other hand, GIS has been fundamentally used to produce a digital elevation model (DEM) for visualization and analysis of possible flood propagation and flood effects. After the simulation was made, post-processing facilitated the automated flood plain delineation based on the simulation output. The dam's performance showed promising results in lessening the flooding effect in the downstream reach, especially on rainfall events of 50%, 20%, 10%, and 4% annual probability. However, rainfall events with 2% and 1% probabilities did not seem to have contributed a significant difference. In the present day, this kind of advanced modeling technology is becoming a potent tool for the decision-making process.

Keywords: *HEC-RAS, GIS, hypothetical flooding, simulation, flood plain*

POLLUTION FORM IN NUCLEAR DISASTERS DEPENDING ON METEOROLOGICAL CONDITIONS

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ABSTRACT

Four nuclear disasters occurred in Hiroshima, Ural, Chernobyl, and Fukushima, and showed four different pollution forms. On August 6, 1945, an atomic bomb was fallen down over Hiroshima city. An fire ball fired this city with victims of 166,000 and black rain polluted the victims. From an aerial photo by B29, the shape of black rain was estimated and fitted with the victim testimony. In Russia, two serious disasters occurred in Ural on September 29, 1957 and Chernobyl on April 26, 1986. Radioisotopes distributed with 20 million Ci in Ural and 24 billion Ci in Chernobyl, Russia. These radioisotope distribution areas were compared in form. Both pollution patterns were quite different. The form of nuclear pollution depends on mainly the terrain and rainfall forms: low pressure and cold front. On the other hand, in Japan, atomic bombs were dropped at Hiroshima and Nagasaki on August 9, 1945, and nuclear power plant accident occurred in Fukushima on March 11, 2011. In these accidents, rains and snow fell down with big amount of radioisotopes. The terrain and meteorological conditions determined pollution forms each nuclear disaster mainly.

Keywords: *Atomic bomb, Chernobyl, Fukushima, Hiroshima, Nuclear power plant, Ural*

SPATIAL ANALYSIS OF THE DROUGHT BY USING SATELLITE REMOTE SENSING AND GIS- A CASE STUDY AT MONARAGALA DISTRICT SRI LANKA

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ABSTRACT

The scientific and geographical identification of weather extremes is an essential component in routine life. Further, the understanding of these weather extremes vital in future planning, policy implementation, and developments. Most of the hazards occurred in a small time and in high magnitude hence people keen on those hazards. But among all hazards, the drought is different due to its silent pattern of spreading from regional to global scale. The remote sensing data integration in Geographic Information Sciences (GIS) in drought assessment provides the best platform for scientific analysis by integrating satellite, meteorological, and other ancillary data in the GIS framework. The Monaragala District of Sri Lanka has been utilized in the investigation as the study area due to the reason that it has been highlighted as one of the prominent drought-affected areas of the country. Precipitation deficiency considered as the foremost factor that affects the drought although drainage, slope, soil, Land use and land cover, wind, temperature could be led to the spreading of the drought. Hence, Meteorological, agricultural, and hydrological related combined drought analysis represent the drought in a more detailed way. The Moderate Resolution Imaging Spectroradiometer (MODIS) satellite images, precipitation data, and the spatial data layers collected over the last 30 years were implemented as the base data sources on the investigation, and further Google earth images were utilized for the cross-validation. Ultimately, the combined drought risk map help to create a correct and meaningful picture of the present situation in a more detailed manner. Rendering to the study it shows that overall, there is a moderate drought condition in the study area while showing the high hydrological drought condition than the meteorological drought condition. Further, it highlighted the importance of having proper water management in the Monaragala area for the prevention of drought.

Keywords: *Agricultural drought GIS, Hydrological drought, Meteorological drought, Remote sensing*

INFLUENCE OF PROPORTION BETWEEN LANDSLIDE AND NONE LANDSLIDE SAMPLE TO LANDSLIDE SUSCEPTIBILITY MODELING

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ABSTRACT

The quality of the statistical-based and machine-based landslide susceptibility map highly depends on the quality of the dataset for model development. When investigating the training samples in the susceptibility analysis, the unbalance area ratio between landslide and non-landslide in any given study area could be an issue in the model training procedure. Therefore, determining a suitable ratio for sampling data of landslide and none landslide can be important to optimize the modeling procedure and improve the quality of the landslide susceptibility map. So, this study introduces a practical method to reduce the uncertainty of none landslide sampling and also experiments with various ratios between landslide and none-landslide samples. The synthesis of time-series land surface disturbance index (produced by Landsat products), the bivariate statistical Frequency ratio (FR) with a budget of landslide, and the experience is considered trustworthy data for reducing the uncertainty when extracting non-landslide samples. In addition, to investigate the suitable ratio of the sample subset, the range from 1:1 to 1:10 of respective landslides and none-landslide are examined. The hybrid of Frequency ratio (FR) and artificial neural network (ANN) is applied in this study to conduct the landslide susceptibility analysis in the Thu Lum watershed in Lai Chau province, Viet Nam. Comparatively, for accuracy assessment, increasing the number of absence samples leads to the problem of specificity value (true negative rate) increase, but sensitivity (true positive rate) value change downward. Overall, the Area under ROC (receiver operating characteristic) curve decreases while we increase the portion of the non-landslide sample of the training dataset. Eventually, this research shows that the unbalance sample ratio does not produce a satisfying model. For example, the unbalance ratio can be obtained when directly using the actual landslide and non-landslide area ratio. On the other hand, a balanced ratio is recommended in this study for statistical-based and machine-based landslide susceptibility analysis because it generally produces a landslide susceptibility map with better model performance.

Keywords: *landslide susceptibility, land surface disturbance index, artificial neural network, influence, sample ratio*

AGRICULTURAL DROUGHT DETECTION USING THE NORMALIZED DIFFERENCE VEGETATION INDEX AND LAND SURFACE TEMPERATURE DATA

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ABSTRACT

Global warming and climate change lead to extreme agricultural drought events which exceedingly affect agricultural production in many countries. The agricultural drought in Tien Giang Province, Viet Nam, which can be induced by inconsistent rainfall, a decrease in the freshwater resource, causes the decline in the yield of crops and affects the local economy. Hence, the detection and assessment of agricultural drought are urgent to mitigate its negative effect. Tien Giang Province, the study area, which falls in the lower section of the Mekong River Delta of Viet Nam, has a relatively gentle topography surface at low altitude and is consequently considered a drought-prone and salinity intrusion region. The objective of the study is to analyze the vegetation stress to detect agricultural drought in the province with the calculation of Normalized Difference Vegetation Index (NDVI), Vegetation Condition Index (VCI), and Land Surface Temperature (LST). This study used the Landsat 8 OLI/TIRS satellite data, CGLS-LC100 land cover map, ground-based air temperature record in 2015. To map the land cover types, the random forest supervised machine learning classifier was applied in this study. The result shows that the estimated LST was higher than the ground-based air temperature, around 4.4⁰C, with the max difference at 8.4⁰C. The random forest classifier categorizes the land cover into five classes (e.g., aquaculture, build-up, annual vegetation, perennial vegetation, and water) with an overall accuracy of 97.4%. The correlation between LST and NDVI, VCI can be clearly remarked as negative relationships with a correlation coefficient between LST and NDVI by - 0.439 ($p < 0.01$), LST and VCI by - 0.483 ($p < 0.01$) for the vegetation region of the study area.

Keywords: *agricultural drought, land surface temperature, normalized difference vegetation index, vegetation condition index*

DINSAR ANALYSIS FOR TOPOGRAPHIC MODEL INTERPRETATION OF FAULT

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ABSTRACT

During long-term erosion after a strong earthquake, cracks in the soil gradually disappear, making it difficult to identify. The rapid development of modern high technology has opened up new and unexpected possibilities for the discovery and detailed study of such hidden structures. Recently, the development and progress in remote sensing allowed for the exploitation of a variety of data sources and techniques in the characterization of lineaments. Data fusion with a radar or the use of synthetic-aperture radar (SAR) images improved the number of lineaments extracted in several studies. Shaded relief models are also widely used and considered as a powerful tool for lineament enhancement in topographic data.

The aim of the present research was the interpretation of tectonic lineaments and faults over Ulaanbaatar city using the differential synthetic aperture radar interferometry (DInSAR) analysis. Ulaanbaatar is the capital city of Mongolia; approximately 50% of the national population lives in the city (1.6 million residents), and this number is rising. The validation of the extracted lineaments is based on the several archive data of research Institute of Astronomy and Geophysics and published research papers last two decades.

In this study, attention was put to exclude the man-made linear features that do not correspond to geological structures in the study area such as roads and non-geo-structural lines in the remotely sensed data.

Keywords:

ASSESSING THE AFFECTED AREA OF TYPHOON-INDUCED LANDSLIDES AND DEBRIS FLOWS

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ABSTRACT

Typhoon events are often accompanied by short-duration intense rainfall. If the slopes are steep and rich in loose soil, rocks, or colluvium, it is prone to induce significant debris flows and landslides, causing heavy casualties and economic losses. The occurrence of debris flows and landslides is influenced by geology, topography, and the hydrological environment. To assess the affected area of the combined process, the landslide and debris flow requires an integrated modeling framework. This study proposed an integrated slope stability model which combines infinite slope stability analysis and debris flow simulation to predict the initiation of typhoon-induced shallow landslides and runout paths. The landslide event induced by Typhoon Saola in Heping Village, Xiulin Township, Hualien County on August 2, 2012, is selected as the study case. By investigating geological, hydrological parameters, and topographic characteristics, the model is expected to predict the affected area of landslides and debris flows in the study areas. Satellite imagery was used to effectively estimate regional parameters for the model application, including vegetation index and topographic variables. Preliminary modeling outcomes, including the landslide location and its runouts, will be validated by comparing with the high-resolution optical image and in-situ investigation data. The research results can be used as a reference for the assessment of the affected area of landslides and debris flows in the future.

Keywords: *Shallow Landslide, Debris Flow, Integrated Slope Stability Model, Vegetation Index, Typhoon Saola*

CLIMATE CHANGE, LAND USE COVER CHANGE AND ITS IMPACT ON COASTAL AREA

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ABSTRACT

Climate change, in conjunction with land conversion, has a major effect on the world's coastline region. Low-lying coastal communities and villages have already suffered devastation from catastrophic floods and must now contend with increasing seas. The world's 11 fastest sinking cities have been identified (CNN, 2018). The source of flooding, impact, mitigation, and adaption strategies within the coastal area are vary across those rural areas. As a result, it is important to examine the influence of the two primary causes of coastal flooding, there is land use change and climate change. The purpose of this article is to assess land use cover change (LUCC), climate change's influence, and the sinking coast's impact due to those phenomenon. The method includes combining multiple-date remote sensing data analysis and spatial analysis, either through change detection of land and water and the accuracy assessment analysis. The findings, deductively, show a link between LUCC, climate change, coastal flooding, and indicate the role of water change detection (WCD), LUCC detection (LUCCD) and Built-up area change detection (BCD) for rapidly mapping the coastal flooding for mitigate any devastation.

Keywords: *Flooding, Climate Change, LUCC*

APPLICATION OF CNN ON LANDSLIDE SUSCEPTIBILITY ANALYSIS: CASE STUDY ON 2018 HOKKAIDO EASTERN IBURI EARTHQUAKE

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ABSTRACT

Japan Meteorological Agency (JMA) recorded a 6.6 moment magnitude earthquake at the coast of Tomakomai City in the eastern Iburi subprefecture on September 9, 2018. Tremors were felt strongly in the neighboring Aomori Prefecture in Tohoku region, with minor shocks experienced as far as Kanto region. The earthquake caused subsequent landslides to occur in the neighboring town of Atsuma where the volcanic soil already saturated by Typhoon Jebi triggered slope failures leaving dozens of homes and leaving several residents dead. Subsequent studies by Zhang, et al. (2019) further concluded that slope failures occurred in stratified pyroclastic fall deposits overlaying Miocene sedimentary bedrock, with sliding liquefaction being confirmed on field investigations. In the subsequent aftermath, an estimated 367.5 billion yen in damages was reported in Hokkaido with 2.95 million households left without electricity due to damages sustained by the Hokuden coal power plant in Atsuma. To mitigate the impacts of future landslides, it is necessary to conduct landslide susceptibility mapping. Landslide susceptibility mapping has been generated for a long time with standard methods such as fuzzy logic, analytical hierarchy process (AHP), and logistic regression. Recently, conventional machine learning algorithms have been considered as an advanced technique for landslide susceptibility mapping. In addition, it is possible to use artificial neural networks and deep learning models in place of conventional machine learning algorithms to provide significant results. This study proposes a deep 1-dimensional convolutional neural network (CNN-1D) model to predict landslides and evaluate its performance on landslide susceptibility mapping.

A total of 4350 landslide points were acquired by identifying landslide scars from a 10m resolution Sentinel-2A satellite image of Hokkaido dated October 20, 2018. For binary classification tasks, an equal number of non-landslide points were randomly generated on locations deemed to be at low risk to landslides based on their topography.

Landslide parameters were selected based on their influence in inducing downslope soil movement. A recent satellite image from Sentinel-2A dated May 7, 2021 was used for extracting the NDVI of the study area. The weather data encompasses a 20-year annual precipitation of Hokkaido prefecture based on readings from 22 stations acquired from Japan Meteorological Agency (JMA) and interpolated using Inverse Distance Weighting. A geologic map of the study area was acquired from Geological Survey of Japan and is digitized to create a generalized map of geologic units in the study area. Unique geologic units are converted into dummy variables. Slope, aspect, curvature, elevation, flow accumulation, TWI, and stream distance were extracted from a 10m digital elevation model acquired from Geospatial Information Authority of Japan. Fault line map was acquired from GEM Global Active Fault Database. Sixteen landslide parameters were used in the study including six geologic units converted into dummy variables. Extracted landslide and non-landslide points were split into 70% training data and 30% validation (test) data and preprocessed using scikit-learn's MinMaxScaler for faster convergence.

The CNN architecture used in this study comprises a single 1D convolutional layer with 30 filters and a kernel size of 3 with a ReLU (rectified linear unit) activation function. The output of the filter is fed to a max-pooling layer with a pooling size of 2 and flattened prior to input into a standard multilayer perceptron (MLP) classifier. The first hidden layer of the MLP is composed of 512 neurons with a dropout of 0.5. The second layer consists of 256 neurons. The third and fourth layers each consist of 128 neurons with the latter having a dropout of 0.25. The fifth hidden layer is composed of 64 neurons connected to the output layer with two nodes. All hidden layers have the ReLU activation function except for the output layer which uses the sigmoid function for binary classification tasks. The architecture is optimized using the stochastic gradient descent method Adam with a learning rate of 0.0003 with 100 epochs.

Evaluation metrics showed that the second CNN-1D model accurately classified 97% of landslide points with a recall (sensitivity) of 94% and F1-score of 96%. In classifying non-landslide classes, the model showed a precision of 94%, while the recall value (specificity) for this class is higher at 97%, with an F1-score of 96%. The model also showed a 96% overall accuracy. Further tests showed that with early-stopping callbacks, the model converged after 22 epochs but performed poorer in identifying landslide classes with a precision of 89% and accuracy of 91%. For benchmark purposes, the model was compared with the standard logistic regression which showed a higher recall of 98% with 94% precision and 96% accuracy however, no further tests were conducted to measure the validity of the standard model.

A total area of 4070.81 sq. km. were successfully mapped and classified. Most of the area has very high susceptibility to landslides at 44.23% or 1800.55 sq. km. while 39.33% or 1601.15 sq. km. have very low susceptibility. Much of the eastern portion where most landslide points have been identified have very high susceptibility. On the western part where the Shikotsu Lake caldera is located, the surrounding areas are also deemed highly susceptible to landslides. Disaster mitigation programs and geotechnical engineering measures must be undertaken in landslide susceptible areas in order to lessen the potential socio-economic impact of future landslides.

The high scores of the proposed CNN-1D model shows the superior predictive capability of applying deep learning neural networks on landslide susceptibility analysis with a score of 96% accuracy. The study also highlights how using geospatial data which directly corresponds to their real-world locations can lead to a model with high predictive accuracy.

Keywords: *Landslide, deep learning, convolutional neural network*

**APPLYING GOOGLE EARTH ENGINE TO ASSESS
THE IMPACT OF URBAN FLOODING
IN NINH KIEU DISTRICT IN THE PERIOD
FROM 2018 TO 2021**

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ABSTRACT

Ninh Kieu District is an important socio-economic center of Can Tho City. According to statistics in 2019, this region has an average population of 280,792 people, with an area of 29.23 km². Ninh Kieu district is a region with relatively low terrain, so urban flooding often occurs due to the impact of rainstorms, high tides and floods upstream of the Mekong River. This paper presents the results of using Google Earth Engine to interpret Sentinel-1 satellite images to identify flooded areas in Ninh Kieu District from 2018 to 2021. Sentinel-1 satellite image is selected in this research because of its ability to receive cloud-penetrating data by using radar waves, which Ninh Kieu District during the research periods had high cloud coverage. The 2019 population data of Ninh Kieu District is used to determine the number of exposed people in the study area. Research results have shown the location and flooded area and the number of exposed people, create the basis for building appropriate solutions for managers in this region.

Keywords: *Urban flooding, Sentinel-1 satellite image, 2019 population data, Google Earth Engine, QGIS software*

COMBINED SATELLITE OBSERVATION AND MODELING THE WAVES IN TROPICAL CYCLONES

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ABSTRACT

A joint analysis of CFOSAT SWIM/SCAT and Sentinel-1 SAR data together with results of recently developed parametric model for rapid estimation of waves in tropical cyclones (TC) is presented. The satellite measurements were obtained over the Philippine Sea on October 29th, 2020, in TC Goni. The model for wave evolution inside TC is based on energy and momentum conservation laws. The coupled equations are written in their characteristic form to provide practical means to rapidly assess how the energy, frequency and direction of dominant surface waves are developing under varying wind forcing conditions and how the waves leave the storm area as swell systems. Being tested on a number of cyclones with different parameters (maximum wind speed u_m , TC radius R_m and heading velocity V), the model results have been reduced to analytical self-similar solution (TC-wave geophysical model function (GMF)) for the immediate first-guess estimate of significant wave height, wavelength and wave direction fields generated by an arbitrary cyclone characterized by a set of u_m , R_m and V .

Results of wave modeling with the wind field input either from Sentinel-1 SAR or CFOSAT SCAT data are compared to CFOSAT SWIM measurements, including altimeter ones. The wave fields inside moving cyclones usually exhibit a strong azimuthal asymmetry, resulting from a resonance between wave group velocity and TC heading velocity. For TC Goni, this effect is well captured, leading to extreme waves with heights up to 8 m, further outrunning as swell with wavelength about 250 m in the TC heading direction. A quantitative agreement between the satellite measurements and model results (both the direct model and its simplified solutions) is observed. In the far zone ($\sim 10 R_m$) local wind is found to be the leading factor of wave formation.

The case study demonstrates that combined radar, altimeter, scatterometer data, numerical modeling and analytical self-similar solutions open new perspectives to study the waves generated by TCs for different scientific and practical purposes including hazard prediction.

Keywords: *Tropical cyclone, wave modeling, CFOSAT SWIM, SAR, hazard prediction*

REMOTE SENSING OF THE IMPACT OF FLASH DROUGHT ON VEGETATION DYNAMICS OVER EAST ASIA

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ABSTRACT

In contrast with conventional drought, which is mainly driven by lack of precipitation, flash drought in the hydro-climate community usually includes abnormally high temperatures, winds, and/or incoming radiation that leads to abnormally high evapotranspiration rates. A flash drought is characterized by its rapid onset and arouses widespread concerns due to its devastating impacts on vegetation health, food security, and ecosystem and environmental sustainability without sufficient early warnings. Flash droughts occur more often than perceived and can cause major agricultural losses if they are not predicted and detected in a timely manner. To date, flash droughts have typically been identified by examining large and rapid changes in one or more metrics that reflect changes in sub-surface soil moisture. This study investigated the remote sensing-based vegetation dynamics based on the joint distribution of positive temperature anomaly (e.g., heatwave) and soil moisture deficits during several extreme events of flash drought with different climates and vegetation conditions over East Asia. In this study, flash drought detection was presented based on the satellitederived drought index Evaporative Stress Index (ESI). ESI is used as an early warning indicator for rapidly-occurring flash drought based on high-resolution vegetation property datasets retrieved from the Moderate

Resolution Imaging Spectroradiometer (MODIS). Here we identify flash drought events by considering the declining rate of soil moisture and the drought persistency, and the linkage between vegetation dynamics and characteristics of vegetation, for example, gross primary productivity (GPP), soil moisture and evapotranspiration associated with flash drought.

Keywords: *Flash drought, vegetation dynamics, soil moisture, evapotranspiration, gross primary productivity*

EVALUATING THE EFFECTS OF SALINITY INTRUSION ON THE AGRICULTURAL LAND USE IN THANH PHU DISTRICT, BEN TRE PROVINCE, VIETNAM

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1. Introduction

Thanh Phu is a coastal district of Ben Tre province, located in the East of the Vietnamese Mekong Delta, between Ham Luong and Co Chien rivers and covering 25 km of coastline along the East Sea. Thanh Phu has great advantages for socio-economic development. However, the impact of climate change in recent years, especially saline intrusion has greatly affected the agricultural production in this district. According to a report of Ben Tre province in 2016, the salinity concentration reached the peak at 4‰ at the intrusion length of 45-65 km from the river. The saline concentration was about 1‰ at the intrusion length over 70 km. The measured salinity at Ham Luong river in Phu Khanh commune, Thanh Phu district was 6.9‰ at the intrusion length of 25 km from the river mouth. In early March 2019, the saline intrusion caused damage of 13,844 ha of rice areas in the Winter-Spring season (over 90%), the total damaged area was about 503 ha. The total number of households affected due to lack of freshwater for daily life was 88,208 households with over 353,000 people over three coastal districts including Thanh Phu. As one of the coastal districts of Ben Tre province, Thanh Phu has been facing the serious impacts of saline intrusion. Therefore, the research aims to analyze the effect of salinity intrusion on the agricultural land use at the household level in Thanh Phu district, Ben Tre province, Vietnam.

2. Methods

The inventory land use map in Thanh Phu district in 2014 and 2019 was used to extract the details of agricultural land use change in each year. An overlap method was then used to assess the change of land use in the period 2014-2019. In combination with a household interviewing (90 households) and experts interviewing method (05 peoples) was conducted to analyze the current impact of salinity intrusion to the agricultural cultivation models in three different zones includes freshwater, saltwater and brackish water. The only households that had changed the agricultural model due to the effects of salinity intrusion were selected for interview.

3. Results and discussion

The results indicated that there were three main farming models in Thanh Phu district including double rice crop, rice-shrimp farming, and shrimp farming (Giant tiger prawn). In which the area of the rice crop in freshwater zone was decreased in the period 2014-2019 (from 10,653.40 ha to 6,330.53 ha), meanwhile the perennial trees and aquaculture land were strongly increased, especially the perennial crops area increased from 6,509.00 ha to 9,683.30 ha, the area of aquaculture increased from 9,840.00 ha to 11,720.66 ha. Simultaneously, the household interview results also highlighted that the salinity intrusion mainly affects the rice crop cultivation in the year 2019, and 2020 in freshwater zone (more than 70% of surveyed households are affected, in which 16.7% of households suffered of over 70% of their income); and more than 70% households affected in brackish water region. Shrimp farming was less affected by salinity intrusion in both saltwater and brackish water. As a result of salinity intrusion, the area and production of rice decreased gradually, while other crops and aquaculture increased very positively compared with the restructuring plan.

4. Conclusion

The context of climate change significantly affects the development of the agricultural economy, especially in Thanh Phu coastal areas vulnerable to saline intrusion. This research found out that salinity intrusion strongly affects agricultural land use, mostly on the rice crop cultivation. Research outcomes provide valuable information to aid the management of agricultural activities and land use orientation under impact of salinity intrusion in this district.

Keywords: *Agricultural cultivation, salinity intrusion, Thanh Phu district*

**FLOOD RISK MAPPING
USING GIS-BASED MULTI-CRITERIA ANALYSIS:
SONGINOKHAIRKHAN DISTRICT CASE STUDY**

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ABSTRACT

Accurate flood risk assessment and mapping is one of the principal components of flood monitoring and prevention in urban areas. The aim of this study is to develop accurate flood risk maps in Songinokhairkhan district, Ulaanbaatar. In this study, the potential flood risk areas in the Songinokhairkhan district were identified using Geographical Information Systems (GIS)-based multi-criteria analysis along with the utilization of Analytical Hierarchy Process method to define the optimal weights for the criteria that contribute to flood risk. In addition, the flood models were developed using Hydrologic Engineering Center's River Analysis System (HEC-RAS) software in the catchment areas that identified as flood risk areas by GIS-based multi-criteria analysis. Using these models, we estimated the total area to be flooded, total residential area to be flooded, and total unit-areas to be flooded in event of flood. As a result, 0.55% or 6.70 km² area of Songinokhairkhan district is determined to be at very high flood risk, 8.32% or 99.78 km² is determined to be at high flood risk. Plus, three catchment areas are considered to have the high flood risk.

Keywords: *Flood risk mapping, GIS-based multi-criteria analysis, AHP, Flood modeling*

EXTRACTION AND QUANTIFICATION OF BURN MARKS OF WAR-DAMAGED TREES USING THE REFLECTANCE FROM TERRESTRIAL LASER SCANNER

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ABSTRACT

In World War II, Japan was hit by repeated air raids by the US military on major cities across the country. 76 years have passed since the war, however there are still some War-damaged trees that have left the scars of the war. War-damaged trees have increased historical value and significance as they have a role in conveying the memories of the war. On the other hand, it has been promoted to preserve historically valuable heritage as 3D data in recent years. Terrestrial laser scanner (TLS) that can record almost complete shapes of features and can acquire highly accurate point cloud data without contact was applied in this paper. The purpose was to visualize the condition of war-damaged trees using the reflectance from the TLS point cloud data. Three types of damage have been confirmed on the War-damaged trees; burn marks, inclination, and hollow. Some of the previous studies using TLS on Atomic-bombed trees are cases focusing on inclination, and there are no studies focusing on burn marks and hollow. Therefore, focusing on burn marks, the purpose was to visualize the damage by using reflectance of TLS. As a result, the usefulness of reflectance was shown for the burn marks of the war-damaged tree. The extracted burn marks were confirmed up to the top of the tree. In addition, from the extracted burn, it was also possible to quantify by calculating the burn marks rate.

Keywords: *War-damaged trees, Terrestrial Laser Scanner, Point cloud data, Reflectance, Burn marks*

GLOCAL MONITORING FOR DISASTER INFORMATION SHARING

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ABSTRACT

In 2016, the authors have initiated a project call “Constructing glocal monitoring system for safe and secure society” at Tokai University, Japan. “Glocal” is the coined word of “global” and “local”. The main concept of the project is to connect the global monitoring system using satellite remote sensing with the local monitoring system using SNS such as twitters for monitoring and exchanging information on disasters and environmental changes. Tokai University owns two ground stations, one in Shonan Campus in Kanagawa Prefecture and the other in Kyushu Campus in Kumamoto Prefecture, which are receiving MODIS data from Terra & Aqua satellites, VIRRS data from NPP satellite, and AVJHRR data from NOAA satellites. Sentinel-1 SAR data provided from ESA via Internet are also used in this study. In case of disasters, the data are analyzed and archived in near real time. On the other hand, the authors have been operating Disaster Information Tweeting System (DITS) and Disaster Information Mapping System (DIMS) for disaster information collection and sharing. The authors have constructed the Glocal Monitoring System by connecting the satellite data system with DITS & DIMS. The latest status and practical examples of applying the Glocal Monitoring System for flooding etc. are presented in this paper.

Keywords: SNS, flooding, SAR, Tweets

A STUDY ON EVALUATING RECOVERY FROM FOREST FIRE IN MONGOLIA USING NDVI AND NBR DERIVED FROM LANDSAT OLI DATA

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ABSTRACT

Mongolia is a country with a harsh natural climate, and as a result, the number of forest and steppe fires has been increasing in recent years. Therefore, forest and steppe fires are a serious problem in Mongolia. For example, statistics show that the number of fires is the highest in the last 10 years, especially in 2015. The purpose of this study is to investigate the possibility of evaluating the forest fire damages and recovery in Mongolia using data acquired by the optical sensor OLI onboard Landsat-8 satellite. The authors have utilized two indices, Normalized Burn Ratio (NBR), and Normalized Difference Vegetation Index (NDVI) derived from the OLI data for the analysis. NBR was used for detecting burnt areas. The color composite of NDVI of the year 2015 and 2018 was quite useful for evaluating the forest recovery. The analysis results suggested that a small difference of NDVI observed just after the forest fire could make a big difference in vegetation recovery.

Keywords: *Landsat-8, steppe, burnt area*

GIS-BASED VULNERABILITY ASSESSMENT OF HOUSEHOLDS TO EXTREME RAINFALL-INDUCED FLOOD HAZARD IN BARANGAY 2, CABADBARAN CITY

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ABSTRACT

Floods are a natural phenomenon on earth and becoming a widespread problem as the global temperature rises. During the tropical storms Sendong, Seniang, and Agaton hit the Philippines, Cabadbaran City was one of the affected areas by floods, and the vulnerability of each household was not yet determined. Thus, in assessing the vulnerability of each household, the socio-economic aspects in different flooding scenarios were used. Analytical Hierarchy Process was used as the medium for the prioritization of weights. Three domains were considered in this study, such as sensitivity, adaptive capacity, and exposure. The equation and ratings gathered from NEDA were used, and the vulnerability of each household was then calculated using GIS. The six (6) classifications used in this study of flood vulnerability of each household were 0, 0.20, 0.40, 0.60, 0.80, and 1.0, where 0 was considered as not vulnerable, 0.20 as very low, 0.40 as low, 0.60 as moderate, 0.80 as high and 1.0 as very high. The outputs of this study were the different levels of vulnerability of each household in different flooding scenarios through a series of maps.

Keywords: *Floods, Vulnerability Assessment, GIS, AHP*

WILDFIRE HOTSPOT CLUSTERING AND FALSE ALARM DATA DETECTION DERIVED FROM SUOMI NPP SATELLITE OVER THAILAND REGION

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ABSTRACT

Wildfire has recently become one of the most significant disaster in Thailand, especially in the northern part during the dry season; as it can be deadly, destroying homes, wildlife habitat and timber, and polluting the air with harmful emission on human health. The increasing number of burned area also worsen by climate change. This compounding effects leads to serious impact on ecosystem. Hence, space-based instruments have become the most essential means to monitor the hotspots due to their daily temporal revisit for nation-wide coverage data provision. Visible Infrared Imaging Radiometer Suite (VIIRS) instrument which onboard the Suomi NPP satellite is one of the most well-known instruments that have been used in wildfire monitoring. It is capable of providing full coverage of Thailand region at 375 m nominal resolutions of fire hotspot data. Although VIIRS instrument is suitable for detecting fire activity, some hotspot data are misinterpreted such as the ones in the factory area. Therefore, it is necessary to detect such false-alarm hotspot data. Additionally, the seasonal distribution of wildfire helps establishing the wildfire clustering map to observe continuation of wildfires/hotspot data for detecting wildfire propagation, and also to detect the damaged areas for assessing the vulnerability of the areas. False-alarm points and wildfire clustering observations can be a few formations of data management to help in reducing the risk of disaster. As in this study, false-alarm hotspot detection applied an idea of hotspot occurrence per pixel should have only one hotspot; therefore, a distance between pairs of a hotspot within one pixel range (375 m) will be suspected as false alarm points. Furthermore, wildfire clustering applied the idea of Density-based spatial clustering of applications with noise (DBSCAN) which is a grouping of continuous hotspots under a condition of specific distances derived from scan and track of each pixel.

Keywords: *False alarm filtering, Forest fire, VIIRS*

APPLICATION OF SBAS-DINSAR TECHNIQUE TO INVESTIGATE THE ASSOCIATION BETWEEN SUBSIDENCE PATTERN, GROUNDWATER LEVELS, AND RAINFALL VARIATIONS IN CHOUSHUI RIVER ALLUVIAL FAN

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ABSTRACT

The Choushui River alluvial fan (CRAF) is a critical region of farming in Taiwan. In this region, groundwater is the main supply for irrigation, industrial and domestic usage. For decades, the amount of extracted groundwater in CRAF has significantly increased, resulting in land subsidence and negatively impacting human lives as well as infrastructures, especially the high-speed railroads and the highways. Therefore, monitoring the ground elevation changes in this area over time is necessary, providing the spatial patterns of subsidence and investigating subsidence mechanisms in the study area. This study applied the SBAS-DInSAR technique to process over 90 Sentinel-1A SAR images acquired from 2018 – 2020 to observe the recent land subsidence patterns in the CRAF. SBAS-DInSAR is a time-series InSAR technique that exploits the distributed scatterers, scattering objects having constant responses over time without dominant ones. The SBAS-DInSAR typically requires the low perpendicular baseline and temporal baseline of the co-registered image pairs, minimizing the decorrelation phenomena. The workflow is shown in Figure 1. Regarding the datasets, Sentinel-1A is the European Space Agency's sun-synchronous imaging radar mission (ESA), providing continuous all-weather, day-and-night imagery at C-band radar wavelength with 12 days of revisiting. Besides the InSAR method, a system of GPS stations and leveling benchmarks has been installed for decades to monitor the vertical displacements in the study area. Over 1100 precise leveling benchmarks are provided by the Taiwan Water Resources Agency (WRA) in the fluvial plain of the Choushui River, consisting of yearly measurements ranging from 2000 to 2019. Moreover, 32 GPS stations provided by the GPS Lab of Academia Sinica, Taiwan, are located within the area of interest, giving daily observations of three-dimensional surface displacements. Each GPS station is separated from another roughly 10 – 15 km. Measurements from GPS and leveling measurements will assess the results achieved from InSAR. The assessment indicated that InSAR average velocities were relatively consistent with GPS velocities in 2018 (MAE = 0.56 cm/y; RMSE = 1.3 cm/y) and 2019 (MAE \approx 1 cm/y; RMSE = 2.33 cm/y). Meanwhile, the resulting metrics

between InSAR and leveling presented a high correlation, with MAE = 0.1 cm/y and RMSE = 0.35 cm/y. The validated InSAR results first show that the sinking rates in both counties were relatively high in 2018 when severe subsidence mainly occurred during this period. Although the subsiding rates significantly decreased in 2019 and 2020, the subsidence situation in some places was still in alarm. Specifically, the regions that severely suffered from land subsidence are located in the western central parts of Yunlin County. The maximum cumulative displacements in these regions reached -13 to -18 cm at the end of the research period. On the other hand, Changhua County only observed moderate subsidence, with the accumulated subsidence values mainly varying from -2 to -5 cm. The maximum displacement values, up to -7 cm, occurred in Puyan and Xihu districts in this county. Next, this study also investigated the correlation between surface displacements, precipitation, and groundwater levels. It is witnessed that the variations of surface deformation were closely associated with the oscillations of groundwater levels. In detail, the remarkable settlement that occurred in the entire CRAF corresponded to steep declines in groundwater levels and vice versa; the uplifting followed the groundwater recovery. The cross-correlation analysis showed that the variations of cumulative displacements have moderate correlations with the groundwater level fluctuations, varying from 0.4 to 0.7. Meanwhile, the rainfall might be a minor factor impacting the subsidence since the correlation between rainfall changes and subsidence was not strong. It is concluded that the groundwater level fluctuations had a superior impact on the surface deformation in the CRAF. Therefore, it is necessary to pay more attention to groundwater monitoring and management in the study area to mitigate the surface deformation. Lastly, this study also provided the spatio-temporal developments of cumulative displacements along the high-speed railroads (HSR). It was observed that the subsidence in the railroad segments located in Changhua County was generally not significant. After three years, the maximum ground elevation sinking was over 6 cm but only occurred in a small area. Oppositely, the HSR segments located in Yunlin County witnessed high-rate sinking. The most severe subsidence occurred in the Huwei, Tuku, and Yuanzhang sections, which were the centers of subsidence of the HSR profile. The maximum cumulative displacements here reach over -17 cm to -20 cm. The results of this study could be an estimation of the spatial and temporal development of land subsidence in the CRAF. Based on this result, the decision-makers could introduce appropriate policies to control the land subsidence issues in the CRAF.

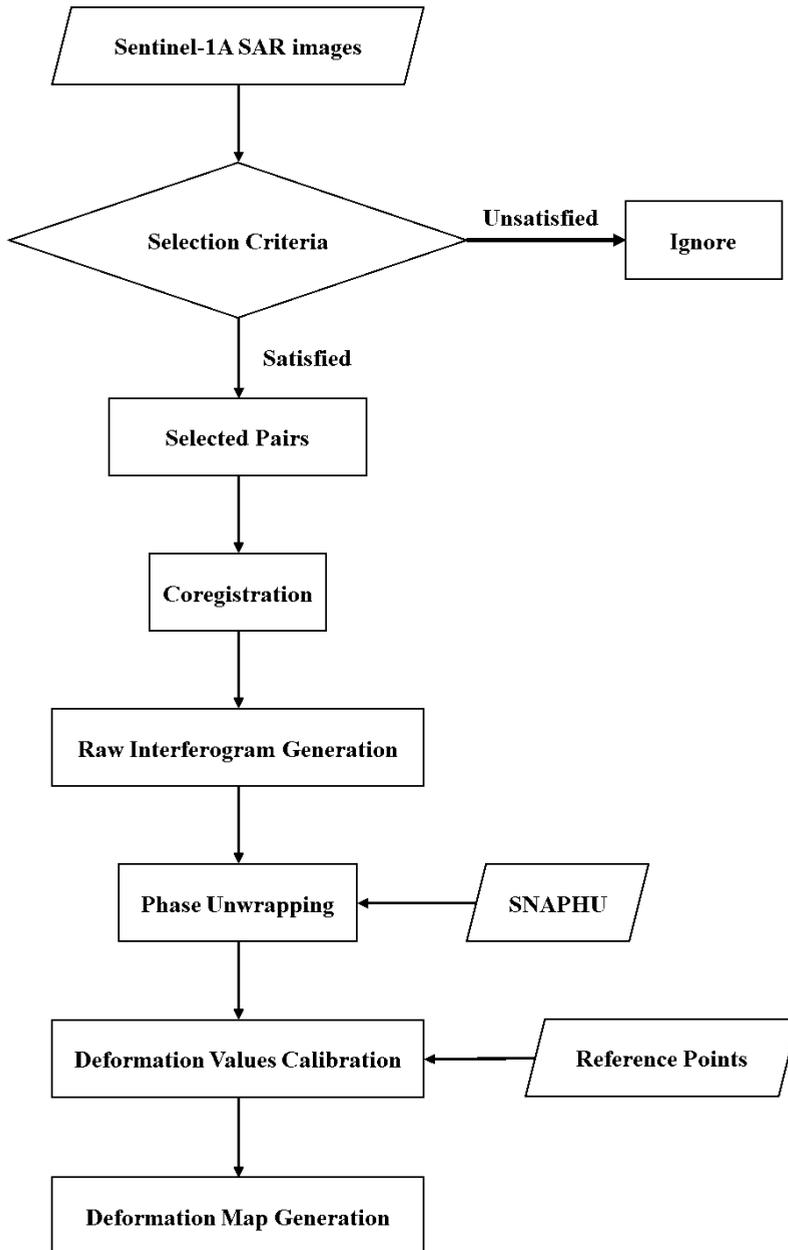


Figure 1: The flowchart of SAR image processing

Keywords: land subsidence, surface deformation, InSAR, SBAS-DInSAR

SURFACE DEFORMATION ANALYSIS IN ISTANBUL, TURKEY USING MULTI-TEMPORAL ALOS-2 DATA

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ABSTRACT

Monitoring large areas can be time consuming considering megacities which have more than ten million citizens. Istanbul is one of the megacities where the population is more than fifteen million inhabitants. The city is vulnerable to various natural and human induced hazards that threaten human life. One of the biggest natural disaster is the earthquake, which has caused severe changes to the socio-economics of the region. Besides, there are also local deformations due to urbanization, ground fillings, metro constructions, and landslides which also affect human life, properties, and transportations. However, previous studies widely focused on earthquake-related deformations, and these local deformations were not studied in detail. Remotely sensed data obtained by Synthetic Aperture Radar (SAR) satellite sensors and processed with SAR Interferometry techniques can be used to monitor deformations in cities thanks to their high spatial and temporal resolutions. The purpose of this study is to determine the deformations using multi-temporal L-band SAR data applying the Persistent Scatterer InSAR (PSI) technique. L-Band data was used for the first time for the investigation of the deformation analysis over this region.

In this study, two regions of the Istanbul megacity were studied. The first one is coastlines of Golden Horn, and the second one is landslide areas of Avcilar-Beylikduzu. The Golden Horn is a natural estuary and it is located at the old city of the Istanbul, which is one of the protected sites of UNESCO. It is a natural port and connects various transportations. Because of its alluvial structure and human made ground fillings the geological structure is not very solid. The second region is located on the west of Istanbul, and it is vulnerable to slowly developing landslides due to the topography and geological structure of the region.

In the InSAR analysis, the ALOS-2 image data of the Golden Horn area was processed. 27 images belonging to the ascending mode and different acquisition times were considered, including the master image. However, 3 images were excluded from the evaluation due to low coherence and high

errors in their orbits although temporal and spatial vases of them were suitable. All images were evaluated in the SARProz software. In this context, initially polarizations were defined as horizontal, master image was selected, co-registration was applied to master and other images, and then PSI analysis was performed. In this way, 21584 persistent scattering points were obtained and deformations of these points in the line of sight (LOS) direction were determined. The displacement values ranges between 20 mm/year to -20 mm/year. The maximum displacement was observed along the river where the coastline is filled and used for recreational areas. Additionally, a displacement is also noticed over newly constructed port that is located at the south. For the same region, 31 Sentinel- 1 data was also used. The data were acquired between 2015 and 2017. Compared to L-band, C-band Sentinel-1 provided displacements over the same locations. However, lower displacement values were determined with C-band data especially over the new port and along the coastal region.

In the regions, a combination of open source SNAP and StaMPS softwares were used and PSI approach was applied. In the analysis 19 ALOS-2 data from 2016 and 2018 with HH polarization was used. Additionally, Sentinel-1 data were also analyzed from 2015 to 2020. Both dataset showed similar displacement pattern. In this region the displacement range is slower and it changes between 10 mm/year to -10 mm/year when ALOS-2 data was used. The results of Seninel-1 showed slower displacement compared to ALOS-2 data. The results of ALOS-2 data showed more PS points over the rural parts of the region that could not determine by Sentinel-1. The results indicated that most of the old landslides were reactivated and there are new locations that were not shown in the current landslide inventory. At the east part of the region a vertical accumulation is identified while the topography is decreasing. The rural part has started to urbanization, and the results showed that they are vulnerable to landslides.

In this study, the first results of the multi-temporal PSI analysis of ALOS-2 was presented over the city Istanbul. Surface subsidence and landslides were determined over the city. In both cases, the results of ALOS-2 data provided higher level values of displacement even providing lower PS points. Moreover, it provided PS displacement where C-band could not achieve due to having shorter wavelength. The results indicated that landslides are dominated by slowly developing horizontal movement. As the results of InSAR just provide displacement at LOS direction at least one descending and one ascending dataset should be used to determine 2D deformation movement. However, in this region the archived ALOS-2 data has only ascending mode data. It is expected to have more data with ALOS-4 data to monitor deformation using L-band. It is planned to combine Sentinel-1 and ALOS-2 data to achieve better results than single sensor analysis.

Keywords: *Surface deformation; landslide; InSAR; ALOS-2*

ENVIRONMENTAL DOMAIN

AGRICULTURAL MONITORING BY HIGH FREQUENCY AND HIGH RESOLUTION MULTIPLE SATELLITES AND ITS APPLICATIONS TO HARVESTING DETECTION

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ABSTRACT

While the use of satellite imagery for various time series analysis has been increasing in recent years, it has been difficult to perform such analysis with high accuracy because of the data missing caused by cloud contamination and the limited frequency of single satellite observation. In recent years, data from high temporal and spatial resolution satellites, such as Planet Labs Dove and VEN μ S, have become available. In this work, we preprocessed these two satellite images, correcting for differences in resolution and geolocation, and removing clouds, so that they can be used in the integrated manner. Then, using these integrated data from multiple satellite observation, we track the behavior of each reflectance and vegetation indexes and detect the harvest date

The first analysis tracked the seasonal behavior of each reflectance and NDVI. It was found that the data from both Planet Labs Dove and VEN μ S satellites could be treated equivalently in tracking NDVI. As a result, periodic seasonal changes of NDVI were captured over three years. In addition, by using NDVI as a relative index instead of directly using a single band reflectance, it was confirmed that it was possible to reduce the noise that may have originated from the instrumental characteristics between different satellites and the acquisition time as well as atmospheric correction error.

Second, we smoothed vegetation indexes, NDVI and EVI2, with Savitzky-Golay filter and compared them with each other. As a result, it was confirmed that the overall variance of EVI2 was smaller than that of NDVI and that EVI2 was more resistant to outliers. Finally, the harvest date was actually detected for the 200 correct data points using a method based on the threshold of time series NDVI. we detected harvesting with a mean absolute difference of 5.4 days, and the overall harvesting detection rate was 71.5%.

Keywords: *Multi-satellite, harvest, NDVI, time-series, fusion*

ACTIONABLE INTELLIGENCE POLICIES (AIP) FOR WASTE MANAGEMENT IN THE EASTERN ECONOMIC CORRIDOR (EEC), THAILAND: CONCEPTS, CHALLENGES, AND OPPORTUNITIES

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ABSTRACT

The Eastern Economic Corridor (EEC) project in three Thailand's eastern provinces, namely, Chachoengsao, Chonburi and Rayong has been developed to be a hub of trade and investments of high technological manufacturing as well as a center for regional transportation and logistics. Since the project has been developed in 2017, increase in level of economic activities and social development has attracted more people to the area. With rapid population growth and urbanization, waste generation in the EEC is expected to increase. To reduce overwhelming amount of waste and strain on local waste management systems, formulating effective waste management policies is needed. Even though there is implementation of common strategies and policies of waste management in the area, typical pain points such as volumes of waste, inadequate waste collection, improper disposal, lack of usable or appropriate landfills still remain. As each area has its own specific waste problems, making policies and forming strategy bases on truly understanding area characteristics could lead to successful implementation. Actionable Intelligence Policy platform (AIP) is an integrated spatial big data platform allowing policy makers to better understand root causes of a problem through intelligence analytics and what if scenarios. Hence, public policies and management practices are properly formulated regarding priority, real community needs, and area characteristics. With its intelligence, AIP is aimed to be used as a main tool to deliver effective waste management policies and measures for transforming EEC into zero waste area. The development of the AIP begins with stakeholder engagements. At this stage, local organizations having an interest in the outcomes of the AIP in the EEC have engaged through providing their perspectives in waste management and their readiness level of cocreating and implementing the AIP. Although they are not ready for the AIP cocreation mainly due to human resources and technical skills, there is a willingness in providing useful information such as problems and requirements of waste management for the AIP conceptual

design process. As waste volume is a major problem needed to be resolved in the area, three indicators related to waste volume management including waste volume, number of waste disposal sites, and condition of waste disposal site have been defined. Spatial and non-spatial data from several sources and analytical techniques based on 5M principles: measuring, monitoring, mapping, modelling, and managing are used to indicate level of those three indicators. For instance, population, number of tourists, number of bins, bin capacity, and waste density are used for mapping existing waste volume whilst predicted population, tourist, land-use, and urban growth boundaries have been analyzed for mapping waste volume prediction in province to district scale. The waste volume maps are then used for policy and strategy formulation, and as such better waste volume

management such as waste separation campaign, waste tax, increase in routing waste collection, and relevant service improvement. Additionally, the waste volume maps has been compared with the second indicator; number of waste disposal sites, extracted from satellite images showing both location and size of authorised and unauthorised dumpsites. The comparison aims to determine whether there is a shortage of dumpsite particularly in areas having high waste volume to formulate further policy and strategy for expanding proper new infrastructure. The information of waste disposal site is also able to support issuing rules and regulations to reduce unauthorised dumpsites. As for areas having enough number of dumpsites, condition of the waste disposal sites is assessed. The amount of leachate, gas, and odour emission from the waste sites are monitored through field sensors coupled with using satellite image analysis. In this regard, vegetation stress and land surface temperature changes surrounding waste sites are proxy for waste sites required high-maintenance. Poor and fair condition waste sites are then used to simulate impact of pollution scenarios on surrounding communities. The pollution scenarios will help authorities to consider issuing proper rules and regulations for infrastructure and service improvement as well as establish action plans to prevent and mitigate health and environmental impacts from polluted waste sites. This AIP conceptual design has been also reviewed and evaluated by stakeholders and ready to be transformed into a system for implementation which eventually could support policy formation and strategy making. Although the conceptual design has been accepted by stakeholders, the implementation stage is challenging. As the AIP needs variety of data, there should not be conflicts and barriers to data sharing and integration. For instance, copyright and license agreements of data for the AIP use need to be issued and permitted. Moreover, data structure needs to be organized and useable between different platform otherwise there will be unavoidable costs of sharing data and time consuming for depositing data to the AIP system. However, there is a good opportunity for finding new techniques for data integration between complex platform. As the AIP platform is integration of

technologies, unless having own all needed technologies defined in the AIP conceptual design, co-creation in implementation between stakeholders is required. Besides, there should be the same readiness level in knowledge, technology, and infrastructure among stakeholders so that those are shared and complemented to each stakeholder without any barrier which will foster creativity in the use of technologies further. However, there is an opportunity for those having limitation to learn and accept technologies from competent stakeholders and to move their readiness level to equivalence. In that case, an offer from technology recipient has to fulfill requirement of higher competent stakeholders. Additionally, clear communication among co-creating stakeholders about goals and process to reach achievement are required in order avoid misperception leading to failure of the implementation. Lastly, the degree of acceptance from users on the AIP platform relies on the usefulness, the ease of use, the cost and effectiveness. In summary, the development of the AIP conceptual design and implementation as well as the challenges and opportunities could provide a better understanding in the AIP concept and be a good guideline to support the development of an optimal and practical AIP for waste manag.

Conceptual Design of Actionable Intelligence Policies (AIP) for Waste Management in EEC, Thailand

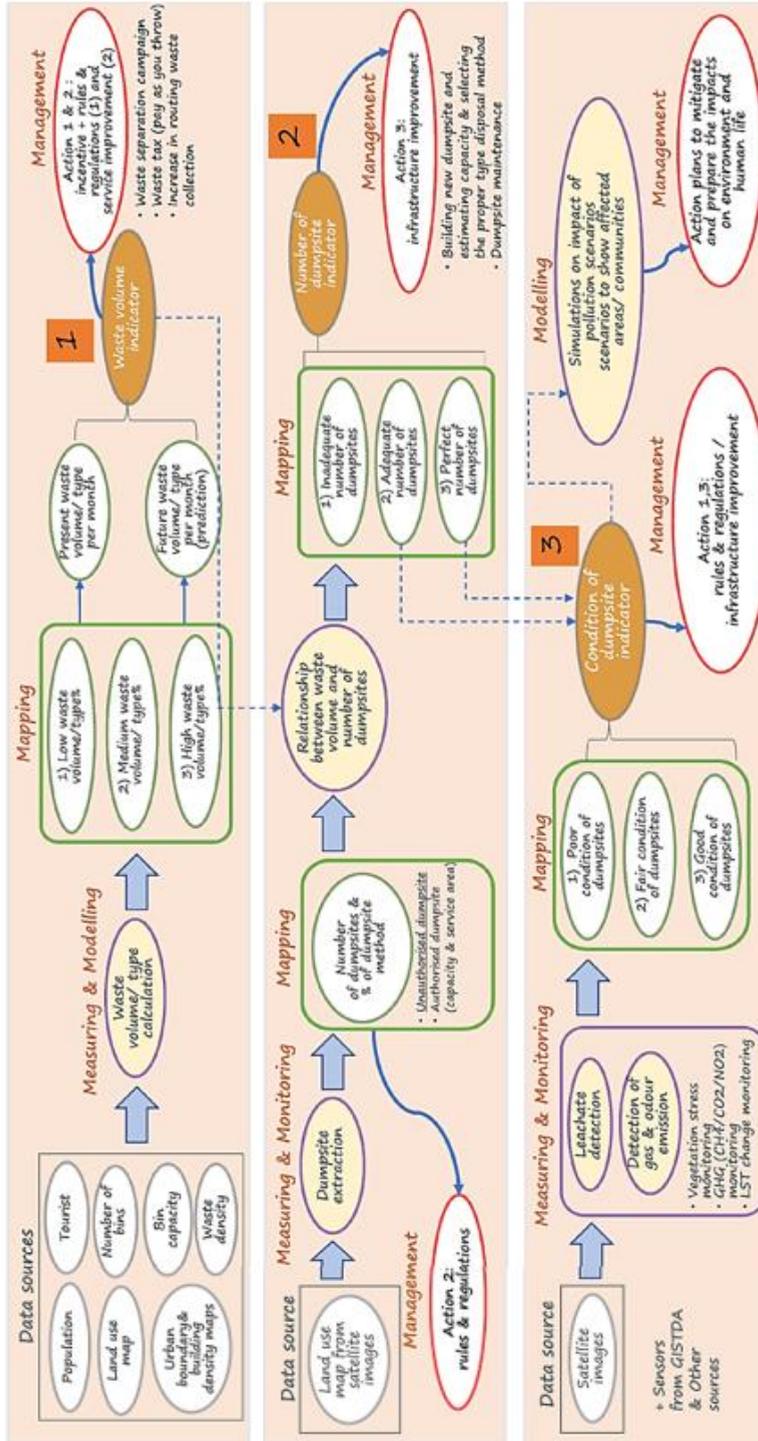


Figure 1. The conceptual design of the AIP waste management including three indicators and sample of management policies for each waste management indicator

Keywords: AIP Conceptual Design; 5M principles; Co-creation in AIP implementation; Strategy and Policy Formulation Tool

EVALUATION AND CORRECTION OF DIFFERENT PRECIPITATION PRODUCTS OVER AKDENIZ BASIN, TURKEY

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ABSTRACT

Accurate rainfall estimation is an essential task for optimal water resources planning and management. However, it is a challenging issue in areas with complex topography. To cope with such problems, remote sensing technology is increasingly used instead of local measurement techniques. This study evaluates the accuracy of five remotely sensed precipitation products over the Akdeniz Basin, Turkey at a monthly scale. The products include Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN) with $0.25^\circ \times 0.25^\circ$ spatial resolution, PERSIANN-Cloud Classification System (PERSIANN CCS) with $0.04^\circ \times 0.04^\circ$ spatial resolution, PERSIANN- Climate Data Record (PERSIANN CDR) with $0.25^\circ \times 0.25^\circ$ spatial resolution, Group InfraRed Precipitation with Station data (CHIRPS) which combines satellite observation with $0.05^\circ \times 0.05^\circ$ spatial resolution and rain gauge stations, and Tropical Rainfall Measuring Mission product Multi-satellite Precipitation Analysis 3B42V7 (TMPA 3B42V7) with $0.25^\circ \times 0.25^\circ$ spatial resolution. To assess the remotely sensed precipitation accuracy, root mean square error (RMSE) and Pearson correlation coefficient (R) between each product and the observed data from four ground-based stations during the period of 2003 to 2018 were calculated used. In addition, the precipitation values of the best product were corrected using a linear regression method. The results showed that TMPA 3B42V7 and CHIRPS have higher accuracy than those of PERSIANN products. The R for TMPA 3B42V7 and CHIRPS were 0.9 and 0.86, respectively which are corresponding to a strong linear correlation between satellite product and observed data. The results also showed that PERSIANN CCS and PERSIANN provide a weak correlation with observed data. Also, RMSE confirms the superiority of CHIRPS and TMPA 3B42V7 over the study area with 23 mm and 19.7 mm respectively while PERSIANN, PERSIANN CCS, and PERSIANN CDR were 53.7 mm, 51.8 mm, and 34.9 mm, respectively. After the correction of TMPA 3B42V7 using linear regression, the RMSE dropped from 19.7 mm to 15.7 mm. The evaluation

proposes that TMPA 3B42V7 and CHIRPS can be promising precipitation products (after a bias correction) to be used as complementary to the ground-based stations for potential applications in the Akdeniz basin in Turkey.

Keywords: *Precipitation products, Rain gauges, Akdeniz Basin, deep learning*

FORMULATION OF AN ENVIRONMENTAL RESILIENCE INDEX AS AN INDICATOR OF SUSTAINABILITY IN SELANGOR, MALAYSIA

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ABSTRACT

It is evident that global climate change has significantly affected the local environmental context in many towns. The abundance of environmental resources in Malaysia provides many environmental services towards the nation's development. However, disasters such as flooding, landslides and earthquakes stress the importance of environmental sensitive areas (ESAs) as natural defence agents for a resilient and sustainable town. Thus, the presence of a framework to measure the level of resilience for an area is crucial. However, there is no detailed model explicitly dedicated to environmental resilience in the Malaysian context. This research aims to develop a methodological framework to measure the environmental resilience index (ERI) in Selangor, Malaysia, which stakeholders could use, especially the Local Planning Authority (LPA). The state of Selangor is chosen as a study area, taking into consideration its rapid economic growth and the availability of its enormous natural resources. The objectives are to identify critical factors of environmental resilience, generate the ERI results to understand the spatial distribution pattern and produce a model of environmental resilience index in the Geographical Information System (GIS) database system. The research undertook comprehensive document analysis and systematic literature review in developing the ERI. This data used to analyse are majorly secondary data from official reports of responsible technical departments and agencies in Malaysia to ensure validity and reliability of data. The research developed a framework of ERI, consisting of five environmental components: environmental resources, built environment, climate condition, natural disasters, and environmental issues with 40 indicators. The output of this analysis was generated using ArcGIS software related to the weightage of different components and sub-components. The results show that all the districts in Selangor have an ERI level of moderate level, reflecting the resilience status should there be any disaster.

Keywords: *Natural resources, disaster, sustainable development, criteria*

A FIRE RISK MAP FOR PROTECTED AREAS OF MONGOLIA: KHANGAIN NURUU NATIONAL PARK (NP), TARVAGATAIN NURUU NP, KHANKHOKHII SPA, ULAAN TAIGA SPA AND KHOVSGOL LAKE SPA

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ABSTRACT

Wildfire is a cause of major disturbance to ecosystems and economies throughout the world. Hence, the wildfire is a vital issue of environment for creating natural disaster and socio-economic damage to affect in ecosystem and human lives. Moreover, the forest and steppe fires are one of biggest natural risks in issues of Mongolian protected areas, and its management. In this paper investigated to predict a spatial distribution of wildfire in the context of climate change and human impacts plays critical role in wildfire management and ecosystem-conservation for some protected areas, Khangain Nuruu National Park (NP), Tarvagatain Nuruu NP, Khankhokhii SPA, Ulaan Taiga SPA and Khovsgol Lake SPA. Moreover, we used long term of Landsat TM imagery from 1991 to 2020 which is obtained from the USGS Global Visualization Viewer (GloVis). In addition, to various parameters are considered by the risk analysis and among the driving factors, climate, socio-economic and human factors to integrate into the GIS tools. Therefore, these analyses are applied to the approach of decision-making support system, particularly as Spatial Multi-Criteria Analysis (SMCA). Consequently, wildfire risk map was created by five categories: very high, high, moderate, low and non-risk for particular the protected areas, it will be baseline data for protected areas managements, fire prevention plans and activities. As results showed that a percentage of the study area was predicted by wildfire risk in the natural protected area for above each category as follows. The fitting result of the SMCA model showed a prediction accuracy exceeding 80%, which represents that the model has a high ability to predict wildfire risks on highlighted the protected area. This study could provide a reference for predictions, make the strategy and prevention of wildfire hazard for the stakeholder, decision-making.

Keywords: *LANDSAT, Burned area, Fire hotspot, Fire risk map, Multi-criteria analysis*

THE RETRIEVAL OF CHLOROPHYLL-A CONCENTRATIONS IN INLAND WATER USING CONVOLUTION NEURAL NETWORK ON SATELLITE IMAGERY

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ABSTRACT

The retrieval of chlorophyll-a (Chl-a) concentration, which is a crucial indicator in monitoring water quality across inland waters, remains a challenging task by using satellite data. Former studies based on semi-empirical and analytical approaches have achieved great progress. However, the Chl-a retrieval models from these approaches suffer from a wide range of uncertainties that originate from inter-seasonal variations of optical water properties and insufficient quantity of in situ samples. Most inland lakes in tropical regions experience different trophic states across wet and dry seasons. The optically water properties are complex and varied due to different trophic states over different seasons that pose difficulty to remote sensing-based models in accurately estimating Chl-a concentrations. To overcome this problem, a season-insensitive model based on a multi-task convolution neural network with a multi-output structure is proposed. In addition, a layer-sharing network structure with data augmentation is adopted to alleviate the problem of insufficient quantity of in situ Chl-a samples in model calibration and validation. To evaluate the proposed method, a largest lake in the Philippines, Laguna Lake, is selected as the study area. The lake is characterized by oligotrophic and mesotrophic conditions in wet season, whereas the states change to mesotrophic and eutrophic conditions in dry season. Several Sentinel-3 OLCI level-2 images matched with 409 in situ Chl-a measurements in range from 1.24 to 22.30 mg m⁻³ are collected. Over 5-fold cross validation, the average coefficient of determination (R^2) and root mean square error (RMSE) of the proposed model are 0.74 and 2.06 mg m⁻³, respectively. In comparison, the estimation accuracy of our model is improved than that of related semi-empirical models. The slopes (m) of regressed lines generated from estimated and in situ Chl-a samples also demonstrate the ability of our proposed model to properly capture seasonal patterns of Chl-a in Laguna Lake.

Keywords: Chlorophyll-a, Inland waters, Convolutional Neural Network, Sentinel-3 OLCI imagery

**UNDERSTANDING THE IMPACT OF RIPARIAN
CORRIDORS ON MICROCLIMATE
(CASE STUDY: BOGOR CITY, INDONESIA)**

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ABSTRACT

The existence of green open space in urban areas is useful for various ecosystem services, one of which is microclimate amelioration. Microclimate condition is strongly influenced by multiple landscape features. River is widely known as one of waterbodies which has good ability in lowering air temperature. Central Bogor Sub-district, is one of the sub-districts in Bogor City with a lot of green open space in various sizes. This study compares the microclimatic conditions in several parks in riparian and non-riparian corridors in Central Bogor Sub-district. The surface temperature in several parks can be determined by using Land Surface Temperature (LST) analysis in ArcGIS software. Based on the results, there are differences in microclimate conditions between green open spaces in riparian and non-riparian corridors. This condition shows that the presence of river as a landscape feature has a significant influence on the microclimate.

Keywords: *Urban heat island, green open space, LST, landscape, park, river*

RANGE FORECASTING OF AN ENDANGERED ISLAND ENDEMIC BIRD SPECIES USING ENSEMBLE SPECIES DISTRIBUTION MODELING

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ABSTRACT

Habitat and wildlife conservation is becoming more difficult to practice due to increasing human population growth, environmental degradation, and climate change. Fortunately, emerging developments in species mapping have become valuable conservation tools in predicting biological diversity trends and identifying important conservation areas. This study aimed to map the present and future distributions of an endangered endemic bird considered as Cebu Island's flagship species, the black shama (*Copsychus cebuensis*). Since the black shama's survival is constantly threatened by habitat loss and fragmentation, exacerbated by climate change, consensus range forecasting might help us better understand the suitability of different habitat zones for this endangered species. We developed species distribution models for the black shama which were projected in the current and future scenarios. Future projections were modeled from two 2070 representative concentration pathway (RCP) climate scenarios, with RCP 4.5 as the 'best-case scenario' and 8.5 as the 'worst-case scenario'. Land cover correction was also considered for the future scenarios to restrict projections onto intact habitats. Results showed localized extirpations of the species in the future scenarios with the remaining species populations concentrated near the key biodiversity areas. Future projections also exhibited an inclination of the species towards the south of the island, and occupying a lesser land area compared to the present distribution. With these results, we discussed recommendations for strategic management including opportunities for protected area expansion, potential habitat corridors, and reintroduction areas for protecting the species' metapopulation.

Keywords: *Ecological Modeling, Species Distribution Modeling, Black Shama, Climate*

HABITAT SUITABILITY ANALYSIS OF TIGERS USING DECISION SUPPORT SYSTEM OF INDIAN BIO-RESOURCE INFORMATION NETWORK (IBIN) PORTAL

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ABSTRACT

India has the highest population of Bengal tigers (*Panthera tigris tigris*) in the world (70%).

Conservation of big cats like tigers is crucial owing to their lower frequencies and the fact that they belong to the top of the food chain as top consumers. In India, tiger population is threatened and belonged in IUCN category of endangered species thereby requiring immediate attention. With advancement in satellite remote sensing and GIS processing techniques numerous avenues of research has unfastened in the field. This study performs a site suitability analysis for tigers in and around Jim Corbett tiger reserve, India using several variables influencing presence of tigers in an area. Ecological factors are used as variables for e.g., remotely sensed variables like vegetation types and proximity from drainage, roadways and settlement etc. The criteria are given relative importance using AHP, a multicriteria decision analysis (MCDA) and areas that are not suitable, moderately suitable and highly suitable for tigers are delineated.

Keywords: MCDA, GIS, Remote Sensing, weighted overlay

AN ESTIMATION METHOD OF APPROPRIATE CHLOROPHYLL-A CONCENTRATIONS VIA THE LINEAR COMBINATION INDEX FOR SENTINEL-2/MSI DATA IN HIROSHIMA BAY

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ABSTRACT

Although many methods by band ratio have been reported in the estimation of the Chl.a concentration by satellite, the chlorophyll-a concentration estimation via the linear combination index (LCI) proposed by Frouin et al. (2006) can mitigate the influence of atmosphere to some extent. When the computing for the LCI, we usually use 3 to 4 bands from visible to near infrared, but there are few discussions of the combination. Therefore, we report the appropriate band combination in estimating the Chl.a concentration via the LCI for Sentinel-2A/MSI data. In the analysis, the relationship between the LCI in Hiroshima Bay calculated from Sentinel-2A/MSI data and the Chl.a concentration based on the water quality survey results was approximated by exponential function. As a result of the analysis, it was clarified that the following: First, for the case of threeband combinations, (1) band combinations of 1, 2 and 3, (2) band combinations of 1, 4 and 8, (3) band combinations of 2, 3 and 8, and (4) band combinations of 2, 4 and 8 indicated the coefficients of determination R^2 greater than 0.5. Here, the R^2 of band combinations of 1, 2 and 3 was the higher with 0.524. Secondly, for the case of four-band combinations, (1) band combinations of 1, 2, 3 and 4, (2) band combinations of 1, 2, 3 and 8, (3) and band combinations of 1, 2, 4 and 8 indicated the coefficients of determination R^2 greater than 0.5. Here, the R^2 of band combinations of 1, 2, 3 and 8 was the highest with 0.637. Thirdly, in these two band combinations, the Chl.a concentration as increased with the LCI increase.

Keywords: Exponential function approximation, Coefficients of determination, Atmospheric influence

ANALYSIS OF FOREST COVER CHANGES AND FOREST GREENHOUSE GAS EMISSIONS IN THE PHILIPPINES FROM 2011-2020 USING SATELLITE-DERIVED PRODUCTS

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ABSTRACT

Timely and spatially-consistent forest cover change information provide invaluable insights for stakeholders and policymakers in making appropriate interventions and responses in the field. In this context, freely available forest cover products derived from earth observation satellite data through the Landsat platform enable researchers to have an annual to decadal forest cover trend for the first two decades of the 21st century (Hansen et al., 2013). In this paper, we analyze annual forest cover loss and forest greenhouse gas (GHG) emission trends in the Philippines from 2011-2020 and group the findings with respect to the Philippines' 81 provinces. Results showed that Agusan del Sur (30,416.06 ha), Palawan (30,286.50 ha), and Zamboanga del Norte (10,165.96 ha) are the top three with regard to total forest loss. By comparing the provinces across similar scales, proportional forest losses were computed which showed that Zamboanga del Norte lost 13.31% of its year 2010 base forest cover, followed by Agusan del Sur (8.92%) and Tawi-tawi (8.55%, total loss = 3,373.10 ha). Ifugao (0.82, $p < 0.05$), Maguindanao ($r = 0.80$, $p < 0.05$) and Mountain Province ($r = 0.78$, $p < 0.05$) exhibited significant and increasing forest loss trends. In terms of forest GHG emissions, Agusan del Sur (25.6 Mt of CO₂e), Palawan (22.3 Mt of CO₂e), and Davao Oriental (8.7 Mt CO₂e) topped the list while linear and increasing forest emission trends were observed for Mountain Province ($r = 0.82$, $p < 0.05$), Maguindanao (0.83, $p < 0.05$) and Ifugao (0.79, $p < 0.05$). This study may contribute to country-wide monitoring of forest cover change that can aid in identifying and prioritizing areas for intervention, possibly down to the municipal level. Therefore, forest-related programs on addressing and halting deforestation need to be re-evaluated in such provinces.

Keywords: *Deforestation, forest monitoring, forest dynamics*

**DECISION TREE BASED CLASSIFICATION AND HABITAT
SUITABILITY PREDICTION OF MIGRATORY BIRD:
A CASE STUDY OF *Vanellus gregarious***

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ABSTRACT

Habitat of any species can be defined as the biotic and abiotic components present in an area that supports the survival and reproduction of the species[15]. If these factors are altered due to any of the natural or anthropogenic reasons, the habitat becomes unsuitable for their survival. As a result of which, they either need to get adapted to the changes or find another suitable habitat. This is the key reason of migration observed in the migratory birds, i.e., when the conditions at their native sites becomes unfavorable for feeding, breeding or nesting, the birds migrate towards the regions with suitable climatic conditions. In this paper, the *Vanellus gregarious* (Socialbe lapwing) is considered for a case study, which is a winter migrant to India from Russia and Europe to analyze the prime environmental factors that constitutes the habitat of this species. The habitat is mainly influenced by ecological components like bioclimatic variables which includes temperature, precipitation and other climatic information, vegetation type or NDVI. The study is carried out by generating a set of decision rules considering the above components as parameters. The values from each component are used with the occurrences data of species from GBIF to derive rules. Further these set of rules are used as a knowledge classifier in decision tree for classification of suitable habitat. Decision tree is considered as one of the most user-friendly machine learning models because they make no linearity assumptions and automatically discover interactions among attributes. Each migratory birds have its own attributes as environment envelopes which provides different decision rules for classification. Such models can be used to analyze the spatio-temporal migration patterns. Also it can be helpful to understand species distribution, population dynamics and can guide in conservation or policy decisions for protecting threatened and endangered species.

Keywords: *Machine Learning, Spatial Modeling, Bioclimatic variables*

DELINEATING GROUNDWATER VULNERABILITY IN METRO CEBU USING DRASTIC MODEL

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ABSTRACT

Metro Cebu's groundwater sources, especially in the coastal areas, are already threatened because of excessive consumption, contamination, and saltwater intrusion. Rapid urban expansion has also inflated the inherent vulnerability of the metropolitan area's groundwater sources in addition to the apparent shortage of the resource. Thus, solutions such as the utilization of remote sensing (RS) and geographic information systems (GIS) for the selection of priority areas for groundwater protection are valuable. In the current study, the intrinsic vulnerability of groundwater from contaminants emerging from the surface was spatially defined for Metro Cebu. This was achieved by developing a groundwater vulnerability map using the DRASTIC model which is an integration approach incorporating spatial information such as depth to water, net recharge, aquifer media, soil media, impact of vadose zone, and hydraulic conductivity. The resulting map classified the study area into very low, low, moderate, high, and very high groundwater vulnerability zones. About one-third of Metro Cebu lies in high (24.77%) and very high (7.17%) vulnerability zones. Meanwhile, areas in very low, low, and moderate vulnerability cover 14.91%, 33.28%, and 19.87%, respectively. Analysis of the map revealed that areas included in high to very high groundwater vulnerability classes were nearshore plains which were characterized by shallow depth to water, moderate to high annual recharge, alluvium and karstic limestone geologic units, clay loam soil texture, and gentle slopes. Evidently, RS and GIS integration techniques provided an appropriate and low-cost tool for targeting priority areas for groundwater protection, water quality monitoring, wastewater treatment facility planning in Metro Cebu through the development of the vulnerability map.

Keywords: *groundwater, vulnerability, DRASTIC, contamination*

ESTIMATING ABOVEGROUND FOREST CARBON STOCKS USING MULTI-SENSOR SATELLITE DATA AND FIELD MEASUREMENTS IN THE PHILIPPINES

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ABSTRACT

Quantifying the amount of carbon stored in tropical forests is needed to inform climate mitigation mechanisms such as Reducing Emissions from Deforestation and Forest Degradation (REDD+). Remote sensing is a cost-effective tool to accurately estimate aboveground forest carbon stocks. Studies that use data from multiple sensors for estimating aboveground forest carbon, however, remain limited despite their tremendous potential. We estimated aboveground forest carbon stocks using multiple linear regression modeling between forest inventory data and satellite data, specifically L-band synthetic aperture radar (SAR) and Landsat, in three study sites in the Philippines. Models built using data from individual sensors versus combined multi-sensor data were assessed to determine which produced more accurate estimates of aboveground forest carbon. Subsequently, the accuracy of a global model developed from forest plot data across sites, was compared

against site-specific models. Across sites, results showed that models using combined multi-sensor data performed better than those using individual sensors, with higher accuracies obtained for larger plot size ($R^2=0.82-0.93$; $RMSE=27.20-42.92$ Mg C ha⁻¹). Textural attributes made up the majority of predictors in these combined sensor models and contributed to improved accuracies and reduced uncertainties in carbon estimates. The global model did not perform better than site-specific models, regardless of sensor data or plot size, which suggests that the predictive power of the global model may be influenced by inherent site-specific variabilities (e.g., forest characteristics and forest inventory methods). Combining multi-sensor satellite data offers an improved approach for estimating aboveground forest carbon, with larger forest plot sizes contributing to this improvement, thus leading to higher accuracies and lower uncertainties for spatially explicit carbon mapping in dense tropical forest regions.

Keywords: *Combined sensors, ALOS-PALSAR, Landsat, aboveground carbon stocks, forest inventory*

VALIDATION OF PRECIPITABLE WATER ESTIMATES DERIVED BY A COST-EFFECTIVE DUAL-FREQUENCY GNSS RECEIVER SYSTEM

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ABSTRACT

The Global Navigation Satellite System (GNSS) can also be used as an all-weather sensor of accumulated water vapor, or precipitable water, by taking advantage of the fact that the speed of microwave transmission used in GNSS slows down in the tropospheric atmosphere. The estimated precipitable water information is being operationally used in numerical weather forecasting at the Japan Meteorological Agency (JMA) to enhance the prediction accuracy of severe weather events. To further enhance the capability, more denser observing network is expected by increasing the number of GNSS station. Recently, low-cost dual-frequency receivers have been released, and a cost-effective system using such a low-cost receiver can accelerate the expansion of the fixed observation network. As a first step in our investigation to confirm the potential of cost-effective systems, we have conducted two experiments with cost-effective (ZED-F9P of u-blox and QZG12fQ of Komine Musen Denki Co., LTD) and geodetic-grade (PwrPak7 and GNSS-850, both from NovAtel Inc.) observing systems. One experiment was to separate the contribution in the Zenith Tropospheric Delay (ZTD) errors from the antenna and receiver. The other experiment was to obtain simultaneous long-term data of geodetic-grade and cost-effective systems covering wide range of ZTD. From two experiments, we found that there was a little difference in performance between two receivers, since time variations of the ZTD error were almost the same when the satellites that ZED-F9P could not receive were excluded in the post-processing. We also found that the bias was larger when the QZG12fQ antenna was used. When this bias was removed, the cost-effective and geodesy-grade systems showed similar performance. Therefore, the possibility of reducing the ZTD error by applying relative antenna calibration needs to be further investigated. In addition, further experiment is necessary to actually confirm the agreement with precipitable water observation such as by radiosonde launches.

Keywords: GPS, Zenith Tropospheric Delay (ZTD), water vapor, Phase Center Variation (PCV)

SOIL EROSION ASSESSMENT IN LAK DISTRICT, DAK LAK PROVINCE, VIETNAM

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ABSTRACT

The Research Systematically assessed the extent of soil erosion in Lak district, Dak Lak province, using the interconnection of the Universal Soil Loss Equation (USLE) and GIS methods. As a result, Experiment has incorporated the following criteria: The Rain Erosion Ratio (R), the Capacity of the Soil Erosion Coefficient (K), the coefficients showing the effect of slope and slope length (LS), the coefficient of erosion restriction by vegetative cover (C), and the graph showing the efficacy of agricultural practices (P) research findings indicate that the erosion status in the town of Lak is predominantly level I (less than 2 tons/ha/year). Level I (25 tons/ha/yr) has an area of 1.316 ha, accounting for 10,66 percent, while level III (510 tons/ha/yr) has an area of 923,9 ha, accounting for 7,48 percent..

Keywords: *Lak district, USLE, GIS, Soil erosion*

**ANALYZING THE RESPONSE OF GROUNDWATER LEVEL
TO TIDAL WAVE IN COASTAL AQUIFER,
TAOYUAN, TAIWAN**

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ABSTRACT

Groundwater fluctuation in the coastal region is affected primarily by tidal oscillation. This study aimed to identify the effects of ocean tides on groundwater levels in the coastal aquifer of the Taoyuan-Hukou Table plain, Taiwan. In this study, Fast Fourier Transform (FFT) analysis was conducted to investigate the frequency of groundwater level based on the field monitoring data. The field observation showed that groundwater level fluctuates following the tide and fluctuations similar to a waveform, which suggested tidal wave-induced groundwater level changes periodically. The frequency analysis indicated that groundwater fluctuation was influenced by the multi constituents tide and significant component of the semidiurnal tide (M2) dominant with a period of 12.3 hours. The results also indicated that the fluctuation amplitudes decreased exponentially, and phase lag increased linearly for dominant tidal signals as they propagated inland. The tidal effects on the groundwater level reached up to 400 m inland from the coast.

Keywords: groundwater level, ocean tides, Fast Fourier Transform (FFT), Taoyuan-Hukou Table Plain

**SPATIAL ANALYSIS OF GROUNDWATER
DISTRIBUTION AND QUALITY USING GIS AND
REMOTE SENSING TECHNIQUES
(CASE STUDY OF BOLGODA RIVER BASIN, SRI LANKA)**

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ABSTRACT

Groundwater is an important natural resource for existence of life and environment. It provides higher quality, better protection from possible pollution, less subject to seasonal and perennial fluctuations and much more uniformly spread over large regions than surface water. The demand for groundwater in Sri Lanka is steadily increasing, particularly for urban/rural water supplies, irrigated agriculture and in industrial sector. Ensure the protection of groundwater has been a big challenge due to the industrial and other development activities especially in urban and suburban areas of the country. Lack of database on groundwater resources is the major barrier to reveal the impact of development activities on groundwater resources. This research aims to identify the Ground Water Quality and Distribution in Bolgoda River Basin of Sri Lanka.

Well water was used as the easiest way to access the groundwater and 567 wells were observed. Data collection was done in dry season to identify the minimum water level and maximum water levels were obtained with peoples' experiences. Digital Portable pH Meter was used to test the quality parameters (pH, Total Dissolved Solids (TDS), Electrical conductivity (EC) and temperature). Inverse Distance Weighting (IDW) and Weighted Overlay were main GIS techniques that used for analysis.

Results show a conspicuous difference on spatial distribution of groundwater level and quality. pH level of the area was ranged between 3.6-7.8, EC between 10-900 and TDS between 0-440. Result of Weighted overlay analysis was reclassified into 4 classes as very good, good, moderate and poor. In order to that 6.01 km² area was identified as very good in water quality and it represents the 1.3% of total land area. Largest portion of 235.3 was identified as good and 190.7 was in moderate quality. Poor quality land amount was 0.49 km². Maximum water level was identified as ground level in both seasons and minimum water level was the 14.63 meter below from ground level in dry season. Results of this research are very important as based data that can be used to ensure the protection of ground water from

industrial and other non point source pollution activities as well as to identify the areas in water scarcity..

Keywords: *Groundwater, water level, water quality*

SPATIAL DISTRIBUTION OF SOIL ORGANIC CARBON FOR SUSTAINABLE FOREST CONSERVATION

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ABSTRACT

Climate change is a serious global threat to be addressed by rapid reduction of atmospheric greenhouse gases. Subsequent to the 1997 Kyoto protocol, there was a consensus among environmental and natural scientists that increasing green cover is the only realistic way to reduce carbon dioxide emission due to anthropogenic interferences. Reduction of emission through deforestation and degradation (REDD) emerged as a prime agenda to be adopted through Clean Development Mechanism (CDM). In 2007, the UNFCCC COP 13 held at Bali, Indonesia appreciated the conservation strategies of developing countries like India, China, Thailand, etc., and recommended adding Enhanced Carbon storage and came up with the concept of REDD+.

In its unique conservation efforts to protect the forests, India strengthened its legal framework and has also undertaken several field conservation measures. It has shown an increase in the forest cover despite massive human and cattle population. It is imperative to measure the carbon stock (both biomass and soil carbon) in the forest in order to estimate the enhanced carbon stock. The enhanced carbon stock in the forest is helpful in compensating the emission reduction activities of India as envisaged in INDC (Intended Nationally Determined Contribution). Eastern Ghats of Tamil Nadu (Javadi hill) in India are taken in the present study and the status of the soil organic carbon (SOC) stock and Normalized Difference Vegetation Index (NDVI) classification are taken up for analysis using sampling techniques and Geospatial technology. The LANDSAT data was analyzed to assess the NDVI and the soil samples were analyzed to estimate the SOC using CN analyzer. All the gridded point samplings were interpolated spatially by Kriging tools. The variations in the NDVI and SOC are spatially estimated for the whole area and the low SOC coupled with low green cover are identified, and precise forest degradation was estimated in the study. As per the Sustainable Development Goals (SDG) 15, reversal of land degradation and eco-restoration are prime components to be addressed with adequate eco-restoration works in conjunction with the agenda of INDC.

Keywords: *REDD+, Climate change, Degradation*

CONTRIBUTION OF TREES OUTSIDE FORESTS IN MITIGATING CLIMATE CHANGE – A REVIEW

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ABSTRACT

Forest Survey of India (FSI) is assessing the forest and tree cover of India since 1987 using geo-spatial technology and publishes State of Forest Report every 2 years. It gives estimate about Forest and Tree Cover in the country. Forest and tree cover consists of contribution of both Forest area and non-forest area which is known as Trees Outside Forest (TOF). It has assessed total carbon in forests for the first time in the India's State of Forest Report, 2011(ISFR,2011). Crisis due to climate change is threatening human kind day by day. Forests play an important role in mitigating the effects of climate change by absorbing the CO₂ from the atmosphere. Afforestation and reforestation are one of the cheapest ways of mitigating effects of climate change.

In the current paper contribution of TOF in total carbon stored in green cover in one of the states i.e., Tamil Nadu has been examined over the last decade in view of forestry target under Intended Nationally Determined Contribution (INDC) which envisages creation of additional carbon sink of 2.5 -3 billion tonnes of carbon dioxide equivalent through additional forest and tree cover by 2030. There is a little scope to increase forest area in the state due to high population density, urbanisation and competing other land-uses. It can be done only through afforestation on nonforest land, social forestry and agro-forestry. An example of how cyclones cause damage to green cover has been shown for Greater Chennai Corporation.

Keywords: Disasters, TOF, Forest Cover, Tree Cover, Carbon storage

DISCUSSION ABOUT THE RISK CONTROL IN LAKE BIWA BASIN BASED ON THE LANDSCAPE ARCHITECTURE

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ABSTRACT

Shiga Prefecture, Japan, is one catchment that constitutes a large basin surrounded by mountains such as Mt. Hiei, Mt. Hira, Mt. Ibuki, Gozaishodake and Suzuka Mountains.

In the center, there is Lake Biwa occupying one-sixths of the total area of the prefecture. Lake Biwa has been a precious water source for Osaka and Kyoto.

We created a landscape image of the entire catchment by overlaying the SRTM_DEM image measured by the space shuttle Endeavor in 2000 and Landsat image. From this image, we attempted to forecast the impacts on the regional environments due to the wind trail crossing Lake Biwa, microclimates along the lake coast, training at the time of typhoon visit, development of a large-scale housing complex, mega solar power plant project, and so on.

In order to foresee the regional environments and disaster risks, we believe that an extensive systematic structure including hydrology, remote sensing and geographic information system becomes necessary from now on.

Considering the disastrous cases in the recent several years in Japan such as landslides and flooding engulfing houses, understanding of detailed landscape architectures in each region is strongly encouraged from the standpoint of risk management when construction of a mega solar power station or a large-scale housing complex is planned on a slope of a mountain or a wetland regarded as a retarding basin.

Keywords: Landsat 8, temperature distribution, Lake Biwa

WATER QUALITY ASSESSMENT AND MAPPING ON MARINE FISH CAGE SITES IN NASIPIT, AGUSAN DEL NORTE, PHILIPPINES USING REMOTE SENSING AND GIS

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ABSTRACT

Water quality serves as a critical component of an aquaculture system. This study explores the applicability of our previously developed geoinformatics-based framework for water quality modeling and mapping in mariculture environment. This study employed Remote Sensing (RS) and Geographic Information System (GIS) technologies in deriving spectral features and regression models to assess and map water quality where marine fish cages are situated. Physico-chemical parameters like temperature, pH, dissolved oxygen (DO), salinity, and turbidity were utilized to perform correlation analysis while the pixel values of the processed Landsat Operational Land Imager were employed together with the water quality parameters to perform regression analysis. Then the regression models were applied in the inverse distance weighted (IDW) interpolation method to generate water quality maps in a GIS platform. Only the recorded readings of pH and turbidity are at a good level and did pass the prescribed standard for marine water aquaculture. The five parameters showed a weak association to each other. DO yielded the highest R^2 of 100% while two regression models for turbidity garnered an R^2 of 92.7% and 88.4%, respectively. Actual value and predicted value of each parameter were validated using the t-test function. The result of the t-test analysis proved that the estimated water quality values using GIS are statistically the same with the on-site water quality values derived using the Horiba water checker. This study proved the applicability of a Geoinformatics-based WQ monitoring framework in marine waters.

Keywords: *Geoinformatics, water quality estimation, water quality modeling*

REMOTE SENSING APPLICATION FOR PUBLIC HEALTH

IMPACT OF TEMPERATURE ON TUBERCULOSIS ESTIMATED FROM SATELLITE REMOTE SENSING BEFORE AND DURING COVID-19 PANDEMIC

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ABSTRACT

Several epidemiological studies have examined the effect of temperature on health, such as tuberculosis (TB). Previous researches have used temperature data from local station sites but the temperature in an area is spatially variable. For example temperature in the urban area is normally higher than in the rural area because of the urban heat island. Satellite remote sensing data can provide area information and is, therefore useful to quantify the effect of environmental hazards on health in a wider region. To study the impact of temperature on TB, this study estimates Land Surface Temperature (LST) using Landsat 8 data in Yogyakarta City, Indonesia from 2016 to 2020 and analyzes the relationship between temperature and TB cases. The LST estimates were first verified by the temperature data obtained from the Meteorological, Climatological, and Geophysical Agency. Tuberculosis cases from 2016 until 2020 were collected from Public Health Office. The correlation patterns have also been examined before and after the COVID-19 pandemic. The result shows that the satellite-derived LST reasonably matches the ground measurement, and a negative correlation between TB cases and LST can be recognized: the cases number is higher in low LST while the cases number is lower when LST is higher. This can be explained that the increase of TB case number in the lower temperature is because ultraviolet radiation kills bacterium, which impedes the spread of TB in dwellings. However, this correlation cannot be observed after COVID-19 outbreak. The number of TB cases in 2020 (during COVID-19 pandemic) is generally lower than the previous year (2016-2019, before COVID-19 pandemic) in the study area. This study suggests that social restriction policy may potentially affect the spread of TB and thus shows the irrelevant relationship between LST and TB cases during COVID-19 pandemic.

Keywords: *Tuberculosis, Land Surface Temperature, Landsat 8, COVID-19*

GIS-BASED SITE SUITABILITY ANALYSIS FOR THE DEVELOPMENT OF HEALTHCARE FACILITIES IN TACLOBAN CITY

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ABSTRACT

The uneven distribution of healthcare facilities, not only in the Philippines but in other countries as well, causes issues of inequity in access and sufficiency. Health inequity is caused by systemic injustice that results in the variation of health outcomes in a group. Particularly in Tacloban City, Philippines, there are areas that had been identified as underserved due to physical distance to the healthcare facilities (HCF). Notably, 127 barangays out of 138 have access to all seven hospitals in the city considering a 30-minute travel time threshold. Meanwhile, two barangays have access to six out of seven HCFs. The remaining nine barangays, however, were determined to be limited to only five or less HCFs within the predetermined threshold. Another factor contributing to the inequity in access is the suboptimal distribution of the HCFs, with six out of seven located within the southern portion of the city. The outbreak of the COVID-19 pandemic had also revealed the vulnerability of the health system in the city as hospitals had already been at full-capacity. Prior to the pandemic, the tripling burden of disease has become an issue due to the rapid urbanization of the city. The burden in medical demand had also increased due to the rising number of patients being referred to one of the city's biggest and best-equipped hospitals; this hospital is the only major healthcare facility that is located in the north. Increased medical demand, inadequate number of HCFs, and suboptimal spatial distribution of HCFs had exacerbated the health system status within the city.

Thus, this study utilized methods that account for the supply-demand ratio between a hospital's capacity and the population as well as incorporating the realistic setting of distance decay and competition among healthcare sites. These variables had been encapsulated within the Modified Huff Three-Step Floating Catchment Area (MH3SFCA) to target the issue of low spatial accessibility to HCFs. The MH3SFCA quantifies the spatial accessibility of each population location given a predetermined time threshold to promote the principle of regional availability. To further address

the issue of inequity, site suitability analysis by means of multi-criteria decision analysis (MCDA) was applied within the study area. Utilizing ArcGIS for the MCDA process, candidate sites were determined while considering primary constraints which are the spatial accessibility indices (SPAI) and the city's land use map.

The results of the MH3SFCA had identified areas with low and high spatial accessibility through a generated SPAI map. The general trend had shown that, for those areas which are typically closer to the city's central business district and had a population which was serviceable in terms of probable medical demand, these are the communities which had higher SPAI. Communities which had a combination of high probable medical demand and increasing distance from the different healthcare facilities are areas which are shown to have decreased spatial accessibility. Due to the concentration of six out of the seven major healthcare facilities within the central business district of the city, the overlapping service areas allow for greater collective medical service provision to the communities within the urban core. The overlap in service areas of the HCFs significantly improves overall medical provision capacity, and ultimately increases the spatial accessibility of the communities within its proximity.

The considerations for the site suitability map include the generated SPAI map and the land use map. For the study, two cases or scenarios were created for the site suitability maps in order to compare the results. The first scenario (i.e., Case A) focused on the combination of low SPAI and the designated institutional land plots in order to find the intersection and generate the site suitability map. For the second scenario (i.e., Case B), this includes the aforementioned criteria in the first scenario with the addition of the designated agricultural land plots within the city. This scenario considers agricultural land since the policy of the local government unit indicates that idle or non-productive agricultural lands may be converted for institutional use. Having considered the generated SPAI map and the land use map, the generated site suitability map had shown that there is a potential of having a more even spatial distribution of HCFs within the city of Tacloban. Despite the resulting suitable areas close to Southern Tacloban, there were more suitable sites identified traversing the northern and the middle areas of the city than that in the southern portion. After identifying the most suitable service sites, an HCF test point was plotted on a candidate site to verify the suitability map and essentially, visualize the effect of adding a hospital with a substantial bed capacity. Magnifying further, the test point was added in the northern portion, being the proposed site by the local city health office for future HCFs. The new dataset for the SPAI, considering the test point, had resulted in a significant increase of accessibility for the northern barangays.

The results of the site suitability analysis through MH3SFCA-GIS had allowed for the identification of areas which are most appropriate for the future development of healthcare facilities within the city. Having identified these areas and conducted validation of a suitable site through the addition of a hypothetical healthcare facility, the results of the MH3SFCA (i.e., SPAI) had shown significant improvement in spatial accessibility for the areas within the test facility's proximity. Ultimately, the results validate and align with the current direction of the local city health office to locate future HCFs in the northern area. Since the city's southern communities had already been sufficiently developed, future development is rapidly shifting towards the north. Thus, a data-driven approach in healthcare planning could be of great significance in alleviating the inequity in access and availability within the city of Tacloban.

Keywords: *Health Care, GIS, Spatial Accessibility, MH3SFCA*

CARBON MONOXIDE EMISSIONS MONITORING DURING COVID-19 PANDEMIC IN JAKARTA

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ABSTRACT

Jakarta has been known as the capital city, has been dealing with air pollution since many years ago. The main contributor of air pollution in Jakarta is due to large population, and high numbers of transportation, of which still running on diesel fuels, emitting far higher levels of pollutants. Carbon monoxide pollution is associate with number of transportations run in the city. Mobility index provided by Facebook Data for Good has managed to identify people's movement during COVID-19 period (stay put and change in movement matrix's). Therefore, this study aims to analyze the dynamic of carbon monoxide emissions during the COVID-19 pandemic in Jakarta. The results showed the distribution of CO emission in Jakarta and its mobility index of each quarter showed a similar pattern. The quarter 2 of 2020) is presented the lowest CO emission distribution value compared to the other five quarters, ranging from 0.0309-0.0334 mol/m². The low value of CO emission distribution during that period was related to the low community mobility index (index of go) in the same period. While in the next quarter which is quarter 3 2020, the CO emission was relatively increased ranging from 0.031-0.037 mol/m², which associated with the rise of mobility index stay of go value. Therefore, in this study, there is a relationship between the distribution of CO emission with the mobility index provided by Facebook.

Keywords: CO, COVID-19, Jakarta, Mobility Index

REMOTE SENSING AND MAPPING

DETERMINATION OF MAIZE PLANTATIONS ON A LARGE-SCALE AGRICULTURAL BASIN WITH SENTINEL 2 SATELLITE IMAGES

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ABSTRACT

This study focused on the determination of maize cultivated lands in Cukurova Basin, Turkey with the object-based classification of Sentinel 2 satellite images assisted with near real-time field campaigns. Cukurova Basin includes one of the biggest agricultural plains of Turkey and ranks first in the production of maize, soybean and pistachio. In addition, a considerable amount of cotton plantations are applied on the plain in addition to citrus farming, which makes the agricultural pattern of the plain too complex. This study uses a single-date image mosaic as input data for classification. Field campaigns provided several ground-truth parcel data with planted crop type, which is used to extract the spectral responses of crops through image bands. This information is used for defining a threshold-based classification schema. Results of the study indicate that, by designing a threshold-based hierarchical classification schema concerning spectral responses of the crops, over 90% accuracy can be achieved in the detection of maize planted parcels.

Keywords: *Sentinel 2; maize plantation, object-based classification, Cukurova Basin*

DRONE IMAGES FOR MANGO PRODUCTION ESTIMATION

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ABSTRACT

Fruit yield estimation is one of the important objectives of precision farming, which makes it easier for farmers to plan ahead and use resources effectively, but in the past, manual counting of fruit on trees was usually done, which was very labor-intensive. Therefore, this study intends to develop yield estimation techniques using drones and to investigate the following questions.

- (1) To explore the feasibility of drone imagery for mango yield estimation.
- (2) The inspection uses low-cost consumer-grade drone images to estimate the accuracy of the yield.

In the pre-harvest stage of mango harvesting, drone images are used for yield estimation, and the drones are equipped with general RGB cameras to perform. Based on the bagging features evident in the images, remote sensing variables are established to estimate the mango yield, allowing it to achieve the goal of precision agriculture in a cost effective manner.

The detection of mango bagging features in the image is mainly combined with RGB-based vegetation index (green ratio vegetation index, NGRD), local maximum method, and leaf surface bright spot filtering technology to effectively extract bagging features and convert them into remote sensing variables for mango yield estimation with field survey data.

The coefficient of determination of the estimation model was 0.8 or higher for the mango yield estimation results. The coefficient of determination of the validation model was 0.9 or higher. The yield error of each mango tree is less than 4 kg on average, which meets the high precision estimation standard.

Keywords: *Irwin mango, drone, yield estimation, precision agriculture*

ENHANCING BATHYMETRIC MAPPING CAPABILITY USING MULTI-ZONE ENSEMBLE FITTING: FACILITATING EMERGING POST COVID-19 DEMANDS

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ABSTRACT

Determination of hydrospatial information across the marine environment has conventionally appeared by vessel-based acoustic surveys. For the first time in history, the unpredictability COVID-19 health crisis has shut down the entire social and economic sectors across the globe. The continuous nationwide lockdown has made it very difficult to mobilize vessels and survey crews for bathymetric mapping. With the emerging remote sensing technology, hydrospatial specialists today have too accustomed to live and work in the new normality. Apparently, hydrography is clearly undergoing dramatic change which an expanded role to serve an increasing number of stakeholders in the blue economy. In order to seek the maximum benefits from the adoption of forth industrial revolution (IR4.0) paradigms, utilization of high-technology sensors and various unmanned autonomous crafts for bathymetric data acquisition to generate actionable data and information to serve the hydrographic communities. In response to the COVID-19 outbreak, hydrographic communities have been forced to accelerate the adoption of emerging technologies to mitigate its impact. Indeed, satellite derived bathymetry (SDB) has become a recognized tool for acquisition to generate actionable hydrospatial data that can alleviate future economic upheavals. Stakeholders are able to extract the bathymetric depth information from the remotely sensed imagery in a split second without physical mobilization and on-site survey. In this paper a new proposed methodology using multi-zone ensemble fitting is introduced for bathymetric determination across the coastal region from high resolution satellite images. By segmentizing the training sets to fit into several designated depth zones, this sequential ensemble fitting approach demonstrates better performance if compares to the traditional single regression algorithm. Derived conclusion points out that newly proposed method can enhance the current bathymetric mapping capability and deliver precise and accurate actionable hydrospatial information in facilitating the emerging demands, in the post COVID-19 era.

Keywords: bathymetry, satellite imagery, hydrospatial, multi-zone ensemble fitting, COVID-19

ADVANCING THE USE OF LIDAR IN GEOTECHNICAL APPLICATIONS IN HONG KONG – A 10-YEAR OVERVIEW

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ABSTRACT

Hong Kong has been facing chronic hazard of landslides on both man-made slopes and natural terrain. Many landslides have occurred on natural terrain which is rugged, steep, not easily accessible and very often covered by dense vegetation. Acquisition of geospatial information for studying these landslides by conventional surveying methods could be difficult. Over the last decade, the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD) of the Government of the Hong Kong Special Administrative Region has been employing various remote sensing techniques including Light Detection and Ranging (LiDAR), Interferometric Synthetic Aperture Radar (InSAR) and photogrammetry to collect useful geospatial data to support geotechnical studies on landslide hazard. Among various techniques, LiDAR is considered the most effective for the unique terrain setting of Hong Kong. We have conducted LiDAR surveys by using different equipment including terrestrial, airborne, mobile, backpack and handheld devices. The first territory-wide airborne LiDAR survey was conducted in 2010 and we just completed the second one in 2020. With the availability of the LiDAR datasets, we are able to establish more accurate terrain models to support a wide range of geotechnical assessments. Detailed landform information can be obtained by combining the LiDAR data with other sources of data. This can help identify important ground features such as drainage lines, relict landslides, boulders and rock outcrop. Moreover, landslide occurrence can be identified by applying change detection of landform in different time domains. Recently, we have successfully developed a new method for measuring orientations of rock joints from point clouds. The technological advancements have significantly changed our practice of handling problems and have brought about improvements in the efficiency, cost-effectiveness and safety of our work. This paper consolidates our ten-year experience in leveraging the use of LiDAR across various geotechnical applications in Hong Kong.

Keywords: LiDAR, Natural Terrain, Landslides, Ground Points, Geotechnical Studies

**ESTIMATING ABOVEGROUND NET PRIMARY
PRODUCTIVITY OF REFORESTED TREES IN URBAN
LANDSCAPE USING INTEGRATED BIOPHYSICAL
VARIABLES AND REMOTELY SENSED DATA**

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ABSTRACT

Urban reforestation initiatives have been identified as reliable approaches for carbon sequestration and climate change mitigation. Thus, knowledge on net primary productivity (NPP) as a surrogate of net carbon uptake by reforested trees is important for understanding the contribution of reforestation program in the global carbon cycle and climate change regulation. Hence, this study sought to predict NPP of reforested trees in urban landscape using remotely sensed dataset and biophysical variables. Using Sentinel 2 image data and 10 x10 m plot sizes to determine landscape biophysical and biochemical variables, the MOD17 model established an NPPD17 of 6.24 Mg C. ha⁻¹ with a coefficient of determination (R²) of 0.91 and RMSE of 0.83 Mg. ha⁻¹. The findings also demonstrated a significant variation in NPP among reforested trees. For instance, deciduous *Acacia* and *Dalbergia* species obtained higher NPP (7.62 and 7.58 Mg C ha⁻¹), whereas, evergreen *Syzygium* and shrub *Artimisia* produced lower (4.54 and 5.26 Mg C ha⁻¹) NPP. These results demonstrate the strength of remote sensing and biophysical parameters in estimating NPP of reforested urban landscape.

Keywords: *carbon flux, species, MOD17, photosynthetically active radiation*

ESTIMATION AND UPDATING OF DIGITAL SURFACE MODEL (DSM) USING WORLDVIEW-3 DATASET

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ABSTRACT

Very high-resolution satellite sensor is delivered with rational polynomial coefficients (RPC) as an alternative representation of the sensor model. The use of these rational polynomial coefficients has become one of the standards for very high-resolution satellite imagery (VHRSI) for the production of relevant spatial data. The RPC model is used in determining spatial data for all features in the captured satellite image. This paper aims to evaluate the accuracy of a digital surface model (DSM) generated by processing Ortho-Ready Standard imagery from WorldView-3 using supplied RPCs. The method consists of a basic photogrammetry approach to solve four residual equations composed of stereo pairs via the RPC model. In our experiment, image pixel matching was performed based on homography transformation stereo matching in conjunction with normalized cross-correlation coefficient in identifying dense corresponding tie-points between the images. These dense point correspondences generated were then used to determine the three-dimensional coordinates by employing the RPC model. To perform the accuracy test, the three dimensional (3D) coordinates estimated at points of interest using 49 ground control points (GCPs) were evaluated for the image acquired over Thimphu, Bhutan on 27th August 2020. The average root-mean-square errors (RMSEs) of easting, northing and height evaluated for the coordinates estimated from stereo images were 2.90 m, 2.92 m and 1.64 m respectively. The result is based on a bias-corrected RPC model with two shift parameters using one reliable GCP. Additionally, visual comparisons of interpolated surfaces generated using Inverse Distance Weighted and Kriging interpolation mechanisms have been compared. The findings highlight that the proposed method is simple and effective in determining 3D coordinates at points of interest that have the potential to generate explicit image based 3D information resulting in a reasonable approximation.

Keywords: WorldView-3, Image matching, RPC model, 3D coordinates, DSM

**COMPARATIVE INVESTIGATION OF GEOMORPHOLOGY
BY AERIAL PHOTOGRAPH INTERPRETATION (API),
DIGITAL AERIAL PHOTOGRAPH INTERPRETATION (DAPI)
AND AIRBORNE LIGHT DETECTION AND RANGING
(LIDAR) SURVEY: A CASE STUDY IN THE FORMER MA
ON SHAN OPEN-PIT IRON MINE**

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ABSTRACT

Aerial photograph interpretation (API) has been widely applied to the study of geomorphology, which is an essential component of natural terrain hazard study and other geotechnical projects. With the extensive archive of aerial photographs taken in Hong Kong, geomorphological features and change in landform can be well observed from API. In recent years, due to technological advancement, new remote sensing techniques enabling geomorphological studies have been evolved, which may supplement the traditional API. These techniques include digital aerial photograph interpretation (DAPI) and airborne Light Detection and Ranging (LiDAR) survey. This paper summarizes the geomorphological study of the former Ma On Shan (MOS) open-pit iron mine and the adjacent natural terrain to compare the working mechanism, data availability, strengths and weaknesses of these three contemporary landscape study methods.

Mining sites in Hong Kong indicate how human activities have altered the natural environment, but have seldom been discussed in scientific papers. The study at the former MOS iron mine provides a good example to demonstrate the application of different technologies on studying geomorphological features and change in landforms over decades, and to document the impact of human activities on natural terrain. The study concludes that the techniques can provide general information on identifying and observing key morphological features such as cut slopes, tension cracks and landslides, but each technique shows different capabilities. With the appropriate and complementary application of the three techniques, the geomorphology of a region can be described in detail for examining site development history, change in landforms and identification of natural terrain hazards.

Keywords: *Remote Sensing, Mining, Cut Slope, Tension Crack, Landslide*

**DELINEATING RUBBER PLANTATIONS
IN LANDSLIDE PRONE AREAS OF KERALA, INDIA
USING REMOTE SENSING AND GIS**

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ABSTRACT

Traditional rubber growing regions of Kerala state contribute around 75 per cent of natural rubber (NR) production in India. The hilly regions of the state witnessed two massive landslides causing many human casualties and serious damages to the environment and properties in the past couple of years. Natural rubber plantations are mostly grown on the undulating and sloping terrains along the foothills of the Western Ghats of the state which are increasingly becoming vulnerable to landslides. Extremely intense rainfall can destabilize hilly terrains where natural rubber is a popular crop among others. To estimate the spatial extent of rubber plantations according to proneness to landslide in Kerala, satellite-based area under rubber (age 3 years and above) was geo-spatially analyzed with landslide susceptible zones of the state and district-wise extent of rubber plantations susceptible to landslide was estimated (low, medium and high). Results showed that out of the total rubber area in Kerala, 1.6 per cent (9,485 ha) was in the high susceptibility zone, 6 per cent (32,398 ha) in the medium and 2 per cent (13,072 ha) in the low susceptibility zone. More than 90% NR holdings are not in landslide prone region. Area under rubber in the highly susceptible zone of landslide was the highest in Kottayam district followed by Idukki, Kannur, Palakkad and Pathanamthitta districts. This information is useful for planning appropriate conservation and management strategies for rubber plantations in the highly vulnerable areas. Rubber farmers can be better advised to mitigate the risks due to landslides. An open source WebGIS based portal was developed for easy dissemination of this information to rubber growers. Good agricultural practices for adoption at a location according to its vulnerability to landslide as well as cultural operations that should not be undertaken are recommended to minimize the occurrence/impact of landslides through this platform.

Keywords: *Good agriculture practices, Kerala, Landslide susceptible zones, Rubber plantations, Satellite data*

AUTOMATIC RETRIEVAL OF RAILWAY MASTS TILT ANGLE FROM MOBILE LASER SCANNING DATA

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ABSTRACT

Mast plays an essential role in supporting objects, i.e., catenary, droppers, etc., in the railway electrification system. The condition of the tilt railway mast can influence the entire railway transportation safety. Therefore, the tilt angle of the railway masts needs to be retrieved to prevent damage. This study proposed an automatic method to retrieve the tilt angle masts by using Mobile Laser Scanning (MLS) point clouds data. Forward, the automatic method was tested into two-track locations, which in New Taipei city and Yilan county, in the north of Taiwan, respectively, had been used in our automatic detection method. The data was acquired two times, on July and October 2019. There were two main steps to retrieve the tilt condition of the railway masts. Firstly, point clouds were clustered by using Euclidean Distance Clustering and detected the masts by setting parameters. Secondly, the tilt angle of the mast was obtained by Principal Component Analysis (PCA) and was calculated based on vector-based. The result showed that 90% and 89% masts were detected in New Taipei City, respectively in the first and second acquisitions. In Yilan county, 82% masts were successfully detected. The RMSE of the tilt angle estimation result was 1.2° and 1.6°, respectively in New Taipei City and Yilan county.

Keywords: *Masts Detection, Tilt Angle, Mobile Laser Scanning (MLS)*

VIRTUAL CAMPUS TOUR GENERATION USING UAV DATA: CASE STUDY GEBZE TECHNICAL UNIVERSITY

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ABSTRACT

In recent years, with the remarkable development in game engines, virtual reality (VR) technologies, which immerse users inside a synthetic environment, became very popular and were increasingly integrated to the visualisation of geospatial data. In Covid-19 pandemic, restricting people's mobility, the interest on VR visits was rapidly increased. In the scope of a scientific research project, a three dimensional (3D) virtual tour for Gebze Technical University Campus was generated by integrating very high resolution unmanned air vehicle (UAV) data into a virtual environment utilizing Unity game engine. Regarding high geolocation accuracy and spatial resolution, low cost, short processing time, and 3D realistic model generation performance, UAV data is largely demanded in varied scientific and commercial applications. In this study, the campus area was collected with 2.18 cm ground sampling distance (GSD) from 80 m flight altitude using 20 MegaPixel UAV digital camera. The UAV data was processed by Agisoft Metashape, structure from motion (SFM) based image matching software, and then high-quality 3D textured models were generated. The aerial imagery was oriented by ground control points (GCP), carefully distributed in the study area. The geometric accuracy of the image orientation was calculated as ± 8 mm (~ 0.4 pixel). For virtual reality integration, first, the 3D textured models derived from UAV data were imported into the Unity game engine. After that, optimization techniques including Occlusion Culling, Space Subdivision were applied to the models to prevent problems that may arise due to transferring high poly models to game engines. Thus, objects and textures have been transferred with the highest resolution to achieve a realistic virtual experience. For creating a more detailed and realistic environment, 3D models of trees, lighting poles, benches, arbours, and information panels were added to the model using available assets in Unity. Also, the metadata about buildings (e.g. building name, floor area and number of staff) were added to the 3D building models. Finally, a player with a first-person camera is implemented for the virtual tour in the integrated 3D models. In this study, the encountered problems and recommended solutions for creating virtual campus are presented.

Keywords: UAV, SFM, 3D Textured Model, Virtual Reality, Unity

3D POSITIONING ACCURACY AND LAND COVER CLASSIFICATION PERFORMANCE OF THE UAVS: CASE STUDY OF DJI PHANTOM IV MULTISPECTRAL RTK

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ABSTRACT

Unmanned air vehicle (UAV) has become an indispensable mobile mapping technology of remote sensing thanks to offering low cost and high resolution spatial data. Particularly, camera equipped optical UAVs are large in demand by land-related professions, including mapping, agriculture and forestry. Regarding the requirements, the technological level of the optical UAVs rise day by day by adding novel payloads. For instance, global navigation satellite system (GNSS) receivers with real-time kinematic (RTK) positioning capability were added to facilitate the field work for ground control point (GCP) set up and measurements before UAV flights. Multispectral cameras were added to increase the automatic land cover classification potential of generated ortho-mosaics. At this point, the most significant question is the contribution level of these technological payloads. In this study, our research group evaluated the RTK GNSS positioning accuracy and automatic land cover classification potential of “DJI Phantom IV Multispectral RTK”, which is one of the most common optical UAVs for scientific and commercial applications. For the evaluations, a study area that includes a large variety of land cover classes was selected. The UAV RTK GNSS positioning accuracy was calculated by comparing with the measured GCPs on the study area. Furthermore, the land cover classification performance of Multispectral UAV was analysed by pixel and object-based classification techniques separately. For this purpose, while spectral angle mapper (SAM), minimum distance (MD) and maximum likelihood (ML) classifiers were applied to perform pixel-based classification, nearest neighbour (NN) classifier was employed to utilize object-based classification. The positioning accuracy results demonstrated that the root mean square error (RMSE) of UAV RTK GNSS is ± 1.1 cm in X, ± 2.7 cm in Y, and ± 5.7 cm in Z. The classification results showed that the highest overall accuracy was estimated as 93.56% with ML classifier and its classification performance was found to be superior compared to those of SAM (73.46%) and MD (75.27%) classifiers. On the other hand, the overall accuracy was calculated as 90.09% for object-based classification and it was 3% lower than pixel-based ML classification result. This could be the result of heterogeneity of the image objects created during the segmentation stage. Further studies are required to improve the object-based classification accuracy by applying different segmentation methods and quality measures.

Keywords: UAV, Multispectral, GNSS, RTK, Automatic Land Cover Classification

THE ESTIMATION OF URBAN EXPANSION EXTENT AND FRACTAL DIMENSION

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ABSTRACT

Urban expansion leads to severe negative impacts such as an increase in motorized transport, air contamination, water and noise pollution, excessive energy consumption, a loss of agricultural land and a reduction of pre-urban biodiversity. Information on current urban extent spatial metrics and the dynamic of land use/cover change is essential for urban planning as a "crucial clue". The aim of this study is to measure the shape of the Khovd town and to prove the 20-year time series change of spatial expansion through the fractal geometry of urban land use with the help of mathematical procedures and GIS analysis. The study area is located in the north-western part of Mongolia in geographic point location N 48 ° 00'15 " latitude and E 91 ° 38'26 " longitude, at an altitude of 1380 m above sea level. Khovd town was chosen for the study area as a major hub for the western economical region and political administration.

The shape, land patches distribution, and expansion of the urban area were analysed based on the created feature layer of the Geographic Information System (GIS). GIS feature layers were developed based on data from cloud-free Landsat images of thermal mapper (TM), enhanced thermal mapper (ETM), and operational land imager (OLI), which were acquired for the nearest same month time frame 2000, 2010, and 2020. The time-series satellite images were downloaded from the website of the US Geological Survey. The Landsat images were additionally rectified to datum WGS84, and resampled using the cubic convolution algorithm with a pixel size of 30 by 30 m for all time-series 3 satellite images. The supervised classification with sampled objects was used for the classification of the land use classes and urban expansion extent. Maximum likelihood classification is one of the well-known parametric algorithms and it was used for supervised classification in our study. To be more accurately represent the urban land use, Landsat imageries (30 m resolution) were reclassified and the accuracy and detailed classes added through onsite land surveyed map layers for the detailed sub-classification of urban land use, such as low-density residential (slum area) and sparse suburban land (peri-urban area) classes.

The fractal dimension index is an accepted method in international urban research, and is especially important for accurately determining urban expansion. Concepts from fractals can be used to optimize the spatial structure of cities in future urban planning. A compactness ratio is a key urban geography index for research on urban spatial expansion extent. Compact urban shape extent is one of the most effective solutions for sustainable development under the rapid growth of the urbanization. The concept of a “compact city” was first proposed by Dantzig and Saaty in 1973, and since then a methodology of measuring urban compactness has been an interesting topic on urban study. The novelty of our study is an application of a compactness index together with fractal dimension index which is not widely used in urban study.

A slight decrease in fractal dimension ($D\Delta t = 0.01$) indicates that in 20 years the urban envelope was already started to extend but in the right geometrical shape forms. The density index in Khovd has increased over 20 years (0.25-0.28) and is relatively stable and the densest urban land patches are concerted right behind and around the downtown center. The expansion of Khovd town shows relatively stable and correct shape form extent and the areal expansion of urban area was 3238 ha or average annual growth of 162.4 ha /years in 20 years, while perimeter growth is 43325 m (2166.25 m/years), which is represented quite compact and relatively stable expansion. Briefly, Khovd town development is sustainable in sense of land management. However, need to pay attention to the slight growing increase in the urban expansion. There's no significant readjustment plan for the low-density slum district reconstruction and therefore urban expansion sustains the most possible way to land exploitation. For that reason, at the municipal level, there are should look at rural area sustainable development in parallel to the town readjustment urban planning. Our study results indicate that it is more effective to study urban expansion (especially fractal geometry), to use GIS and remote sensing methods for urban spatial metric study.

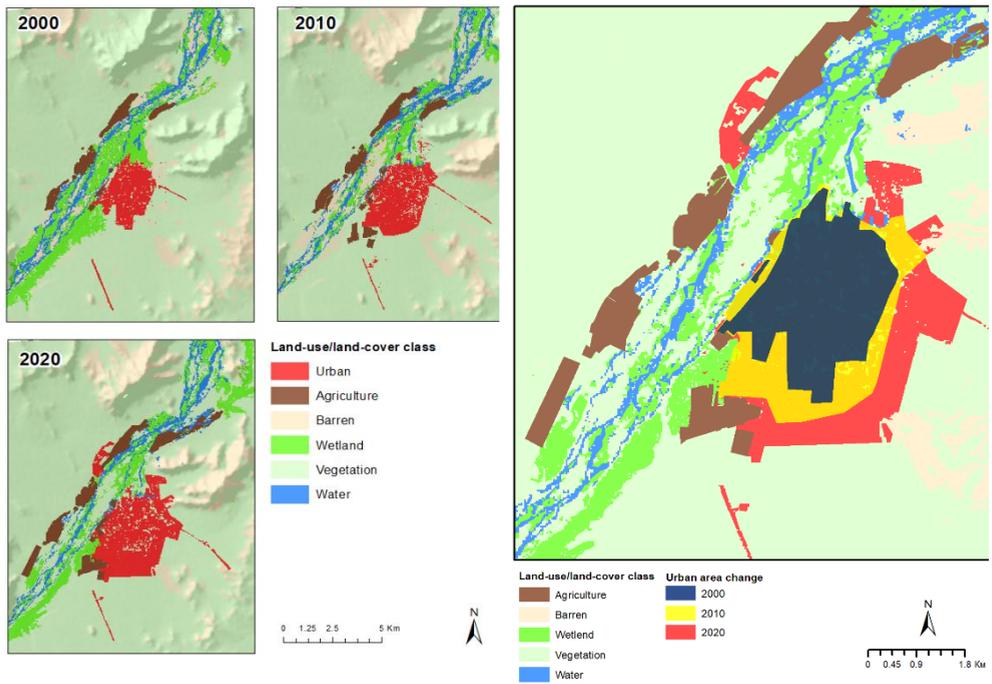


Figure 1. Main land use/land cover change of Khovd town (2000-2020)

Keywords: Spatial metric; Urban growth; Urban remote sensing; Urban area perimeter relationship

EVALUATION OF SATELLITE IMAGERY DATA FOR CROP YIELD SIMULATION IN SARABURI PROVINCE, THAILAND

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ABSTRACT

Climate change could be a severe cause of disaster as well as food shortage. As the climate, society, and the environment change, these could bring more difficulties for agricultural planning because of unexpected decreasing yields of food crops; this could create a poverty situation. Therefore, an appropriate crop yield estimation methodology should be developed to help individual farmers plant crops. It is not only for adequate and safe food crops but also sustainable agricultural planning. A crop yield model is a technology that could be the best tool for farmers and researchers to develop yield products and farm management. Many crop-model studies have applied low-resolution data over a large area, and therefore the yield calculation of a whole district or village has resulted in the exact figure, whereas in reality, many paddy areas have a fragmented pattern with small rice plots. This study emphasized transplanted rice in a tiny area in Saraburi province. Field survey experiments have been conducted at observing rice characteristics to calibrate the crop parameters for local rice varieties. The cultivar-specific and agricultural practices were measured and evaluated. Integration of moderate-resolution satellite image and the AquaCrop model was performed to extract the essential crop parameters of paddy for yield simulation using the model. The green canopy cover (CC) information derived from the satellite data has provided acceptable results through the rice yield simulation and observed yield validation.

Keywords: *CC, Crop model, Landsat 8, Saraburi, Vegetation Index*

UP-TO-DATE GEOLOGICAL MAP OF LAKE CHAD IN CENTRAL AFRICA USING GEOSPATIAL APPROACH

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ABSTRACT

The Lake Chad area has witnessed many years of shrinkage for over 50 years in the region and also geological features played a vital role. This has led to the shortage of food supply and low level of economic activities which directly affect livelihoods of the inhabitant of the environment. For that reason, there is an urgent need for remediation and prevention of further devastation to the environment in the area. Hence, this requires extensive and comprehensive investigation. The research is aimed at investigating the impact of geological features of water surface area fluctuations using geospatial approach in Lake Chad, Central Africa. Likewise, all the relevant published maps and information from different data sources in respect to geological structures of the study area were considered with a view of providing an up to date map and all the map layers were collected to show diverse levels of details geographical features at various scales to enhance uses of the map. Map compilation, GIS digitisation and map production were performed for final map production. The results revealed that the geological map of the study area illustrates the area covered for each class in terms of percentage. Therefore, this percentage indicates the composition of geological types within the study area.

Keywords: *geological map, geological features, geospatial approach, fluctuations*

CORRELATION MODEL OF OIL PALM AGE BASED ON OPTICAL AND RADAR SENSORS

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ABSTRACT

Indonesia is the largest producer of palm oil that is 80% of palm oil is used for edible products and 20% is used for the oleochemical industry. Oil palm is one of the plantation commodities that provides the highest income, however nowadays the oil palm production has decreased because of older, pest and diseases. One way to increase the productivity of oil palm it can do by continuous monitoring through the age of the oil palm. Monitoring the age of oil palms can be done by applying remote sensing technology using optical and radar sensors. The objective on this study is to investigate Correlation between Oil Palm Age with NDVI on Landsat 8 and backscattering on Sentinel-1A satellite imagery. Study case in the Asahan area, North Sumatra Province, Indonesia. Processing data in this study using the Cloud Computing Google Earth Engine platform. The data that is used as a parameter in the extraction process for Landsat-8 images uses the NDVI vegetation index value, while the Sentinel-1 SAR data uses C-Band with 2 VV and VH polarizations which produce backscatter values. The result was found correlation model of Landsat-8 image is $y = -0.0002x^2 + 0.0052x + 0.7685$ with $R^2 = 0.85$. In sentinel image the correlation model generated for each polarization is $y = -0.0039x^2 + 0.1193x - 7.9247$ with $R^2 = 0.85$ on VV polarization and $y = -0.0036x^2 + 0.1242x - 15.344$ with $R^2 = 0.81$ on VH polarization. From these results, both have different model values with different R^2 values. On this case NDVI and sentinel-1 on VV polarization is the best result and the most correlated.

Keywords: *Oil Palm, Age, NDVI, Sentinel, Google Earth Engine*

STUDY ON MMS POINT CLOUD AND UAV IMAGES FUSION TO CONSTRUCT 3D MAP

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ABSTRACT

Due to rapid growth and changes in urban areas and the importance of updating data and information rapidly, accurately, and seamlessly, having a system that can provide 3D information with those characteristics is very important for smart cities. These 3D data can be very essential for generating and establishing Geospatial Information Science (GIS). Utilizing GIS techniques provides an opportunity for analyzing, studying, and modeling of environment and structure in urban areas. For that reason, methods and platforms for acquiring and collecting 3D data are important, because the accuracy, speed of gathering, and obtaining data from every possible view for covering everything are very important factors. In order to generate 3D maps, there are two main ways to obtain data, acquiring 3D data directly by using laser scanners or reconstructing 3D data from 2D overlapped images.

To simulate the situation in the urban area and covering every possible view, data were acquired by using two different platforms, Unmanned Aerial Vehicle (UAV) was used for obtaining data from the top view, and Mobile Mapping System (MMS) was utilized to gather 3D point cloud data from the ground view, data were gathered from Yonsei university campus and Yeonhui-dong area in Seoul, South Korea. To cover the study area with the size of 1.6 km², four thousand images with 80 percent forward and lateral overlap were captured by using UAV, the height of flight was 120m and the ground sampling distance for images was 3cm. 3D point cloud by employing MMS obtained from the same area within 1 hour, the number of points were around 477 million points and size data was 15 GB. In this research, we assume that the point cloud from MMS is calibrated and well georeferenced with the accuracy of ± 12 mm.

The first step is to reconstruct point cloud from UAV images but because GPS/INS data for EOP parameters are not accurate enough and the purpose of this research is obtaining accuracy at cm level, it is necessary to have enough Ground Control Points (GCP) from the study area, however gathering GCPs using GNSS receiver or field surveying over a large area is time-consuming, as mentioned earlier since MMS data are calibrated and

well georeferenced then point cloud obtained from MMS can be a good reference for extracting GCPs. For the purpose of extracting GCPs from the 3D point cloud, the Cloth simulation filter (CSF) is applied, in order to segment point cloud to ground and non-ground points, CSF turns the original point cloud upside down and puts a cloth on the overturned point cloud, the ground and non-ground points segments by analyzing nodes of the cloth. Because MMS data are from the road and in this research, our goal is to extract objects from the road and use them as GCPs just ground points were preserved for extracting roads. The top view 2D image is generated from ground and road points. In the next step with using deep learning methods, roads were extracted from UAV images to reduce the possibility of miss matching between 2D images from MMS and UAV images. By using SIFT algorithm and RANSAC well-matched points between UAV images and MMS 2D images were extracted, then 3D coordinates for matched points are extracted from the point clouds. With using of matched points as GCPs in the process of SfM 3D point cloud reconstructed from UAV images. Results for Point cloud construction from UAV and MMS data were registered by using the method of 3D rigid body transformation. 3D rigid body transformation keeps the scale equal to one shape of objects do not change, therefore in the 3D rigid body transformation angles and lines length will not change, but point positions will change. Therefore 3D rigid body transformation has three rotations, three translations and the scale factor is equal to one. This transformation is useful in point cloud registration for reducing distortion in the whole dataset. Point cloud from MMS and reconstructed from UAV integrated by using K-d tree and application of that, Nearest Neighbor search, to replace MMS point cloud in the UAV point cloud and integrate them.

In order to check the accuracy of the proposed method, the same procedure was done without using any GCPs. 10 checkpoints were acquired with the VRTK method by utilizing GPS. And RMSE for both integrated data for 10 checkpoints were checked. The RMSE for Dataset with GCPs from MMS point cloud for X, Y, Z were 0.126m, 0.177m, 0.066m but without using any GCPs RMSE for reconstructed data was 1.686m, 6.035m, 8.404m. By comparing results with using extracted GCPs from MMS and without using any GCP we can see the accuracy improves considerably and also we can see that the time of acquiring data is much shorter than acquiring data from GNSS land surveying and also MMS gives many GCPs compare to the GNSS. Most importantly data from two different views were acquired and better and seamless coverage for the area was obtained.

Recently in many filed such as smart cities, autonomous cars, utility management, and so on accurate 3D information is necessary. Since cities rapidly change updating 3D information in a short time and accurately is needed. This research proposed a method to obtain 3D information from the urban area by using UAV and MMS. By performing the fusion of 3D

information from the UAV and the calibrated MMS data, we can obtain the following conclusions. RMSE of 0.126m, 0.177m, 0.066m for X, Y, Z was obtained by improving the EOP of UAV images by extracting GCPs from calibrated MMS point cloud. This indicates that calibrated MMS point clouds can be useful sources of ground control points for UAV imagery. 3D rigid body transformation was applied for registration of point cloud. Finally, an integrated point cloud was successfully generated by using the K-d tree, KNN searching algorithm. The proposed method shows the efficient way of obtaining seamless 3D geospatial data by integrating UAV imagery and a 3D point cloud from the calibrated MMS.

Keywords: UAV, MMS, Point Cloud, Fusion

OBSERVATION OF SUSPENDED SEDIMENT ALONG THE NORTH OF TAIWAN COASTAL WATER REGION FROM THE FORMOSAT-5 HIGH-RESOLUTION IMAGERY

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This extended abstract describes the use of the Formosat-5 (FS5) high-resolution imagery to observe suspended sediment along the coastal water belongs to the north of Taiwan.

1) Context/Purpose

Formosat-5 (FS5) was launched on August 25, 2017, continues the mission of its predecessor, Formosat-2, which was decommissioned in August 2016. FS5 is operated by the National Space Organization (NSPO), Taiwan, and provides high-resolution images with the spatial and temporal resolution are 4-m resolution multispectral (color) and one-day visiting, respectively [1]. There is not any study to consider FS5 to determine the optical characteristics of water in coastal regions. Therefore, we propose the use of the satellite for observation of suspended sediment (SS) concentrations in Taiwan's coastal water regions. We believe the key findings of this study will be a significant contribution to not only the 42nd Asian Conference on Remote Sensing but also the scientific community.

2) Methods and materials

The data processing consists of two steps: removing the atmosphere's influence and calculating suspended sediment concentration.

We propose a simple approach to convert the digital number (DN) into remote sensing reflectance (R_{rs}) using linear regression based on five different ground targets belong to the north of Taiwan. These targets include 60 samples were divided into two categories, namely bright targets and dark targets [2],[3]. The bright targets included the surface materials such as asphalt, concrete, roofs. The dark targets included vegetation and the surfaces of lake water. The remote sensing reflectance (R_{rs}) of ground targets derived from the Landsat-8 Operational Land Imager (OLI) satellite images were atmospherically corrected using the Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH) model in the ENVI application [4].

Suspended sediment concentrations were computed by using a model developed for Taiwan coastal waters with a good agreement between transformed data and observed SS concentrations. To ensure a developed model makes sense, we set the smallest correlation coefficient for each band to be 0.82 ($R^2 \geq 0.82$). We used nine designated positions from the Environmental Protection Administration (EPA) located in Taiwan's north coastal waters to develop the model. SS values from EPA were transformed by using data from Landsat-8 images at the same positions [5].

3) Results and Discussion

The results of removing the atmosphere's influence part indicated that linear regression performed well done on the four bands of the images between FS5 and OLI. Particularly, the largest correlation coefficient was obtained by the red band ($R^2 = 0.94$), whereas the smallest correlation coefficient was obtained by the blue band ($R^2 = 0.87$). Furthermore, we used the spectral profiles belonging to both vegetation and water objects to cross-check from the blue to NIR band. The results regarding spectral profiles provide good performance in spectral forms.

The results also indicated that the remote sensing reflectance of FS5 images can be useful for estimating SS concentration (g/m^3) in the north of Taiwan coastal water region with both green band ($R^2 = 0.83$) and red band ($R^2 = 0.85$).

$$SS = 392.80 * Rrs(\text{Green}) - 5.63 \quad (1)$$

$$SS = 425.97 * Rrs(\text{red}) - 3.02 \quad (2)$$

Both equations (1) and (2) provided $R^2 > 0.82$, so they make sense for computing suspended sediment concentration. We decide to choose equation (2) for Taiwan's coastal water region.

There are some issues such as the accuracy assessment, discussion of SS algorithms, and cross-check of SS derived from FS5 with in-situ measurements that need fully investigated in the future.

4) Conclusions

The linear regression provided a good relationship between FS5 and OLI with the coefficients of determination for blue, green, red, and near-infrared bands with a range of (0.87-0.94). It indicates that the remote sensing reflectance derived from the FLAASH provides a good bridge to convert DN to Rrs conversion aim to remove atmospheric effects on FS5 images. The results also suggested that after removing the effect of atmospheric, suspended sediment concentration in the north of Taiwan coastal water region can be observed by using the red band of FS5 high-resolution imagery.

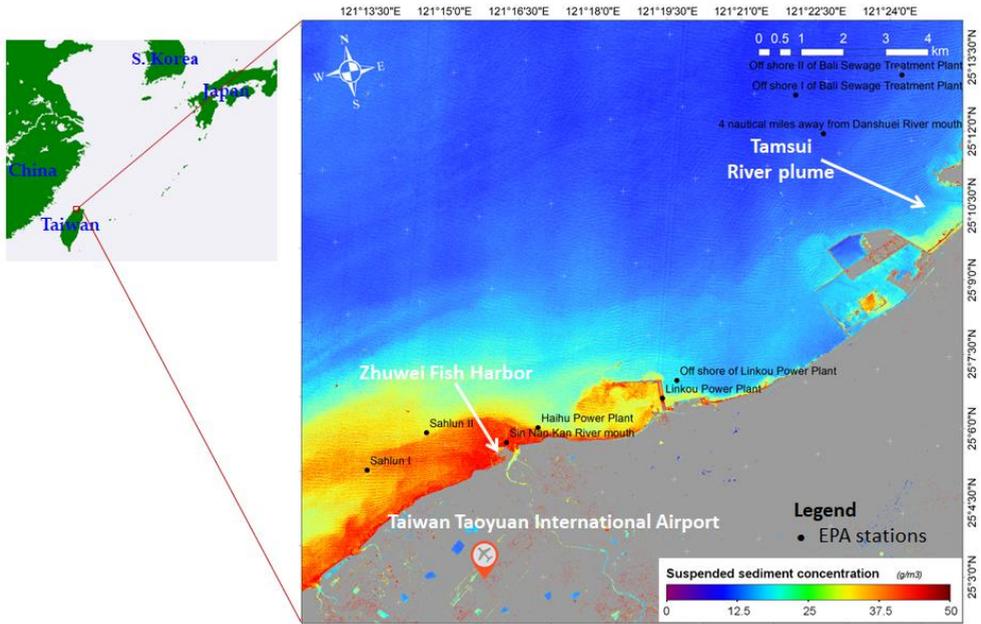


Figure 1. FS5-derived SS concentrations in the north of Taiwan coastal water region

Keywords: *Formosat-5, suspended sediment, coastal water, Taiwan*

Acknowledgment

The authors would like to thank the NSPO of Taiwan for providing FS5 satellite images.

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A COMBINATION OF NORMALIZED DIFFERENCE VEGETATION INDEX AND MULTI-TEMPORAL RADAR VEGETATION INDEX OF SENTINEL DATA FOR LANDUSE/LANDCOVER CLASSIFICATION

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ABSTRACT

Landuse/Landcover (LULC) plays an essential role in managing and monitoring natural resources and the environment in many countries. Optical satellite imagery provides a primary data source for LULC mapping. Unfortunately, the application of the optical image is limited due to the effects of clouds, especially in the tropical area in Vietnam. Microwave imagery can observe during the day and night with nearly all-weather capability. Currently, Sentinel-1 satellite with microwave sensor, operated by the European Space Agency, supplies SAR data with global coverage free of charge. This article presents the combination of the Normalized Difference Vegetation Index (NDVI) of Sentinel-2 data and the multi-temporal Radar Vegetation Index (RVI) of Sentinel-1 data for LULC mapping. The Support Vector Machine (SVM) method was used and the classification accuracy achieved 86%. The study area is in Hanoi, Vietnam, with many landcover features and various plants such as fruit trees, paddy rice. As a result, combining the NDVI index and the multi-temporal RVI index can classify the species of trees and help to improve the applicability of Sentinel satellite data in landcover change monitoring.

Keywords: *LULC, NDVI index, RVI index, Sentinel images*

PERFORMANCE IMPROVEMENT OF VISUAL ODOMETRY WITH IMU-STEREO CAMERA FOR INDOOR UAV

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ABSTRACT

UAVs used for infrastructure inspections require positioning and ranging to protect against collision accidents with structures in worse GNSS positioning environments such as spaces under a bridge. In this study, we focus on Visual Odometry to achieve positioning without GNSS. Each camera estimates rotation and translation parameters with Visual Odometry processing. In addition, we discuss an adjustment control of accumulation errors in Visual Odometry. First, relocalized positions are detected as a loop closure point in Visual Odometry processing. Second, detected positions are used to estimate an error adjustment value. Finally, the accumulation errors are gradually rectified after the relocalization in a flight. Because the error correction with loop closure causes sudden behavior-changing of UAV, the error correction is processed step by step. Through the accuracy evaluation experiment of Visual Odometry, we confirmed the position estimation accuracy was less than 0.02 [m] in indoor environments. Moreover, we confirmed our methodology can achieve an accumulation error control to improve relocalization processing in Visual Odometry for stable flights of indoor UAVs.

Keywords: *Visual Odometry; Stereo camera; IMU; Indoor UAV*

EXAMINATION OF TIME-SERIES GENERATION METHOD OF SATELLITE DATA FOR VEGETATION MAPPING IN A CLOUDY REGION

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ABSTRACT

With the recent developments in satellite remote sensing technology, the spatial resolution of observation data has increased, and detailed spectral information of the land surface has become available. The high resolution satellite images have been utilized frequently for producing vegetation maps in wide areas by applying machine learning techniques to their analysis. However, cloudy and outer values are major obstacles in the production of vegetation maps with higher accuracy from the satellite images. In the conventional method, cloudy pixels are removed based on a quality assessment that estimates the probability of clouds, and composite images are generated on a monthly or seasonal basis. The monthly or seasonal composite images generated by the conventional method can be useful to the discrimination of vegetation physiognomic types such as deciduous broad-leaved forests. However, the monthly or seasonal composite images might be lacking the temporal information required for distinguishing vegetation types at a community level such as beech forests. The purpose of this research is to generate time-series data that maintains high temporal resolution without losing the temporal information while removing the clouds and outer values, as a prerequisite for producing improved vegetation maps in a cloudy region. This research was conducted in Tadami Biosphere Reserve located in Fukushima prefecture in the north-east of Japan. The Tadami Biosphere Reserve is a mountainous and cloudy region with plenty of snowfall in winter. This research was implemented for 2020 by acquiring and processing Sentinel-2/Multispectral Instrument (MSI) data (95 scenes in total) from November, 2019 to February, 2021 that included the scenes of 60 days before and after the study period. In the newly proposed methodology in this research, cloudy and outlier pixels were detected and extracted by quantile analysis in a 60-day moving window period, and the time-series data were generated by applying movement statistics in a 30-day period. In comparison to the conventional method that depends on the quality of cloud flags and is susceptible to the loss of temporal information in the course of generating monthly or seasonal composite images, the newly proposed methodology in this research could generate a smooth, continuous and stable time-series data by retaining the temporal resolution.

Keywords: Temporal resolution, Vegetation map, Sentinel-2, Complement method, Tadami Biosphere Reserve

**ANALYSIS OF THE RELATIONSHIP
BETWEEN URBAN HEAT ISLANDS AND LAND
USE BY REMOTE SENSING TECHNIQUES
(A CASE STUDY OF COLOMBO DISTRICT, SRI LANKA)**

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ABSTRACT

Urban Heat Islands (UHI) can be described as areas that experience high temperature conditions when compare to the surrounding rural areas. UHI is one of primary impacts of Global Warming and there is a high probability of creating UHIs in urban areas. Colombo district represents the 77.6% (1,802,904) of total urban population while it has been developed as the major commercial city.

The main objective of the study was to determine the relationship between urban heat islands and land use (LU) types in study area and specific objectives were to estimate the pattern of Land Surface Temperature (LST) using Land sat 5/8 images, to identify the UHIs in the study area, to identify the different land use types and their thermal properties and to analyze the relationship between temperature and different LU/LC types.

LST was derived using Landsat images of 1997, 2007 and 2017 which were downloaded through USGS website. The software ArcGIS 10.3 version was used to calculate LST and Google Earth Pro software and land use maps developed by Survey Department were used for ground verification. Both Normalized Difference Vegetation Index (NDVI) and Normalized Difference Built Index (NDBI) indices were used for this study to analyze the relationship between UHI and LU/LC types.

According to the results totally 46.3 km² (6.77% from total land area) in Colombo District have been found indications of intensifying UHI effect. Municipal Councils (MC) has highest extent of UHI areas and lower extent of UHIs identified in Pradeshiya Sabhas (PS). The maximum temperature recorded as 31.550C from an industrial zone located in one of the MCs and minimum temperature was 21.610C reported from a Rubber land located in PS. Properties of LU/LC in urban areas decide the albedo of the surface that

directly relate with urban temperature. The lands which are densely covered with vegetation, water areas and wetlands represented low temperature values while built-up areas represented high temperature values. There was a direct relationship between UHIs and LU/LC. The output of this study can be utilized effectively for sustainable development of urban areas and proper urban planning in future. The public can aware regarding effects of UHIs to minimize impacts and encourage maintaining of green environment. Further it is recommended to do studies on the impacts of UHIs on human health.

Keywords: *Land Surface Temperature, Land Cover, NDVI, NDBI*

URBAN RIVER MAPPING BY BOAT-BASED MOBILE LASER SCANNING WITH PPP-RTK

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ABSTRACT

In recent years, Mobility as a Service (MaaS) has been discussed to provide new transportation technology services with GIS, IoT, and automated driving technology. In waterfront areas, autonomous water buses and taxis have been developed to integrate land transportation services, such as trains, buses, and taxis. As well as autonomous vehicles and trains, autonomous ships require precise 3D maps and position data obtained by GNSS positioning. Therefore, we focus on 3D measurement with laser scanning and PPP-RTK with QZSS CLAS (centimeter-level augmentation service) to improve the accuracy and performance of GNSS positioning. However, rivers in urban areas, especially in Tokyo, have poor GNSS positioning environments such as places under bridges and highways. Thus, we also focus on Simultaneous Localization and Mapping (SLAM) using laser scanners as a self-positioning approach to achieve indoor-outdoor seamless positioning. In this study, we experimented with 3D river mapping for autonomous ships. We used two laser scanners and a multi-frequency GNSS receiver mounted on a quick charging plug-in electric boat. We selected two rivers as our study areas. The first is Kanda-gawa river as a typical river in Tokyo. The second is Nihonbashi-gawa river as a GNSS-denied environment. In this paper, we present the results of our preliminary experiments.

Keywords: *3D mapping, PPP-RTK, SLAM, Indoor-outdoor seamless positioning, Mobile Laser Scanning*

ASSESSMENT OF LAND SURFACE TEMPERATURE IN DRY AND WET SEASON USING SENTINEL IMAGERIES IN CAMERON HIGHLANDS, MALAYSIA

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ABSTRACT

Land Surface Temperature (LST) is a fundamental aspect of climate and ecosystems from local to global scales. LST and its spatial variations are the main parameters of highland climate and human-environment interactions study. Agricultural activities in high topographic elevation influence climate change, where without proper land cover (LC) planning of agriculture activities have resulted in various environmental issues such as soil erosion and muddy flood, water quality, and rising LST. Due to weather suitability, Cameron Highlands has extensive agriculture activities which resulted in rising LST variation. Thus, this study was carried out to investigate the relationship between LST and Land Cover (LC) in Cameron Highlands based on Normalized Difference Vegetation Index (NDVI), Normalized Difference Build-Up Index (NDBI), and Modified Normalized Difference Water Index (MNDWI) qualitatively from Sentinel Imageries over the dry and wet monsoon seasons in Malaysia. The results of the study show that the accuracy of LC and LST output is better than 90%. As the impervious surface increases, the surface temperature of the area increase, whereas decreased in the vegetated areas. The quantitative relationship between LST and NDVI, NDBI, and MNDWI are then analyzed using a linear regression model to find the impact of LC on LST. It is found that the satellite-derived emissivity values are in the acceptable range with the vegetation indices (VI) and fractional vegetation cover is effective in deriving surface emissivity. LST is also highly dependent on seasonal radiation conditions, especially during the monsoon season and its effects, resulting in an excessive estimation of cooling values. This study is crucial for land planning and environmental care on the climate impacts of land-use change for appropriate policy measures for sustainable agriculture management in Cameron Highlands.

Keywords: Land Surface Temperature, Land Cover, Vegetation Indices, Sentinel 2, Sentinel 3 SLSTR

A REGIONAL SCALE MAPPING OF BAMBOO GROVE DISTRIBUTION USING MACHINE LEARNING WITH MULTI-TEMPORAL LANDSAT-8 OLI IMAGERY

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ABSTRACT

This study created a map of bamboo grove distribution over a regional scale, aiming to support the forest management planning in Japan. First, the classification performance of Machine Learning methods was evaluated using multi-temporal Landsat-8 OLI imagery acquired in the period from 2013/04/26 to 2019/12/23. Representative six Machine Learning methods such as Artificial Neural Network (ANN), Support Vector Machine (SVM), k-Nearest Neighbor (kNN), Random Forest (RF), C5.0 and eXtreme Gradient Boosting (XGB) were employed for predictive modeling of land use / land cover (LULC) classes including a bamboo grove class. 500 points of ground reference data were used to calibrate the model parameters and to validate their classification performance. The classification performance of each model was validated based on the 10 times repeated 10-fold cross validation method with Cohen's kappa. The result showed that the highest performance was achieved by RF (0.818), closely followed by XGB (0.814), C5.0 (0.803), SVM (0.799), ANN (0.756), and finally kNN (0.739). Variable importance metrics suggested that the NIR and SWIR portions observed during spring and autumn seasons were the key to distinguish bamboo groves from other landcover classes. Based on the result, the RF predictive model was used to create a regional scale map of bamboo grove distribution. The map created is expected to be used as a source of information for understanding the status of bamboo grove distribution.

Keywords: *Random Forest, C5.0, eXtreme Gradient Boosting*

ANALYZING THE EFFECTS OF BLUE-GREEN-GREY INFRASTRUCTURE PATTERNS ON LAND SURFACE TEMPERATURE: A CASE STUDY OF HUE CITY

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ABSTRACT

City is considered as a main source of greenhouse gas emission which might cause environmental modification, such as urban heat island (UHI) phenomenon, ecosystem fragmentation and degradation. The role of Blue-Green-Grey infrastructure (BGGI) in mitigating the UHI effects has become a hybrid approach for sustainable urban under climate change. In this paper, the combination of remote sensing, GIS, and spatial landscape metrics was conducted to analyze the relationship between BGGI and land surface temperature (LST) of Hue City. The LST was extracted from Landsat 8 OLI/TIRS image, while BGGI was grouped from land use/land cover was classified from Sentinel-2A image. The spatial landscape metrics, including the percentage of landscape (PLAND), edge density (ED) were calculated for BGGI by using 10 x10 pixel grid. The multiple regression analysis between landscape metrics and LST show a high adjusted R^2 value at 0.816 ($p < 0.05$). In which, the PLAND of Blue and Green infrastructure contribute to decreasing LST ($\beta = -0.725$ and 0.780 , respectively). Conversely, the ED of Grey infrastructure has a negative contribution on increasing the LST ($\beta = 0.080$). In addition, the ANOVA test result demonstrates the Blue and Green infrastructure help the LST ease by approximately 2°C and 3.5°C compared to Grey infrastructure ($p < 0.05$). The findings from this study will contribute to providing a significant basis information for urban planning in orienting green space.

Keywords: spatial landscape metrics; infrastructure patterns; LST; multiple regression, Hue City

USE OF UAV BASED VEGETATION INDICES FOR MAPPING AND MONITORING OF PLANT HEALTH IN VIETNAM'S COFFEE PLANTATIONS

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ABSTRACT

High spatial and temporal resolution images obtained with Unmanned Aerial Vehicles (UAVs) provide valuable information for precision agriculture. In addition to map various surface features, accurately delineate farm boundaries, identify and count individual trees, multispectral UAV-images are increasingly analyzed for species differentiation and crop dynamics monitoring. The objective of this study was to develop a practical methodology to use vegetation indices (VIs) derived from UAV-images for mapping and monitoring of plant health in Vietnam's coffee plantations. This study was conducted with UAV aerial photography using MicaSense red-edge multispectral sensor in four flight missions in seven locations of Robusta and Arabica coffee plantation in Lam Dong province during the 2020-2021 season. Different VIs, including Normalized Difference Vegetation Index (NDVI), Normalized Difference Red Edge (NDRE) and Leaf Chlorophyll Index (LCI), were computed and compared with coffee leaves' chlorophyll contents measured by the SPAD-502 Chlorophyll Meter during ground truthing. The observed high correlations between VIs and SPAD readings suggested the significance of VIs for plant health/nutrient monitoring. Based on these empirical analyses, NDVI and NDRE were then selected to develop scoring parameters for plant health/nutrient mapping and monitoring. With integrated geospatial analytics, 558 smallholder coffee farms were mapped/ranked in terms of general plant health and spatially monitored 4 times during one crop cycle for nutrient level and early detection of plant stress such as nutrient deficiencies, water stress, pest or disease attacks. The results of this study showed that the streamlined use of UAV-based VIs, especially NDRE scores in an integrated system for farm monitoring can be established and used in other coffee plantation areas.

Keywords: *Unmanned Aerial Vehicle, Vegetation index, Coffee plantation, Chlorophyll content, Crop health*

MAPPING LAND USE LAND COVER OF TRA VINH PROVINCE IN 2020 USING MULTI-TEMPORAL AND MULTI-SOURCE OF REMOTE SENSING IMAGERY

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ABSTRACT

This paper discusses research methodology to develop Land Use Land Cover (LULC) map for the Tra Vinh province, using MODIS, Landsat 8 OLI and Sentinel 1A imagery in 2020. The MODIS MOD09A1 8-day reflectance product was processed into NDVI maps and then used to classify LULC types using ISODATA algorithm in unsupervised classification. The Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), Normalized Difference Built-up Index (NDBI) and brightness value extracted from Landsat 8 OLI was used to map locally common LULC types using the Object Based Image Analysis (OBIA) method. Sentinel-1 was used to extract the threshold backscatter values for the performance of two commonly used classifiers of Support Vector Machine (SVM) and Random Forest (RF) for land use classification. The accuracy of LULC map was evaluated for 9 classes including triple-rice crop, double-rice crop, perennial/orchards; aquaculture, shrimp-single rice crop rotation, build-up area, upland crop, mangrove forest and rivers/canals in which rice crops (triple-rice crop and double-rice crop) and perennial/orchards areas occupied the highest area, approximately 44,36% and 19,39% of total natural area, respectively. The archived LULC map was also compared to geospatial reference data and local inventory statistics data. The result shows that the accuracy of LULC map could be improved by combining different classifiers with an overall accuracy of $87 \pm 1.5\%$ and Kappa coefficient of 0.77 ± 0.2 and difference about $\pm 5\%$ in comparing to the local inventory statistics data. This study has indicated the potential performance of integrated different sensors in mapping LULC. The strengthened understanding of multiple resource imagery provides better results in updating details of agriculture land use maps on a regional scale.

Keywords: *Sentinel 1, Landsat, MODIS, Object Based Image Analysis (OBIA), Random Forest (RF)*

IMPROVEMENT OF LAND COVER CLASSIFICATION USING MULTI-BAND IMAGE COMPOSITION ANCILLARY GEOGRAPHIC INFORMATION

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ABSTRACT

Remote sensing data and a variety of classifier methods are applied to obtain more accurate Land cover (LC) information. However, the topographic effect, seasonal vegetation condition, heterogeneous land practice, and similar reflectance among different land objects are still challenges for image classification. In this research, we will compare the classification accuracies by applying different indicator selection subsets (ISS) to explore that the improvement of LC classification can be achieved when additional image-derived indexes and ancillary geographic information are incorporated. Specifically, twenty-three indicators, including Landsat spectral bands, vegetation indexes, geomorphological topography data, distance to the road, and road density are used in image classification practice. All data were grouped into three different ISS. The first group (ISS1) only considers six spectral bands of Landsat data, the second group (ISS2) includes ISS1 and six more vegetation indexes, and the third group (ISS3) covers ISS1, ISS2, and added eleven ancillary geographic indicators. The random forest classifier is applied for LC classification in the Northern part of Taiwan. Subsequently, the land cover map in 1995 north of Taiwan with eight land cover types (bare land, waterbody, build-up area, cropland, grass, forest, riverbed, and cloud) are classified with different accuracies. Overall accuracy values are 87.8%, 88.8%, and 97.5% for ISS1, ISS2, and ISS3, respectively. The misclassification of the riverbed, cropland, grass, build-up, and bare land is much improved with ISS3. Additionally, the contribution analysis reveals the effect of each indicator in the classification performance that is also figured out in this work based on the function of the random forest method. This study concludes that a more accurate LC map can be obtained when incorporating multi-band image composition and ancillary geographic data in the classification scheme and therefore provide reliable data for land use planning and land management.

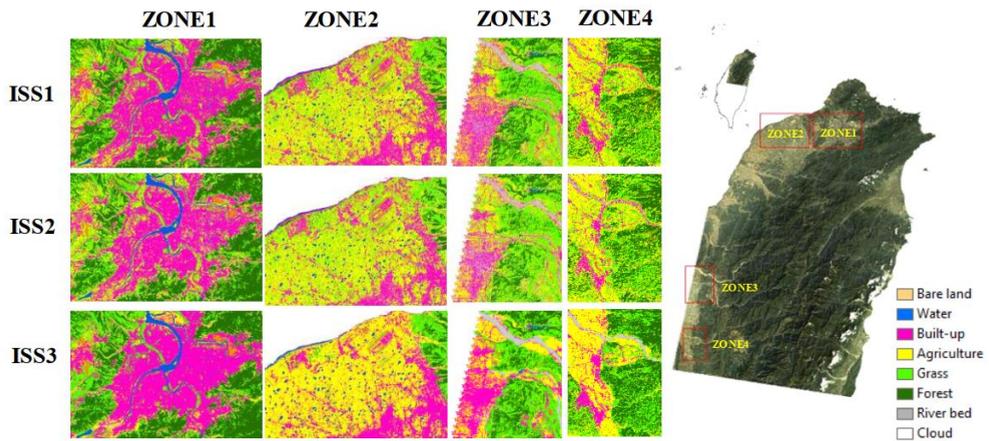


Figure. Land cover classification results are based on different indicator selection subsets (ISS). The right image is clipped from a scene of Landsat-5 acquired 25/11/1995

Table. Accuracy assessment

		Bare land	Waterbody	Build up	Cropland	Grass	Forest	River bed -	Cloud	Overall accuracy
ISS1	Producer' acc	0.710	0.919	0.695	0.921	0.524	0.994	0.692	0.928	Acc: 0.878
	User' acc	0.996	0.897	0.849	0.619	0.388	0.944	0.967	0.999	Kappa: 0.831
ISS2	Producer' acc	0.739	0.999	0.680	0.921	0.818	0.997	0.661	0.902	Acc: 0.888
	User' acc	0.992	0.897	0.939	0.655	0.458	0.939	0.954	0.999	Kappa: 0.844
ISS3	Producer' acc	0.739	0.999	0.680	0.921	0.818	0.997	0.661	0.902	Acc: 0.975
	User' acc	0.992	0.897	0.939	0.655	0.458	0.939	0.954	0.999	Kappa: 0.966

(note: Acc means Accuracy)

Keywords: land cover, image classification, multi-band image composition, ancillary geographic information, random forest classifier

DETERMINATION OF SEA SURFACE MUCILAGE FORMATIONS USING MULTITEMPORAL SENTINEL-2 IMAGERY

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ABSTRACT

In recent years, there has been a markedly increase in temperatures of the Earth's surface including oceans and seas due to global warming. Mucilage, or sea saliva observed in the inland seas and bays is one of the destructive results of this phenomenon. Mucilage formations have been widely observed in May 2021 in the Marmara Sea, especially in the Izmit bay. The main purpose of this study is to determine mucilage formations observed in the Izmit bay using Sentinel-2A (S2A) imagery captured on May 19 and 24. For this purpose, three datasets were formed and utilized for classification of mucilage formations. While the first dataset is consisted of only the 10m spatial resolution bands of the S2A imagery, the second dataset is included 6 bands of the S2A imagery at 20m resolution. The third dataset includes 10 bands of the S2A imagery resampled at 10m spatial resolution. Random forest (RF) and XGBoost ensemble learning algorithms were utilized to classification of these three datasets created separately for the 19 and 24 May imagery. To assess the classification performances, overall accuracy and Kappa coefficient measures calculated from confusion matrix were utilized. Results showed that the highest overall classification accuracies were estimated as 98.9% and 98.5% with RF and XGBoost, respectively for 19 May 10-band S2A dataset. On the other hand, the lowest overall accuracies were obtained with the use of 4-bands at 10m spatial resolution for both 19 and 24 May S2A imagery with RF and XGBoost algorithms. This result confirms that the use of the 10m and 20m bands of S2A images together can have a positive effect on the classification accuracy. Whilst the mucilage covered area on Izmit bay was calculated as 15.3 km² on May 19, it was calculated as 20.13 km² on May 24. In other words, it was observed that mucilage formations increased by about 31% in the 5-day time period in the study area. This clearly indicating the harmful effect of the mucilage phenomenon on the Izmit bay.

Keywords: Mucilage, Sentinel-2A, Random Forest, XGBoost, Marmara Sea

RESEARCH ON FOREST COVER CHANGE USING SENTINEL-2 IMAGES IN COMBINATION WITH SENTINEL-1 IMAGES ON GOOGLE EARTH ENGINE PLATFORM

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ABSTRACT

The research focuses on determining the area of forest lost due to a forest fires and deforestation in Ha Tinh province, Vietnam on Google Earth Engine platform in the period 2019 May to 2019 September. This platform makes image processing in general easy and fast, and a highlight is that it can be processed directly in the cloud without having to download it to the computer. Our research area is Nam Mountain, Huong son Ha Tinh province. With two times of Sentinel-2 images before and after the big fire in July 2019 and the series of images from January to December 2019 of Sentinel-1 images, we calculated the difference of Sentinel-2 images before and after the fire. Besides, the Random Forest classification method for Sentinel-1 images classification was used to determine the land cover of this area. Then, the agricultural land has been separated from the forest cover and it is used as Mask to cover the agricultural land. The difference between the two times of the Sentinel-2 image is thresholded as 0.2 and using the Mask of agriculture land will be the result of forest cover change in the Nam mountain area. The results were compared with image on Google Earth and forest fire statistics documents during the study period and found that many points of forest cover change were similar. The study demonstrated the feasibility of using Sentinel-2 and Sentinel-1 images to detect the forest changes over a study area quickly and in the closest possible way to real-time.

Keywords: Sentinel-2, Sentinel-1, Google Earth Engine, Forest cover change, Huong Son- Ha Tinh

LAND USE/LAND COVER DETECTION AT UNIVERSITI PUTRA MALAYSIA USING GOOGLE EARTH ENGINE

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ABSTRACT

Land use/landcover (LULC) change provides us insights on the human-environment interactions over time. These insights would be useful to come up with land management strategies as well as for future planning. In this study, the LULC change of Universiti Putra Malaysia (UPM) from year 2010 to 2020 is studied from Landsat-5 and Landsat-8 images. By leveraging Google Earth Engine (GEE), all the tedious satellite data preprocessing can be skipped as it is a cloud-based platform equipped with a multi petabyte analysis ready data catalogue. The classes studied are water, road, urban, vegetation as well as barren land. The built-in machine learning algorithm, for supervised classification known as classification and regression tree (CART) was used to create classification maps for the years 2010, 2015 and 2020. The ground truthing was done by referring to historical images from Google Earth. The classification maps were assessed using confusion matrix. It was found that there were spectral similarities between road and urban which resulted certain misclassification. Next, the areas represented by each class was computed and compared from the year 2010-2015 and 2015-2020 to qualitatively detect the change. It was found that areas of roads and urban increased while barren land, vegetation and water decreased. However, in all three years vegetation covered the largest areas. Throughout the span of 10 years, vegetation covered most of the areas in UPM. The output of this research will aid the UI Green Metrics as it provides an objective assessment of the green areas of the campus. It will also help the university management as a tool in their tasks of better managing university facilities.

Keywords: *Land use/Landcover, supervised classification, Google Earth Engine*

GENERATION OF INFORMATION BASE ON APPLE ORCHARDS USING GEO-INFORMATICS IN SHIMLA DISTRICT OF HIMACHAL PRADESH

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ABSTRACT

Recognizing importance of horticulture in promoting livelihood and employment opportunity and bringing prosperity to the state, the Govt. of India has extended National Horticulture Technology Mission Programme to Himachal Pradesh. The objective of Mission is to develop horticulture based farming system that is economically viable and ecologically sustainable using all the modern tools and techniques available. The space technology including remote sensing, Global Positioning System (GPS) and Geographical Information System (GIS) are the advanced tools that aid in gathering and updating information and develop scientific management plans. Updated and accurate database is pre-requisite for systematic planning of horticulture sector be it area expansion, increase in productivity or creating post harvest handling facilities. With this aim, a study was carried out to generate block wise database on apple plantation in Shimla which is the largest apple growing district of Himachal Pradesh. Remote sensing data from the Indian Remote Sensing satellites like IRS P6 has been used along with other international sensors to generate apple orchard maps, orchard conditions in term of density, terrain parameters like elevation, slope, aspect etc. The GIS tools have been used to characterize the orchard distribution pattern in relation to terrain parameters. The final outputs are in digital form amenable to produce maps at different scales as well as statistics as required by a user.

Keywords: *apple orchards, Blocks, DEM, Shimla*

ESTIMATION OF MANGROVE BIOMASS USING LANDSAT DATA ON GOOGLE EARTH ENGINE (GEE) PLATFORM

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ABSTRACT

Segara Anakan is one of 3.5 million hectares of Indonesian mangrove forests, and local deforestation has affected the mangrove area leading to the shrinking and decreased biomass of mangrove forests. For management of the mangrove forest is needed information of the biomass in Segara Anakan area. The objective of this study to estimate the biomass using Landsat data time series on the Google Earth Engine (GEE) platform. The methodology including built a Landsat normalized difference vegetation index (NDVI) time series in 1990, 1995, 2003, and 2019 and estimating the biomass in GEE platform, and after that we did the validation with field data. The result showed that the trend of biomass estimation per year in 1990 was 12.8 ton/ha, and it has been increased in 1995 around 14,3 ton/ha, decreased in 2003 with 11.2 ton/ha, and in 2019 was 11.29 ton/ha. The validation showed with $R^2 = 0.8$, which means that the biomass estimation from imagery have a strong correlation with field data.

Keywords: Biomass, GEE, NDVI, Segara Anakan

MULTI-LAYER PERCEPTRON-MARKOV CHAIN-BASED ARTIFICIAL NEURAL NETWORK FOR MODELLING URBAN EXPANSION IN ULAANBAATAR, MONGOLIA

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ABSTRACT

Urban growth in various cities across the world, especially in developing countries, leads to change in land use. Thus, predicting future urban growth in the rapidly growing region of Mongolia becomes a significant endeavor.

The vast majority of Mongolia's population lives in Ulaanbaatar. Since 2000, natural disasters such as droughts and dzuds in agriculture have hit herders hard, and migration to large cities and towns, especially Ulaanbaatar, has increased. The availability of reliable jobs in urban areas is attracting more people and expanding the urbanization process. In the near future, migration is expected to continue having a significant impact on Ulaanbaatar's population growth. This is due to the over-concentration of social forces in Ulaanbaatar, such as education, health, economy, infrastructure, public administration, and culture. In the “ger district” (circular nomad’s tent-yurts detached to a land lot is a type of slum settlement district in Mongolia) sprawl area, which covers about 32% of all territory of the city, urban expansion has accelerated so far so it adversely impacts green belt areas, wetlands, riparian zones, open space, and public land.

According to the 2019 survey, 67.2 percent of the total population of Mongolia lives in urban areas, of which 45.3 percent or one in two people live in the capital city. Ulaanbaatar, which accounts for only 0.3 percent of the country's territory, is densely populated, with a large population. In particular, 95.1 percent of the total population of the capital city lives in the six central districts.

Mongolians are starting to use GIS with remotely sensed data and artificial neural network modelling techniques for urban expansion studies. The aim of this study is to simulate urban growth using multiple Landsat data of 2018, 2019 and 2020 by integration of multi-layer perceptron neural network and Markov model. This study primarily considered Ulaanbaatar, the capital of Mongolia, which experienced rapid Land use land cover (LULC)

change due to anthropogenic factors. Multi-layer perceptron neural network approach has been used to calculate conversion probabilities for urban growth. These conversion probabilities have been used in Markov model for urban growth simulation. This method has been implemented to Ulaanbaatar to find out urban growth.

The satellite data were classified in the most similar way by creating a total of 5 class segments: buildings, forests, plants, soil, water, and sand. Landsat-8 was classified using the most similar method using satellite data. In the calculation of the change, each classified class had different spatial increases and decreases, which resulted in significant changes in the size of the constructed area depending on the redevelopment. The greatest change occurred in the soil, and in terms of location, a significant amount of soil cover was reduced in the southern part of the study area. Clark Lab's (Clark University) Geospatial Monitoring and Model software had been used for the urban expansion prediction.

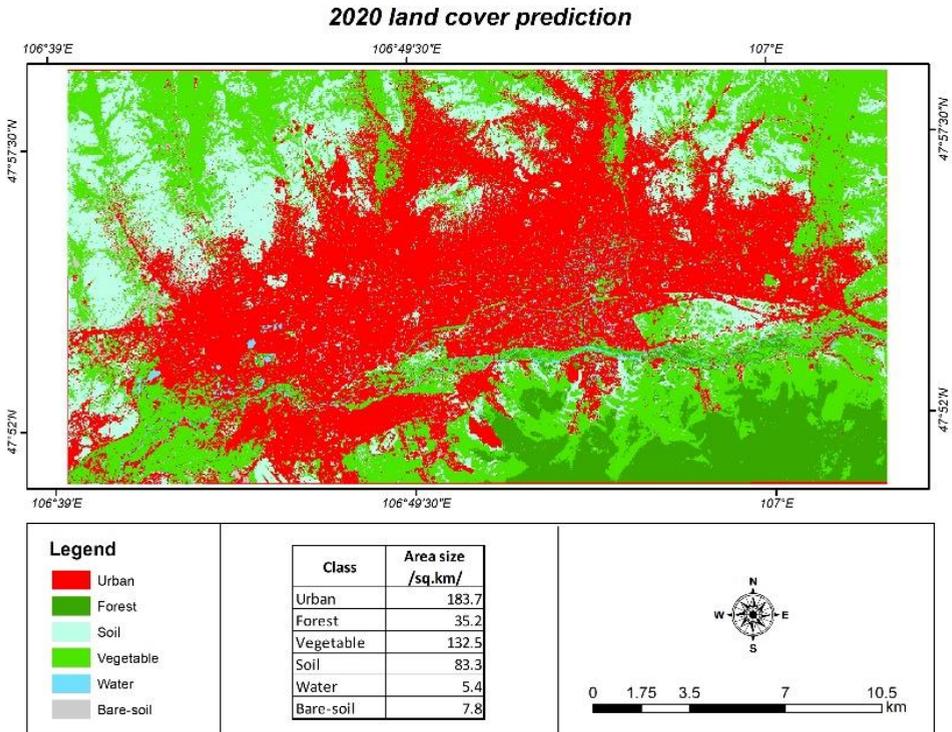
A new 22.4 sq.km built-up area or residential area has been created within the study area, of which 20 sq.km, or the largest change, has been converted from soil to built-up area. Between 2018 and 2019, the location of the newly constructed area has increased significantly to the southwest, west, and suburbs of the study area. The new settlements indicate that Ulaanbaatar is expanding in an unorganized and chaotic manner.

The results of the 2018 and 2019 classifications were used to calculate the surface change using the "Land Survey Calculation Model" (LCM). To calculate the probability of the transition, the multi-layer perceptron model, one of the artificial intelligence network structures, was used as the baseline, using the results of ground cover changes and sub-data such as roads, city centers, surface water, and buildings. When using multi-layer perceptrons, 7 hidden layers were created to make the calculations more accurate, with an accuracy of 70.63 percent.

In 2018-2019, the vegetation cover in the study area increased by 26.9 percent, while the soil cover decreased by 13.1 percent. The results of the study show that the urbanization trend in Ulaanbaatar is to the west and southwest, with vegetation and built-up areas increasing, while soil cover tends to decrease.

For the data validations, and accuracy assessment error matrix was calculated to compare with archived field reference data mapped in two years 2018 and 2019. The simulated urban growth for 2020 is cross tabulated and validate with actual urban growth of 2020. Based on the LULC analysis the classification results showed that the overall accuracy of LULC maps achieved from 59.2 to 94.4 percent. We found that the land use/land cover map resembles previous field survey data assessments of areas with the same

classes of land use. Our Markov chain model map corresponded with the field reference map. The Kappa coefficient of urbanized area in 2020 had a positive 0.88 value, which indicates that the classified map has a strong agreement with ground truth data. This result showed that the CA-Markov chain model has good potential to accurately predict future land-use changes.



Keywords: Simulation validity; land use/land cover; growth prediction; Ulaanbaatar

FLOOD HAZARD MAPPING FOR A REPEATED FLOODING AREA IN NORTHERN THAILAND

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ABSTRACT

Bang Rakam district in Phitsanulok is located at the lower Yom River Basin, and holds excess water from upstream districts, resulting in a persistent annual flood. The Thai government has declared flood management a national priority and as a result, this study area was chosen for this pilot project. The Bang Rakam Model 60 was established at the left bank of the Yom River and covered an area of 265,000 rai (424 km²). This study aims to evaluate the flood hazard posed to the area using geographic information systems (GIS) and the fuzzy analytic hierarchy process (Fuzzy AHP). Parameters were created and classified using GIS, and the preference weights of the alternative decisions were calculated using a Fuzzy AHP based on Chang's Extent Analysis. The findings showed that the most significant predisposing parameter to flood hazard is average annual rainfall. The results of our analysis have shown with levels of very high flood hazard, high hazard, moderate, low, and very low flood hazard accounted for 8.31%, 23.83%, 30.47%, 26.52%, and 10.87% of the total area, respectively. The results of our proposed GIS analysis concept in this study can be applied in real situations to help government agencies to put in mitigation measures for saving lives, properties, and money spent on reliefs and compensation campaigns for suffering people.

Keywords: *Bang Rakam Model 60, Flood hazard, Fuzzy Analytic Hierarchy Process (Fuzzy AHP), Geographic Information System (GIS), Repeated flooding area*

**DEFORESTATION OF FOREST TYPES BETWEEN
2009 AND 2019 ALONG A TOPOGRAPHICAL GRADIENT
USING REMOTELY SENSED DATA IN CAMERON
HIGHLANDS, MALAYSIA**

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ABSTRACT

Land encroachment activities and deforestation patterns are the major contributors to land cover change in Cameron Highlands. In this paper, the relationship between forest type deforestation along a topographical gradient is determined through the means of remote sensing data and geographical skills. The results have shown a major change in the upper dipterocarp forest region where the majority of urban and agriculture activities thrive. Hence, leading to uncontrolled deforestation on the sensitive slopes of the Cameron Highlands thus jeopardizing the environmental ecosystem. Forestry degradation has led to severe repercussions, hopes to mitigate the effects and current ongoings outcomes of this study might lead to possible developments to uphold the law of forest governance, management, conservation, and monitoring.

Keywords: *Deforestation, forest types, mountain areas, remote sensing, OBIA*

EVALUATING PERFORMANCE OF MAJORITY RULES IN PER-PIXEL AND OBIA LAND-COVER CLASSIFICATION USING WORLDVIEW MULTISPECTRAL IMAGERY OF URBAN FRINGE AREA, INDONESIA

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ABSTRACT

OBIA classification has been considered as being able to overcome the limitations of per-pixel methods for high-spatial resolution images. On the other hand, per-pixel classification also often relies on the use of majority filters to generalize the appearance of various classes that give a salt-and-pepper effect. This study aimed to evaluate the performance of the two classifications with different approaches, i.e. simple OBIA and majority filters of the per-pixel classification results, using Worldview multispectral imagery of Salatiga, Indonesia. In this study, each classification method applied a combination of several different parameters to derive land-cover maps. In the OBIA classification, the author used two main steps, namely segmentation and object-based classification. For the segmentation process, several parameters were combined with different values including the weights of input spectral bands, average and variance, moving window size, and similarity tolerance. Hundreds of generated segments were selected in spectral sampling of each land cover class. Based on these samples, per-pixel classification was then run to derive a pixel-based land-cover map. After that, the pixel-based map was processed in two different ways, i.e. (a) combined with the segmentation result to generate an object-based land-cover map through majority rule in each segment, and (b) majority-filtered at various window sizes to derive land-cover maps with different levels of generalization. Independent field data was used for accuracy assessment of the maps. We evaluated the accordance between maps by superimposing the OBIA-based with the majority-filtered maps. It was found that the combination of different parameters resulted varying accuracies of OBIA classification, and likewise with the accuracies of the majority-filtered results. We also found that the accordance between the OBIA classification results

and the classified images varied with the window size, where the 7x7 filter gave the highest match between the OBIA and the filtered per-pixel classification, i.e. 80.29%.

Keywords: *OBIA, majority filter, land-cover classification, Worldview, Indonesia*

COMPARING TWO DIFFERENT RADIOMETRIC CORRECTIONS IN A VEGETATION MAPPING OF MOUNTAINOUS AREA USING FOREST COVER DENSITY TRANSFORMATION

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ABSTRACT

Vegetation mapping has been mostly carried out using remote sensing imagery. Vegetation index and forest cover density (FCD) transformation were frequently used for this purpose. The FCD transformation assumes that the vegetation index is less able to distinguish structural composition-related density, so that new approach involving several indices at once has been introduced. Meanwhile, radiometric correction is also strongly required for any spectral transformation including FCD. This study aimed to compare the effect of two kinds of radiometric correction on the vegetation structural composition in Arjuno-Welirang volcanic areas. East Java, Indonesia. Landsat 8 OLI image dataset which includes blue to mid-infrared and thermal bands were used to generate the FCD models. The Landsat dataset was treated with two kinds of radiometric correction, namely atmospheric correction with FLAASH and additional topographic correction using SCS+C. To derive FCD map, we transformed the original image dataset into Advanced Vegetation Index (AVI), Soil Brightness Index (BI), Shadow Index (SI), and Thermal Index (TI) images. We also added NDVI for a comparison. All indices were combined in three stages to derive the FCD models. All inputs made use of atmospheric corrected images in one treatment, and additional topographic correction in another one. Field surveys were carried out to produce two independent types of vegetation density and structural composition data for classification reference and for of FCD estimate accuracy assessment. This study found that in very rough mountainous terrain conditions such as in the study area, the FCD transformation was less able to produce maps of structural vegetation composition, since the accuracies obtained were only about 30%. However, the use of topographic correction was able to increase the accuracy from 29.92% (with atmospheric correction only) to 32.53%. The less accurate estimates of the vegetation density and structural composition mainly occurred on the slopes with 40-56% steepness.

Keywords: Forest Cover Density (FCD), atmospheric correction, topographic correction, Indonesia

ANALYSIS OF URBAN HEAT ISLAND AND ITS RELATION WITH LAND USE LAND COVER IN NAGALAND, INDIA

Kedovikho Yhoshü

Department of Geography

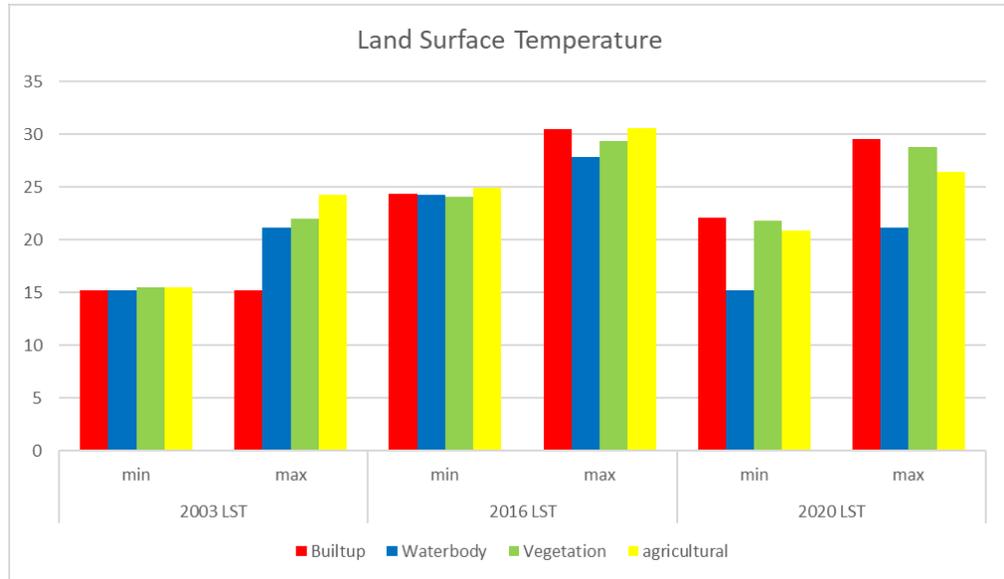
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ABSTRACT

The impact of urbanization has been far reaching. Urbanization has impacted not only the lives of human but the physical landscape has also taken a whole new turn. In the process of urbanization, vegetation and agricultural lands have given ways to concrete infrastructural development. Along with anthropogenic development and progress, environment has taken a backfoot which can become lethargic, if no proper planning's are undertaken. This study is an attempt to estimate the relation between landuse landcover and urban heat island (UHI) in Dimapur, Nagaland, India. Dimapur, the main economic hub of Nagaland lies towards the northeastern part of India. It has witness tremendous anthropogenic activities over a short period of time. The study plans to bring out the impact of urbanization especially surface heat effect owing to anthropogenic intrusions. The main objective was to determine the urban heat island phenomena with respect to different land use land cover classes. Remote sensing techniques as a tool have helped in estimation of various geospatial applications. Satellite imagery data's like Landsat data has the potentiality to estimate the earth surface temperature with high accuracy and precision. In this study, Landsat 7 ETM+ and Landsat 8 OLI have been analyzed to generate normalized differentiation vegetation index along with emissivity parameter. Land use landcover classification was performed after pan sharpening using maximum likelihood classifier for classes such as builtup, vegetation, agricultural land and water body. The urban heat island and its relation with land use land cover was calculated and correlated basing on time series period from 2003 to 2020. It was observed that from 2003 to 2020, the city of Dimapur has witness increase in UHI mainly in the builtup zones. The result of UHI was in 2003 reading of UHI showed builtup had minimum temperature of 15.24 °C and maximum was 23.97°C, vegetation had minimum temperature 15.54°C and maximum temperature 21.99°C, water body had minimum temperature 15.23 °C and maximum temperature was 21.13°C. Agricultural land had minimum temperature of 15.54 °C and maximum temperature 24.25°C. In 2020 the temperature of the various classes are- builtup had minimum temperature 22.08 °C and maximum temperature was 29.59°C, vegetation had minimum temperature 21.83°C and maximum temperature 28.81°C, water body had minimum temperature 15.23 °C and maximum temperature was 21.13°C. Agricultural land had minimum temperature of 20.89 °C and maximum

temperature 26.49°C. Proper planning and management is needed to tackle the issue of urban heat island in an ever increasing urbanization city such as Dimapur.

Table 1. UHI of different parameters shown in the study area



Keywords: Urban heat island, builtup, urbanization, Landsat

MAPPING AND MONITORING THE RICE CROP IN VIETNAM: EXPERIENCED USING RIICE TECHNOLOGIES

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ABSTRACT

The Remote sensing based Information and Insurance for Crops in emerging Economies (RIICE) project (2013-2021) is a collaborative initiative between the International Rice Research Institute, SARMAP, Ministry of Agriculture and Rural Development, Vietnam. The project makes use of Earth Observation technology to regularly and timely monitor rice area and yield. These are the underlying seasonal information produced by RIICE technologies at the commune level in seven provinces since 2016. This study summarizes the methodological development carried out to produce detailed maps of rice area, start of season, and yield using RIICE technologies for the case of study of seven provinces in the main rice regions of Vietnam. For the purpose of this study results of the last three years from 2018-2020 were illustrated and discussed. The rice area was verified with a deviation that varied from 2.2 to 9.5%. On the other hand, rice yield estimates were compared with the reported statistical data and it shows an agreement of more than 90% at the province level. With RIICE's products being utilized by BaoViet, insurance products/schemes have been implemented and being practiced in rice crop insurance. This shows that RIICE technologies are a useful tool for rice monitoring and possible application to agricultural crop insurance.

Keywords: MAPscape, crop insurance, ORYZA model, remote sensing, RIICE, RiceYES, SAR

DETERMINING RICE CROPPING PATTERNS IN TRA VINH PROVINCE USING REMOTE SENSING TIME SERIES S-1

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ABSTRACT

The study utilised farmer and field surveys, as well as time series Sentinel-1A data with a 12-day revisit time and a spatial resolution of 10 m, to detect rice cropping patterns (rice-rice-rice, other-rice-rice, fallow-rice-rice) in Tra Vinh province's three rice-growing areas. We specified the parameters determined from an agronomic perspective, as well as the related temporal features from SAR signatures, in the study to discriminate rice, other crops, and fallow land. The prediction performance of decision tree and rule-based classifiers was compared in terms of overall accuracy and kappa values. When compared to the decision tree classifier, the validation findings yielded the highest overall accuracy (86 percent). Using a rule-based approach, multitemporal Sentinel-1A imagery was used to identify rice cropping patterns at the field level with high accuracy. It was determined that the best discriminatory information for separating rice from other crops and fallow land in three consecutive seasons came from time series of co-polarized and cross-polarized polarised backscatter (VV and VH), as well as band ratio (VV/VH). When considering the major differences across crops at the crop establishment stage and its sensitivity to rice crop growth, we found that VH was the best single polarisation for classifying distinct cropping patterns. According to the study site, crop type, crop calendar, and farming methods, the parameters were appropriately set using expert knowledge and in-situ surveyed data. In the future, greater training samples may allow for more precise threshold selection. The resulting classifications map demonstrated reasonable distributions of various rice farming patterns in Tra Vinh province.

Keywords: *indices images, backscatter values, multi-temporal satellite imagery, land use/land cover types, Tra Vinh province*

EVALUATION OF LAND COVER CHANGES USING DCP VALIDATION DATA

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ABSTRACT

Various research institutes have produced global land cover maps. The accuracy of the existing global land cover maps ranges from about 60% to over 80%. In addition, time-series global land cover maps such as CCI-LC and MCD12 have been developed. There is a possibility to extract information on land cover change from such time-series global land cover maps by taking the differences. The information on land cover change is important for environmental assessment and future prediction. However, since each land cover map contains errors and sub-pixel misregistrations from year to year, which leads error propagations, it is difficult to detect the true land cover change by taking the difference between two periods, and the frequency of land cover change becomes over or underestimated. Thus, although information on land cover change is important, a method to extract it over a wide area using remote sensing technology has not been established. There are several possible factors for this, one of which is the inadequate maintenance of land cover validation data at the global level. Therefore, it is necessary to create validation data that can evaluate the accuracy of land cover change. If validation data for time series are developed, it can be evaluated the accuracy of land cover maps, and in the future, highly accurate time series land cover maps will be possible to produce. However, such data sets are currently not sufficiently developed. The Degree Confluence Project (DCP) is a volunteered validation project started in 1994, which publishes ground photographs and related descriptions for integer latitudes and longitudes on the web. The total number of integer latitudes and longitudes visited so far is 7,186. Of these, 2,905 have been visited multiple times. These sites that have been visited multiple times may be able to see land cover change. DCP validation data has been used to evaluate the accuracy of global land cover maps, but has never been used to validate land cover change. Therefore, the objective of this study is to investigate the possibility of using DCP data to validate land cover change.

In this study, we used DCP points that existed for both the five years centered on 2005 and the five years centered on 2015. The land cover class of these points were visually interpreted by two people. We used only for points where the interpretation results of the two people matched. Eight land cover classes were defined: Forest, Grass/Shrub, Wetland, Cropland, Urban, Mosaic of natural vegetation and cropland, Barren, and Water. During the visual interpretation, we used not only photographs and texts from the DCP, but also aerial photographs from Google Earth. In addition, if there was a change in land cover during each of the five years, those DCP sites were excluded. As a result, the number of DCP sites covered in this study was 600. We also created a transition matrix for the 600 DCPs to see which class they changed into which class. For the points that had changed, we again checked the photographs of DCPs and Google Earth to examine whether they had really changed.

Of the 600 DCPs for which land cover classes were visually interpreted independently, 37 points of land cover classes were changed. The most frequent pattern of change was from Cropland to Grass/Shrub (18 points). The second frequent change was from "Forest" to "Grassland/Shrub" (seven points). When we reconfirmed the DCP points using Google Earth and ground photographs, we found that there were points where the class had not actually changed due to visual blurring caused by misalignment, ambiguity in the definition of the class, and differences in the survey season. Only 15 points which is about 40% of the 37 points, were found to have actually changed. In terms of the pattern of change, the change from "Cropland" to "Grass/Shrub" had the highest rate of decrease, decreasing from 18 points to two points.

The DCP sites that were identified as having changes in the time series were examined in detail. In terms of countries, Brazil and Russia had four and three points, respectively, which are relatively high. In Brazil, the patterns were deforestation, afforestation, and change from bare land to natural vegetation, while in Russia, the patterns were deforestation, growth of natural vegetation, and conversion of agricultural land to abandoned land. Deforestation was also observed in Malaysia and Sweden. Urbanization were observed in Mongolia, Georgia, and China. In Italy, a change from sandy beaches to natural vegetation was observed. These results indicate that most of the land cover changes observed in the past 10 years are anthropogenic factors. Conversely, the time scale of land cover change as a natural phenomenon is probably larger than about 10 years.

From the results of this study, it is clear that the amount of land cover change differs between the cases where visual interpretations of land cover classes are conducted independently and the cases where visual interpretations are conducted as a set of time series for DCPs at the same

latitude and longitude. In other words, in order to correctly extract land cover change in DCP validation data, it is necessary to also perform visual interpretation as a time series. The results of this study also indicate that it is difficult to determine Cropland and Grass/Shrub classes from only DCP photos. Therefore, to use DCP validation data for accuracy assessment of land cover change, it is necessary to ensure the quality of the validation data in combination with other information. In addition, in order to establish a validation database for land cover change, it is necessary to collect information on land cover change by conducting surveys preferentially, especially for sites that have been surveyed less than twice.

Keywords: *Degree Confluence Project, time series change, validation dataset, global land cover map*

ANALYSIS OF THE SURFACE URBAN HEAT ISLAND IN CAN THO CITY USING LANDSAT DATA

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1. Introduction

Can Tho city is currently undergoing a rapid urban sprawl process which has well documented negative consequences for society and human beings, including the loss of greenspace, spatial temporal change to urban surface temperatures, and an intensification of the surface urban heat island phenomenon (SUHI). Surface urban heat island describes surface temperature differences between urban and surrounding rural areas, which is a vital concern in urban and urban climate studies. SUHI effect is a most crucial issue, as its generation and evolution are closely related to social and economic activities. Studies on the distribution of SUHI and its evolutionary mechanism have become a concerned topic in multi-disciplines. Hence, research aims to analyze SUHI phenomenon in Can Tho city in 2019 using Landsat imagery.

2. Methods

As primary data freely available Landsat 8 imagery which covered the Can Tho city area in 2019 was downloaded in this study from the U.S Geological Survey (USGS). The land surface temperature (LST) retrieval from Landsat thermal infrared band (Band 10) was estimated as following steps (1) Converting digital numbers (DNs) on thermal band to Top of Atmosphere (TOA) spectral radiance, (2) Converting TOA spectral radiance values to TOA reflectance, (3) Converting TOA reflectance values to brightness temperature, (4) Estimating the LST by calibrating brightness temperature using NDVI-based Land Surface Emissivity (LSE). The spatial surface urban heat island is defined as the difference between average temperature of urban area and that of rural area, which is observed based on the land surface temperature (LST). The surface urban heat island intensity (I_{SUHI}) is determined as a difference between the LST of the UHI areas (LST_{urban}) and the temperature in rural areas ($LST_{non-urban}$). Simultaneously, the land use map in Can Tho city in the year of 2019 was used for extracting the built-up areas which is the key factor for analysis of the driver of the urban heat island.

3. Results and discussion

According to the land use map in 2019, the urban area was estimated at 17,775.3 ha (12.34% in the total area) mostly located in Ninh Kieu, Binh

Thuy, Cai Rang districts, and sparse in the surrounding areas. In combination with the LST results, research pointed out the spatial variation temperature within urban areas above 29°C. By 2019, the SUHI proportion was about 24.18% which covers 34,740.45 ha areas. The results also highlighted that the area affected by a highly SUHI intensity around 4-6°C covered a total of approximately 87 ha, mainly in industrial zones and Can Tho international airport (> 4°C), thermal power plants (5-6°C), densely populated areas (3-4°C) (Figure 1). Production activities, energy consumption are the major contributing factors to the increase of SUHI, which are of concern for reducing heat island.

4. Conclusion

Research investigated the SUHI using the Landsat 8 imagery and the land use map in Can Tho city in 2019. The strong intensity of SUHI (3-6°C) was found within urban areas, a few central districts are facing the increasing heat island trend. The research outcomes provide an important practical basis to encourage maintaining green space in long-term urban planning in the future, heat mitigation, assessment of health impacts, and energy load estimation.

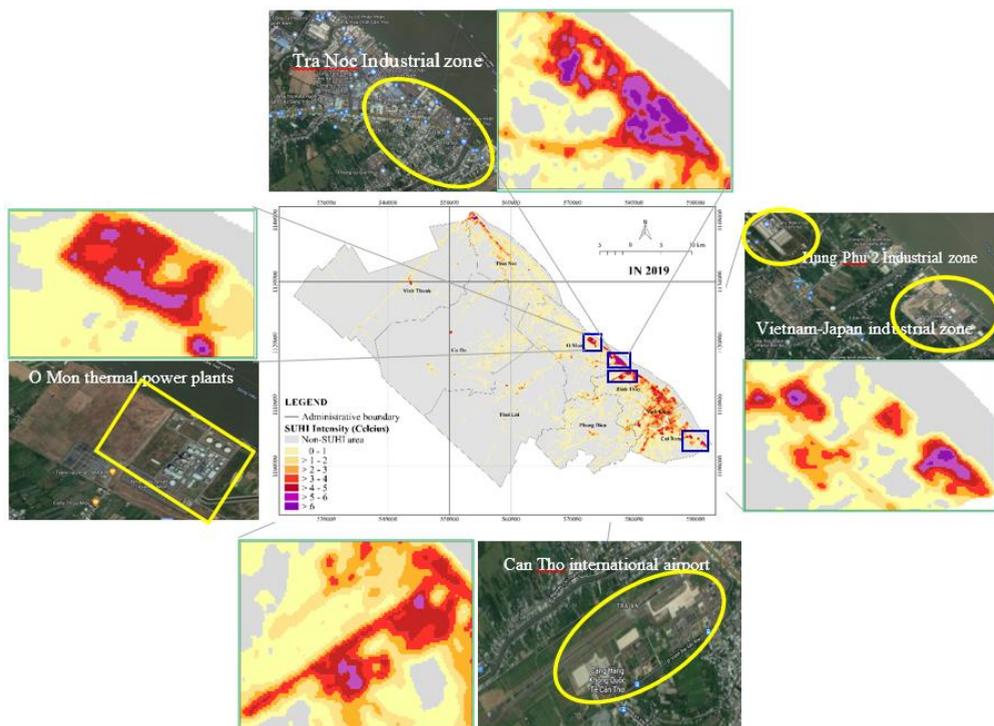


Figure 1. Map of surface urban heat island and pointed the areas within high intensity

Keywords: Surface urban heat island, land surface temperature, Can Tho city

EVALUATING THE GROSS PRIMARY PRODUCTION (GPP) IN DIFFERENT AGRICULTURAL LAND USE TYPES IN THE VIETNAMESE MEKONG DELTA USING VEGETATION PHOTOSYNTHESIS MODEL (VPM)

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ABSTRACT

Research aims to estimate the gross primary production (GPP) on different agricultural land use types in the Vietnamese Mekong Delta (VMD) using the vegetation photosynthesis model (VPM). The data of air temperature and the Photosynthetically active radiation (PAR) collected at the meteorological stations in VMD were used to calculate the effect of temperature on plants (T_{scalar}). The Land Surface Water Index (LSWI), and the Enhanced Vegetation Index (EVI) extracted from remote sensing data (MODIS MOD09A1) were used to calculate the effect of water (W_{scalar}) and growth stages (P_{scalar}). The light use efficiency (ϵ_g) on different agricultural land use types is calculated through the optimal amount of light combined with temperature and water for each growth stage. The GPP was then calculated using PAR, ϵ_g and EVI. The result shows that, by 2018, GPP was estimated at 8,093.67 tons C/year in the VMD. In which, the double rice crop accounts for about 3,282.14 tons C/year (40.55%), triple rice crop about 3,240.25 tons C/year (40%), Rice - Upland crop about 201.19 tons C/year (2.49%), Rice - Shrimp about 376.26 tons C/year (4.65%), and forest with about 993.82 tons C/year (12.28%). In general, rice cultivation contributed the largest share to the gross primary production for the whole region (80.96%). This study also indicates that GPP estimation from the VPM model can be used to consider carbon uptake in the large region which is supported for environment management.

Keywords: *Gross primary production, vegetation photosynthesis model, Vietnamese Mekong Delta*

THE CALCULATION OF THE NORTH BANTEN GEOID FROM GRAVITY RESOLUTION OF 5 BY 5 KM

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ABSTRACT

The use of GNSS altitude requires geoid height information so that the elevation information can be converted into orthometric altitude. This orthometric height is usually used for practical purposes. In 2015 the Jakarta geoid was created and has an accuracy of 0.080 m. Airborne gravimetry carried out for the whole of Java Island did not cover the DKI Province because there were obstacles from Airnav. with terrestrial gravimetry carried out in this region outside the area measured in 2012. In this paper the Global Geopotential Model used is gif48. The use of the "delete and restore" method as well as the Stokes and FFT kernels to speed up calculations is carried out in calculating the geoid in the Jakarta area. The geoid produced was verified with 11 points in DKI Jakarta Province. This verification yields a standard deviation of 0.166 m and a mean square root of 0.411 m.

Keywords: *Geoid, Global Geopotential Model, Stokes, FFT*

ANALYSIS OF CLOUD-BASED NDVI TRENDS OF A COUNTRY-WIDE FOREST RESTORATION PROGRAM

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ABSTRACT

The Philippine government embarked on a country-wide forest restoration program in 2011 targeting 1.5 billion trees in 1.5 million hectares of public lands over a six-year period, from 2011 to 2016. The program aimed at poverty reduction, sustainable management of natural resources, provision of food, goods, and services, promote public awareness on importance of forests and watershed, climate change alleviation. The program was expanded with the goal of rehabilitating all the remaining unproductive, denuded, and degraded forest lands, estimated at 7.1 million hectares, from 2016 to 2028.

This paper makes use of satellite imagery in measuring the success of the program in terms of planting trees in the selected areas. Vegetation indices derived from remotely sensed data were used in validating ground measurements and observing the temporal trends in the growth of vegetation.

Considering the large volume of data required for the analysis, we used Google Earth Engine, a web-based platform for cloud-based processing. We used several regions of interest to determine levels of success in order to elucidate what particular policy interventions show greater success in forest rehabilitation. We compared the NDVI values of the planted areas in protected areas, ancestral domain areas, local government units. Results reveal that forest restoration perform better in partnership with local governments although silvicultural treatments and logistical provisions were identified as key elements of success.

Keywords: *Remote sensing, Google Earth Engine, National Greening Program*

**IDENTIFICATION OF BEST MACHINE LEARNING
TECHNIQUE AND MONITORING AND DETECTING
CHANGES OF LAND USE LAND COVER (LULC)
FROM 2005 TO 2019: A CASE STUDY IN
COLOMBO DISTRICT, SRI LANKA**

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ABSTRACT

Monitoring and mapping landscapes of rapidly developing city can significantly contribute to understand the complex growth of urbanization. However, generating accurate and temporal Land Use Land Cover (LULC) maps of such cities are a requirement as well as challenge due to spatial heterogeneity as well as fast dynamic land use practices. To monitor the changes of occurring in Earth surface features, it is required to perform change detection using temporal remote sensing data. Now a days many machine learning (ML) classifiers are used for generating to LULC classified maps. Here most major challenge is identification the best technique. This study not only focuses on the comparison of some ML classification algorithms but also monitoring and detecting changes using time series data.

In this study an attempt is made to observe the changes in LULC features of Colombo, the capital of Sri Lanka. The Landsat multispectral data was used in this study and was acquired from 2005-2019. Three different ML classifiers, Random forest (RF), support vector machine (SVM) and artificial neural network (ANN) was performed for LULC classification on Landsat 2005-2019 data. Among this ML classification the best classification algorithm observed for this study was identified. The multispectral data was classified according to both standard color and scheme of LULC maps in Sri Lanka. There are seven classes according to base map. Such as urban, plantation, forest, paddy, grass, scrub land, and water. By using all the data sets from 2005 - 2019 (2005, 2008, 2011, 2015, 2019), was identified both the best ML classifier and change detection. It was observed from the classified data of Landsat- 2019. Here ML classifier's out performances are SVM-(OA- 92.500% kappa-0.9124), RF-(OA- 85.2778%, kappa-0.8280), and ANN-(OA-71.9403% kappa-0.6703). So SVM was used for classify other data. The urban land use patterns were increased from 2005 to 2019 and paddy fields were reduced. There has been no significant change in water and forest land use classes.

Keywords: *LULC, SVM, RF, ANN, Change detection*

UTILIZATION OF HYPERSPECTRAL DATA AND MACHINE LEARNING ALGORITHMS FOR ESTIMATING CHLOROPHYLL CONTENTS IN WASABI LEAVES

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ABSTRACT

Chlorophyll content is effective indicator of photosynthesis and then it can be indicative of plant physiological activity. Nowadays, Hyperspectral remote sensing data are having been used for evaluating chlorophyll content. Especially, it has been shown that combining hyperspectral data and machine learning algorithms could be more effective to evaluate vegetation properties. The wasabi plants were cultivated individually in Wagner plot (1/5000 a) containing 3L of tap water adjusted to a pH of 6.0 using HCl and NaOH. 7 different treatments were applied including Control, 0N, 2N, 0P, 2P, 0K, 2K. A total of 100 Wasabi (*Eutrema japonicum*) leaves were sampled from plant tops among expanding leaves and reflectance was measured using Fieldspec4. The objectives of this study were to examine the potential hyperspectral remote sensing approaches for estimating chlorophyll content of wasabi and to identify an optimized preprocessing technique for estimating chlorophyll content. The regression models were generated base on Random Forest (RF) machine learning algorithm using Original Reflectance (OR) and 5 preprocessing methods including First Derivative Reflectance (FDR), Continuum Removed (CR), Detrending (DT), Standard Normal Variate (SNV), and Multiplicative Scatter Correction (MSC). The results indicate that all preprocessing technique were effective for improving estimation accuracies. Based on the ratio of performance of deviation (RPD), SNV was the best preprocessing technique with the RPD value of 2.48.

Keywords: Chlorophyll, Hyperspectral Remote Sensing, Machine Learning, Preprocessing, Wasabi

ACCURACY ASSESSMENT OF DSM AND DTM USING MAXAR IMAGERY (15 CM)

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ABSTRACT

High-resolution satellite data generate constructive conditions for creating a digital terrain model/ digital surface model. HD technology intelligently increases the number of pixels through a complex mathematical model that is tuned to the specific requirements of the imagery, resulting in a superior visual experience. In this study we have generated gridded data, which is a regular arrangement of elevations derived from original point cloud using interpolation and generated 30cm and 50cm grid spacing products. Fifteen centimetres (15 cm) HD imagery significantly expand the level of detail, maximizing the ability to see smaller features. This research includes the ultra-high resolution 15cm HD imagery as input and involves the creation of the most demanding and significant 3D terrain models DSM and DTM. As our aim is to achieve the highest level of accuracy and so we have included both the system based and manual photogrammetry approach that results in Horizontal Accuracy at 95% confidence level (CE95): 0.32cm and Vertical Accuracy at 95% confidence level (LE95): 0.38cm. We have generated the 30cm and 50cm grid spacing terrain models using 15cm imagery. The checking of the accuracy of the product was carried out by comparing it with reference value. Reference values were determined in the field by geodetic method that is global navigation satellite system (GNSS) with very high accuracy. The accuracy of the checkpoints depends on the sensor altitude from which the images are taken and the quality of the sensor. To improve the DTM, we have done the measurements of checkpoints (photogrammatic approach) in order to remove systematic errors and blunders for large areas. The results of the study are highly accurate because of which such models are very much useful and significant in engineering projects.

Keywords: *Ultra high-resolution satellite data, digital terrain model, digital surface model, GNSS*

IDENTIFICATION OF OPTIMUM METHOD FOR SENTINEL-1 SAR IMAGE FLOOD MAPPING DURING TROPICAL STORM KROVANH IN AGUSAN DEL SUR, PHILIPPINES

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ABSTRACT

Flooding is one of the most severe and destructive natural hazards, posing significant threats to human lives, properties, and the economy. An accurate flood mapping is a vital component to understand the risks to plan for a mitigation measure. This study utilized Sentinel-1 SAR images to map the flood extent that occurred during December 2020, the onslaught of Tropical Storm Vicky (International Name: Krovanh) due to the sensor's capability to penetrate clouds which enables flood mapping during typhoon events. Before actual flood mapping of the area, backscattering parameters such as VV and VH Polarizations and NDDPI, VV+VH, and VV-VH indices were used to generate maps using machine learning algorithms, random forest (RF), and support vector machine (SVM). The traditional way of flood mapping, which is binarization, was also used to generate maps. The flood maps generated from these methods were assessed, identifying which has the highest flood mapping accuracy. To determine the practical way in flood mapping, the results from the combination of Sentinel-1 polarizations have to undergo an accuracy assessment using the actual ground truth validation points. The results of flood mapping showed that SVM best classified the flood extent. The flood mapping process was then applied to the study area using the identified combination of the polarization and SVM method.

Keywords: Flood mapping, Sentinel-1, binarization, RF, SVM

HUMAN-ELEPHANT CONFLICT TRIGGERING FACTORS IDENTIFICATION USING FUZZY LOGIC MODELLING

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ABSTRACT

Human-elephant conflict (HEC) occurrences is becoming more frequent every year in elephant range countries. Changes in landscape from forested to non-forested areas have fragmented elephant habitat, forcing elephants to approach human-populated areas in search of food and water. This resulted in HEC, in which elephant occurrences always terrify people because they destroy property, cause injury, and death. Therefore, identification of HEC triggering factor is crucial to overcome this issue. Thus, this study hypothesized that factors such as landscape change, greenness, slope, and water resource availability are triggering HEC occurrence. Geospatial approach has capability to provide multi-temporal data and data product at large spatial extent to identify the triggering factors. A fuzzy logic spatial modelling was applied to geospatial data in identification of HEC triggering factors. Results suggested that fuzzy logic model was strongly influenced by proximity to the water source (less than 1.5 km), greenness status (high vegetation), slope (less than 10°) and landscape change. The HEC triggering factors demonstrated that water resource availability ($R^2 = 0.981$, p-value < 0.001) and slope ($R^2 = 0.927$, pvalue < 0.005) has significant relationship with the HEC occurrences. As a conclusion, the results obtained from this study would be useful for the Department of Wildlife and National Park (DWNP) and the local communities to alleviate the HEC occurrences.

Keywords: Human-Elephant Conflict (HEC), Triggering factors, Spatial Analysis

TEN-YEAR COMPARATIVE ANALYSIS OF INFRASTRUCTURE GROWTH OF STATE UNIVERSITIES AND COLLEGES IN CARAGA REGION, PHILIPPINES USING REMOTE SENSING AND GIS

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ABSTRACT

The state universities and colleges (SUCs) infrastructure growth signify improving its core functions like academic, research, extension, administration, and allied services. This study aims to analyze the infrastructure growth of SUCs in Caraga within ten (10) years by calculating the area, the number of buildings, and the length of roads using Remote Sensing (RS) and Geographic Information System (GIS). This study employed remote sensing techniques to assess the spatial and temporal changes of land cover (LC) in the study area and applied GIS calculations to estimate the infrastructure growth rate (IGR). This study showed that the university with the lowest IGR in building area is Surigao State College of Technology (SSCT), with an IGR value of 15.76%. In contrast, Agusan del Sur College of Agriculture and Technology (ASSCAT) has the highest IGR value of 71.78% for building area among the four (4) SUCs in Caraga. According to the number of buildings, Caraga State University (CSU) has the lowest IGR with an IGR value of 8.42%. In comparison, the Surigao del Sur State University garnered the highest IGR of 54.29%. In terms of road length, SSCT has the lowest IGR value of 58.09%, while ASSCAT yielded a superior IGR value of 200.13%. Further, based on the LC change detection within the study sites, CSU has the lowest change in vegetation with 15.93%, in contrast to the SSCT's 69.02% vegetation change rate. Based on these results, baseline comparison data was established to understand the infrastructure growth rates of SUCs in the region. It can provide insights to assess if social development is adequate and responsive to the region's needs. Particularly, the approach demonstrated in this study is highly beneficial for policymakers as they need to monitor regional and national scale infrastructure development in the education sector.

Keywords: Higher education infrastructure, academic facilities, physical assets

OPTICAL SATELLITE TIME SERIES ANALYSIS FOR GANODERMA BONINENSE ATTACK DETECTION ON OIL PALM PLANTATION

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ABSTRACT

One of the causes of the decreasing in oil palm production is the presence of pests and diseases on the oil palm. Various efforts have been made to prevent an increase in the intensity of pest and disease attacks, especially *Ganoderma boninense* which frightens farmers. This study aims to detect the presence of *Ganoderma* attacks on oil palm plants by monitoring the greenery of oil palm plants using optical satellite data, namely Landsat. The method used is regression and time series analysis of the greenness index of oil palm plants, namely NDVI, with the study area of oil palm plantations in North Sumatra, Indonesia. The analysis was carried out on oil palms that were not attacked by *Ganoderma* and those that were attacked by *Ganoderma*. The results of the analysis showed that the oil palms that were most affected by *Ganoderma* were at age more than 4 years and before 6 years with 0.04 difference of NDVI with healthy oil palm, and at the next age there was a decrease in the NDVI value of 0.17 due to a decrease of number of oil palm fronds followed by oil palm deaths. With the gap of the NDVI value at a certain age of oil palm, *Ganoderma* attacks can be detected quickly so that preventive action to increase the intensity of attacks can be carried out quickly as well.

Keywords: *Ganoderma boninense* attack, NDVI, time series analysis

SPATIOTEMPORAL EPIDEMIOLOGY OF ANTHRACNOSE-TWISTER DISEASE OF ONION IN PRODUCTION AREAS OF STO. DOMINGO, NUEVA ECIJA, PHILIPPINES

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ABSTRACT

Epidemiology of anthracnose-twister disease of onion using Geographical Information System (GIS) and UAV in 10 onion-producing barangays of Sto. Domingo, Nueva Ecija was carried out from December 2019 to March 2020. The disease which is caused by the complex of *Colletotrichum gloeosporioides* and *Gibberella moniliformis* was identified to be a major problem in the onion production of the province. The study is initiated to determine, monitor, and map the damage, distribution, hotspot areas, and spread rate of the disease to onion fields. Through ground surveillance, five (5) barangays which include Concepcion (1.21 ha), Dolores (2.03 ha), San Agustin (4.07 ha), San Fabian (4.33 ha), and San Francisco (3.95 ha) were detected to have an increasing magnitude of disease incidence from its detection until the harvesting season. High level of disease severities was also observed from the fields wherein black concentric rings of acervuli were formed on the leaves. Disease spread from barangays which ranges from 0.06 to 0.28 percent/week was computed using the derived Vanderplank's disease formula for disease rate. Moreover, onion fields from the northern area of San Fabian, southeast area of Concepcion and central east area of Dolores showed disease high hotspot areas. Lastly, SVM-facilitated UAV classification confirms the mean reflectance of healthy onions and discriminate infected classes of onion using multispectral imaging. A 0.012 ha of onion fields were detected with anthracnose-twister infection, but, the extent of actual infected areas based on the field evaluation and interpolation recorded 0.35 ha. This entails that remotelysensed approach of disease surveillance can offer additional tool in disease evaluation especially in larger scope of areas but still with the support of on-field evaluations and monitoring.

Keywords: *Anthracnose-Twister, GIS, hotspot analysis, mapping, UAV*

USES OF MULTI-DATE SATELLITE IMAGES FOR MONITORING OF LAND COVER CHANGES OVER COAL-FIRED POWER PLANT SURROUNDED AREAS IN THE QUANG NINH PROVINCE

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ABSTRACT

In the Quang Ninh province, the social-economic activities related to the Coal-fired power plants causes considerable impacts to environment features in their surrounded areas, particularly changing of land cover classes. This study aimed to use multi-date remotely sensed images to evaluate changes in land cover features over an area in Quang Ninh province (Viet Nam) where many coal-fired power plants are operating. Landsat 8 OLI images acquired at different dates from 2014 to 2020 has been collected and utilized. Land cover classes at different dates were generated using both traditional Maximum Likelihood (ML) and machine learning based Support Vector Machine (SVM) classification techniques. In order to improve the classification performance, various textured features including Gray level co-occurrence matrix (GLCM) had been integrated into classified datasets. Obtained land cover classes are then compared and analyzed to work out changing of land cover features taking into consideration operation status of existing coal-fired power plant and other social economic activities in the study area. Results revealed that the remote sensing technology with multi-date satellite analysis techniques is very effective tool for monitoring of changes of environment features such as land cover subject to social-economic activities, including the operation of power plants running by burning coal. Furthermore, it is shown that the integrating of textured features has improved classification results and the machine learning based SVM algorithm has outperformed the traditional ML algorithm when classify complex datasets.

Keywords: Landsat 8 Operational Land Imager (OLI), Maximum Likelihood (ML), Support Vector Machine (SVM), Gray Level Co-occurrence Matrix (GLCM)

SAR AND OPTICAL SENSOR DATA FUSION FOR EARTHQUAKE DAMAGE ASSESSMENT AND ANALYSIS OF THE SIGNIFICANT FEATURES

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ABSTRACT

The resolution and detection capabilities of synthetic aperture radars (SAR) and optical sensors have increased significantly in the past decade to detect damages of earthquakes. However, the processing and analysis of large-area images obtained by these sensors is labor-intensive, time-consuming, and requires domain expertise. Recently, the use of neural networks has been a great asset in this regard. This paper proposes a neural network that combines relevant features from a SAR and an optical sensor. This multi-sensor-fusion neural network has been used for earthquake damage detection in Sulawesi, Indonesia. We also propose inverse-mapping dynamics that aims to understand the significant input features that are impactful for the output of the neural network.

Keywords: *Synthetic aperture radar, Optical satellite, Neural network, earthquake damage detection, Inversemapping*

INSAR ANALYSIS OF TERRAIN DEFORMATION DUE TO AN ONGOING SERIES OF COLLAPSE EARTHQUAKES IN THE CENTRAL HIGHLANDS OF SRI LANKA

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ABSTRACT

As series of collapse earth quakes in the central mountain region of Sri Lanka has hindered the daily life as well causing turmoil due to the placement of the country's highest altitude hydropower dam Victoria. Limestone quarrying, long time drilling to extract limestone creating cracks causing the areas to collapse due to water pressure, existing crack towards the eastern slope of the Mahaweli River, changes in soil layers in the interior of the earth could be the major causes for a continuous series of earth tremors. This study investigates the effects of the earthquakes for probable terrain deformation. PS-InSAR which is an extension of D-InSAR utilizing long time series SAR images with stable point like targets staying unchanged for a long period of time to detect slow movement was implemented in this study. PS-InSAR in mountainous terrains become challenging due to heterogeneous land scape, selection of the time series images, APS and phase unwrapping. A series of 34 Sentinel 1-A images in the ascending node from the year 2019 to 2021 was used. The results suggest possible movement along the line of sight (LOS) in the slant range at the maximum magnitude in the range 40mm/year. It was also observed that the areas in the main city shows more stable topography while the southern part of the Vitoria Dam are subjected to deformation. Eastern slopes of the Mahaweli river lying in the far range of the ascending swath with minimal fore shorting and layover effects has also shows deformation the range -29mm/year to -36mm/year.

Keywords: PS-InSAR, Collapse Earthquakes, Terrain Deformation

APPLICATION OF LANDSAT IMAGERY FOR THE INTERPRETATION OF SURFACE WATER QUALITY – A CASE STUDY OF DE VONG – CO CO RIVER, QUANG NAM

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ABSTRACT

Co Co River is located in the lower section of Thu Bon River and flows parallel to the shoreline. It flows into Han estuary (Da Nang) toward the North and flows into Cua Dai (Hoi An) toward the South. The river has a total length of 27,5 km and it is divided into 2 branches. The study area is called De Vong, belonging to Hoi An city, Quang Nam province. The objective of the study was to (1) apply images of Landsat 8 satellite for interpreting surface-water quality in the De Vong and Co Co River basin, (2) to analyse the correlation with observed data and (3) to build simulator maps in July and September of 2020. The study focuses mainly on the parameters: BOD, COD, DO, NH₄⁺-N and TSS, with at-satellite reflectance values of Landsat 8 OLI-TIRS C1 LEVEL-1 spectral bands, in order to calculate the simulations following correlation and regression by the method of combining spectrum bands using different algorithms, serving to increase the accuracy of the results. The results of the analysis show that the water quality parameters had significant relationships with the models. From these correlation models, water quality parameters were extracted from Landsat 8 image. Results for accuracy of the model evaluation using coefficient of determination (R^2) shows that the accuracy of extracted results is relatively good and high for some parameters such as COD, BOD and TSS with $0.6 < R^2 < 0.99$. In the final step, ArcGIS software was used to create a map that simulates the spatial distribution of calculated water quality parameters, extracted from Landsat 8 OLI-TIRS C1 LEVEL-1.

Keywords: *Landsat 8, De Vong River, Co Co River, water quality, reflectance, coefficient*

NOVASAR AIS DATA PRODUCT POST-PROCESSING AND VISUALIZATION

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ABSTRACT

Synthetic Aperture Radar (SAR) satellites with Automatic Identification System (AIS) has capability to provide better monitoring services to the Maritime traffic/fishing activities which have accelerated considerably over the last decade, with an impact on the marine environment and its resources. Satellite AIS(S-AIS) is a communication tracking system which utilizes transceivers on ships that exchanges information (e.g., the ship's identity, type, dimensions, position, speed, etc.) between ships and coastal stations via satellites, thereby extending its surveillance capability of onshore and offshore vessel tracking.

NovaSAR-S is a small SAR mission designed for low cost programmes using latest commercial off-the-shelf technologies developed by Surrey Satellite Technology, Ltd. (SSTL). NovaSAR-S launched on 18th September 2018 has also carried an additional AIS receiver which, when used to collect data with SAR imagery of the same area and will provide additional information on the identification of legal ships and highlight non-AIS transmitting vessels located in restricted areas. The AIS data logged at ISRO Ground Station is processed by SSTL and are mostly susceptible to errors originating from AIS transmitters, onboard AIS receiver problems and finally in formatting of the AIS data. AIS receivers can be easily spoofed using wrong signals either received by GPS spoofing or an erroneous transmission of AIS message. Other sources of error include loss of acquisition over an area. There are cases when the date/time information is corrupted by the onboard AIS processor. This loss of robustness in the algorithm/system design is not the sole cause of problem; the huge volume of data acquired creates another set of problem that need to be addressed. All the required information is encoded in NMEA AIVDM format, which is decoded by the AIS processor of SSTL and the data product denotes typical AIS messages. In this paper, we discuss about the bottlenecks encountered in S-AIS data products, mitigation approaches adopted for retrieving correct AIS messages and visualization of position/track of ships.

NovaSAR AIS data product contains .csv file with all the fields processed in AIS receiver and a comprehensive xml file which houses the original AIVDM raw sentence alongside the decoded fields. For a single day, the AIS data amounts to approximately 0.1 million unique packets of AIS messages, this huge amount of data/messages from AIS transmitters can be classified into 27 different types of messages out of which two categories are primarily position update and trip status/update. Each AIS packet corresponding to a ship which is identified by a unique Maritime Mobile Service Identity (MMSI), and the following relevant fields/parameters received are noteworthy: MMSI, Navigation Status, Rate of Turn, Speed over Ground, Position Accuracy, Longitude, Latitude, Course over Ground, True Heading, Timestamp, Maneuver indicator & Radio Status etc., The outputs generated from the same are to be filtered properly to visualize global view of all the acquired MMSIs.

Figure 1(a) and (b) represents the plot of single ship (Ex: MMSI: 635030000) and all ship positions as received after dropping duplicate messages in AIS packets. Even then, Roll over effect at edges of themap is observed for few ships wherever Lat-Lon discontinuities are present in AIS data. This is a serious problem which needs to be addressed and rectified so as to obtain the correct path of the ships. Various strategies to prune the erroneous AIS packets like Format based, Absolute Value based and Feasibility based approaches are implemented. All the above approaches are implemented in Python. In Format Based Filtering, the corrupted records are filtered out based on standard AIVDM format compatibility. In Absolute Based Filtering, AIS messages having positional values (Lat/lon) out of their principal values are filtered along with messages originating out of the footprint of NovaSAR. In Feasibility Based Filtering Approach, the track of each ship of corresponding MMSI is derived from the AIS message, and rule out the ships covering unrealistic distances in short span of time based on the speed, rate of turn, position etc., from which decision making module is invoked to identify whether the vessel is deemed fit or unfit for use. After performing these filtering approaches on each AIS packet corresponding to each MMSI, then correct position of ship can be identified as shown in Figure 1(c) without any Lat/lon discontinuities. Upon Analysis, after discarding/scraping data from ill formatted files, the average number of unique AIS messages received per day is significantly less than all received AIS messages. Study has also been extended for throttling down the data volumes using the Adaptive Resampling technique which provides efficiently data storage without losing essential information.

Conclusion: The AIS messages along with AIVDM format is understood for NovaSAR-AIS data where all the parameters are retrieved. As AIS receivers can be easily spoofed using wrong signals either received by GPS spoofing or an erroneous transmission of AIS message, which demands

appropriate filtering operations for correct retrieval of parameters and hence its further association with maritime SAR data. This data when fused with other AIS sources can also improve the tracking capability of a given vessel. In this paper, we made an attempt to successfully extract AIVDM packets, implementation of various filtering approaches to remove duplicates, roll over affects at edges, ships covering unrealistic distances etc. The approach is deemed very apt for better utilization of Ship information and detection of rogue ships. Nevertheless, unrealistic ship location on landmasses can be handled by overlaying land mask vector layers. The current work will aid ocean surveillance users to visualize the track and position of shipping vessels using NovaSAR AIS data and further to appropriate decision making for mitigating marine environmental impact.

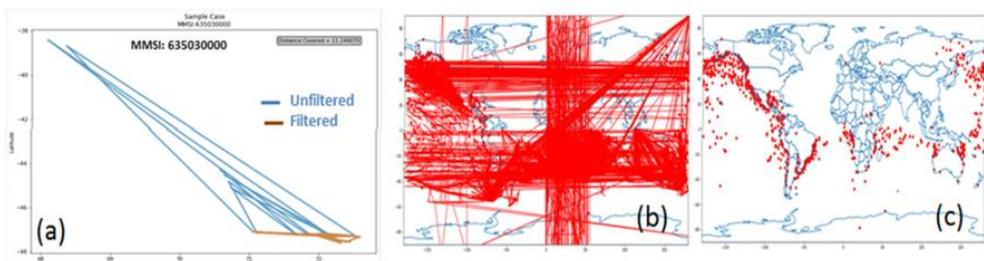


Figure 1. (a) Plot of single ship positions (b) Plot of all ships positions
(c) Plot representing all ship locations after removing duplicates
and applying filtering approaches

Keywords: Automatic Identification System; Synthetic Aperture Radar; NovaSAR; AIVDM packet

EDUCATION AND TRAINING

THE DOWN CONVERTER IN-HOUSE DEVELOPMENT PHASE 2: LESSON AND LEARNING

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ABSTRACT

The communication between the control ground station and the satellite is the most important part to receive and command the information between both.

Thailand by Geo-Informatics and Space Technology Development Agency (GISTDA) has received the data of the Earth Observation satellite by the receiving station for more than a decade. In 2008, the THAICHOTE satellite was the first Earth observation satellite owned by Thailand. THAICHOTE's S-band control ground station performs receiving the telemetry and transmitting the telecommand to the satellite.

In this decade GISTDA's operators and engineers have gained more experience to operate the satellite and maintain the ground control station. GISTDA has initiated the improvement the performance of the operation system and first developed the in-house S-band antenna system named WATER. The main objective is to improve the operational procedures and building capability of GISTDA engineers.

This paper presents the development of the GISTDA ground control station and focuses on the first in-house manufactured down converter. Since 2017 the in-house converter phase 1 has been developed, which is related to understanding of the down converter. This paper presents the in-house down converter phase 2, which is consist of the prototype specification and and the lesson and learning for GISTDA's engineers from this project.

The down converter for S-band converts the frequency from 2GHz to 70 MHz. This project is the co-operation between GISTDA and Mahanakron University of Technology, Thailand. Experts have transferred their knowledge in the area of satellite communication to GISTDA engineers via hands-on development and training courses. The prototype has been subjected to a factory test. It is ready to be integrated and tested with THAICHOTE existing S-band station.

GISTDA has a plan to develop a small satellite in the near future. This in-house development down converter will be a benefit by supporting the multi mission ground station.

Keywords: Downconverter, Satellite ground station, Project learning, In-house development

CASE STUDY OF GIS TECHNOLOGY TRANSFER AND TRAINING IN CAMBODIA FOR RECONSTRUCTION ASSISTANCE AND FRIENDSHIP WITH JAPAN

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ABSTRACT

GIS technology is very important technology of that associates a lot of information on the base map. It is used in a great many fields such as agriculture, agricultural civil construction, road construction / maintenance / management, city planning, and environmental preservation. etc.. GIS is also used in reconstruction assistance projects of Cambodia at JICA from Japan. For practical use GIS technology to the Reconstruction Assistance of Cambodia, we established the Meiho Engineering's branch office in Phnom Penh, Cambodia. We had planned to create employment and training by OJT (On Job Training) for numerical mapping and spatial data editing of GIS technology. At the support, we had three purposes. 1. Transfer GIS technology to Cambodia. 2. Create a GIS job in Cambodia. 3. Sharing to Cambodia, to reduce the workload of Japanese engineers. We made the specifications of the spatial data editing to be created and the materials for the specific creation method, at PDCA-cycle. P: Instruction of editing, D: Editing, C: Check and Instruction of correction from Japan, A: Correction and Confirm. Move to the next new phase. Accumulating with in this PDCA-cycle, the entire editing work had come to rotate, and burden on engineers could be reduced, work efficiency had improved. We will continue to create employment for GIS engineers and improvement of GIS technology through branch in Cambodia. In order to, we will continuously carry out editing work at OJT, and we will support the development of friendly relations between Japan.

Keywords: GIS technical support, ArcGis, Employment creation, OJT (On Job Training), JICA Cambodia

REMOTE SENSING FOR ENVIRONMENTAL EDUCATION USING GOOGLE EARTH ENGINE

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ABSTRACT

Global environmental problems are becoming increasingly diverse and serious. To realize a sustainable society under these circumstances, it is essential to fundamentally review our current socioeconomic activities and lifestyles. Therefore, it is important for every citizen to understand the current state of the global environment and to take action toward to improve the situation. For this purpose, environmental education and training for each citizen, including students, is crucial. Satellite remote sensing technology is one of the most powerful tools for understanding the current state of the global environment. In this paper, we report on a method of using satellite imagery in Google Earth Engine (GEE) to understand the marine environment from a regional to a global scale as part of environmental education for students. The GEE is a cloud computing platform designed to store and process a vast amount of satellite imagery for analysis with free of charge. The GEE API is provided in JavaScript and Python, making it easy for students to use. On the other hand, we have developed a method to estimate sea surface temperature and chlorophylla concentration from Landsat-8 OLI and TIRS data in the Hiroshima Bay and Uwa Sea, Japan. Thus, we coded the equations for estimating sea surface temperature and chlorophyll-a concentration by GEE so that we could generate and display data for any season at any location for environmental education. The marine environmental information using satellite imagery and GEE is useful for students to learn about changes in the local and global marine environment and to think about the impact of these changes on marine life and fisheries.

Keywords: *Sea surface temperature, Chlorophyll-a concentration, Landsat-8*

SCIENTIFIC CONFERENCE PROCEEDINGS
THE 42nd ASIAN CONFERENCE ON REMOTE SENSING (ACRS2021):
REMOTE SENSING FOR DISASTER RISK AND RESOURCES
DEGRADATION REDUCTION TOWARD
SUSTAINABLE DEVELOPMENT

Prof. Vo Quang Minh and Prof. Kohei Cho

Publishing Partner
CAN THO UNIVERSITY
ASIAN ASSOCIATION ON REMOTE SENSING

Director	TRAN THANH DIEN
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Cover Designer	DO VAN THO
Technical Editor	DANG THANH LIEM
Proofreader	PHAN KIEU DIEM PHAN HOANG VU

CAN THO UNIVERSITY PUBLISHING HOUSE

Printed in Can Tho University Publishing House, Campus 2, Can Tho University, 3/2 street, Xuan Khanh ward, Ninh Kieu district, Can Tho city.

Publication License No. 3551-2021/CXBIPH/4-142/ĐHCT.

ISBN: 978-604-965-591-3.

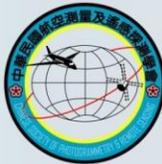
Publication Decision No. 95/QĐ-NXB ĐHCT dated on November 08, 2021.

Volume: 50. Size: 17 x 25,5 cm. Printed and Registered in November 2021.

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ISBN: 978-604-965-591-3



(Not for Sale)