UNDERSTANDING GLOBAL DIGITAL ERA TECHNOLOGIES AND TRANSFORMATIONS IN SOCIAL, ENVIRONMENT, PEACE & BUSINESS DEVELOPMENT PERSPECTIVES IN SOCIETY

Editors

Assoc. Prof. Dr. Muhammad Ali Tarar
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PREFACE

The edition of the Global digital era perspectives, just like it's previous editions , has been enriched by working together of various authors from different universities and counties across the globe. The authors and co-authors enriched this edition by considering feedback from the 9th CEO Congress publications, readers and audiences. The editors wish to thank all those who offered comments, commitment, advice and also thank NCM Publishing House for it's decision to publish this edition.

We would also like to thank all participants who made it possible through out the 9th CEO Congress presentations and all the universities for excellent research assistance throughout this edition of Global digital era, as well as help with online resources to gather different talents internationally.

As for the content, this edition includes chapters in technology, social, environmental sciences, public issues, green technologies, monetary policies, community well-being, law and society development, AI and multi-media creation.

The editors hope that, by collection of case studies from various and cross sectional fields around a common topic, Global digital era, the conditions for grouping, comparing, and analysis cases , countries and systems has been met.

All the chapters are new research which was scientifically and methodologically put together by authors who paid attention to global digital era technologies and perspectives in business and society.

The edited chapters, includes intealia: fresh new digital era technologies, educative content, illustrative diagrams, which encourage further research and reading. In terms of chapter arrangement, a logical order and a conscious effort has been followed to guide readers on fresh global digital era technologies and perspectives. More importantly, to impart knowledge to readers about the impact of ICT on society. The selection of authors was a conscious exercise that considered equality in gender parity and global outreach CEO Congress program of sourcing participants and authors.

Assoc. Prof. Dr. Muhammad Ali Tarar
Mr. Lawrence Walambuka
Bursa – July 2024

CONTENTS

CHAPTER 3

The Relationship Between Land Surface Temperature and Water Availability: A Preliminary study

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ABSTRACT

Land Surface Temperature (LST) is an indicator of climate change, which can influence urban climatological conditions, global environmental changes, and human-environment interactions. In the field of water resources, it is closely related to the hydrological cycle, which has an impact on water security. This research is an initial study of the relationship between surface temperature and water security as climate change mitigation in the Java Island region. The methods used include Supervised Machine Learning with the Random Forest algorithm, Cook's method, and remote sensing using Land Surface Temperature (LST) parameters and Temperature Vegetation Dryness Index (TVDI). The research results show that an increase in built-up land and a decrease in vegetation result in an increase in surface temperature. The surface temperature classification in Jakarta from 1990 to 2021 includes two classes: medium (25–30°C) and high (30–35°C). The increase in built-up land cover reached 25.48%, while the decrease in vegetation 1 and vegetation 2 was 9.26% and 14.73% respectively, so it is predicted that it has the potential to influence the hydrological cycle.
Keywords: Land Surface Covering, Land Surface Temperature, Vegetation, Water security, Climate Change.

1. INTRODUCTION

Satellite remote sensing is a method of observing environmental changes due to human activities physical activities and phenomena. This method can address extraordinary changes in land use/cover, sea level rise, especially in monitoring environmental protection, river deltas, biodiversity and the sustainability of coastal development. Remote sensing systems provide extensive coverage the range of acquisition of spatial data to assess an area using Geographic Information Systems (GIS). In recent years, satellite remote sensing data has been used in research, especially regarding climate change.

Climate change has 5 indicators, including atmospheric composition, temperature and energy, rainfall, ocean conditions and the cryosphere. Understanding changes in these indicators such as CO_2 concentrations, land and sea surface temperatures, rainfall patterns, sea level rise, ocean acidification, and glacier changes is critical to understanding the impacts of climate change and responding effectively.

Based on IPCC data in 2023, global climate change is caused by human activities where air temperatures have increased up to 1.45 and there have been several heat waves in certain countries including the United States, Bolivia, Nepal, Thailand, Japan, Italy, Greece, Morocco, Africa and Indonesia. So 2023 is certain to be the hottest year ever recorded. Heat waves occurred simultaneously in many regions on an unprecedented scale.

The development of climate change is the fundamental reason why problems occur. One of the causes of climate change in Indonesia is that increasing temperatures cause water to evaporate more quickly from land, so that heat waves, droughts and severe forest fires due to climate change become more frequent and intense. This research will discuss the relationship between surface temperature and the condition of water resources in a watershed (Ciliwung Watershed, Jakarta-Indonesia). This research will continue because Indonesia is an archipelagic country which has different characteristics on each island and watershed.

2. LITERATURE REVIEW

Global Climate Change

Climate change (CC) has an influence on the ecological, environmental, socio-political and socio-economic components of the discipline (Adger et al. 2005; Leal Filho et al. 2021; Feliciano et al. 2022). Climatic conditions uncertainty involves increasing temperatures across the world (Battisti and Naylor, 2009; Schuurmans, 2021; Weisheimer and Palmer, 2005; Yadav et al. 2015). Some signs of climate change include the presence of comprehensive long-term trends in temperature and precipitation and other components such as pressure and humidity levels in the surrounding environment. Besides irregular weather patterns and intensity, shrinking global ice sheets and rising sea levels are among the most well-known international and domestic effects of climate change (Lipczynska-Kochany, 2018; Michel et al. 2021; Murshed and Dao, 2020).

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Sources of green house gases (GHG) include natural resources, including volcanoes, forest fires, and seismic activity which contain compounds such as CO2, CH4, N2O, and H2O into the atmosphere (Murshed et al. 2020; Hussain et al. 2020; Sovacool et al. 2021; Usman and Balsalobre-Lorente 2022; Murshed 2022). At the PBB level regarding climate Change (UNFCCC) reached a major agreement that must be addressed climate change and accelerate and intensify action and the investments needed to achieve a sustainable low carbon future at the Conference of the Parties (COP-21) in Paris on 12 December 2015 at which the Paris Agreement was expanded. Aims and objectives of the Paris Agreement is to increase the global response to the threat of climate change by controlling the rise in global temperatures century well below 2 °C compared to pre-industrial levels and up to make efforts to limit the temperature rise to 1.5° C (Sharma et al. 2020; Sharif et al. 2020; Chien et al. 2021).

Along with the acceleration of infrastructure development in Indonesia, the need for concrete is increasing. Minimizing environmental, energy and CO2 impacts is very important in anticipating the effects of greenhouse gases that cause climate change. In the world of construction, the intensity of concrete used for construction plays an important role because it is directly proportional to the decline in natural resources and the increase in the greenhouse effect. Cement is the main ingredient in conventional concrete which is important for society and the construction industry, but in the process it emits greenhouse gases, including carbon dioxide (CO2), which contributes to global warming (Nelfia, LO., et.al., 2024).

Land Surface Temperature

Land surface temperature (LST) is an indicator of climate change (Dash et al., 2002; Li et al., 2014). This is an indicator of energy and water exchange between the land surface and the atmosphere which influences the rate and timing of growth and plant density (Myneni et al., 1997; Peng et al., 2014; Zhang et al., 2007) , LST is widely used in analyzing balance surface energy (Friedl, 2002; Tajfar et al., 2020; Vancutsem et al., 2010; Xu, Guo, et al., 2019; Xu, He, et al., 2019), the urban heat island effect (Alexander, 2020; Fu & Weng, 2016; Estimated surface soil moisture (SM) and evapotranspiration (ET) (Colliander et al., 2017; Gallego-Elvira et al., 2019; Kalma et al., 2008; Karnieli et al., 2010). The development of LST knowledge can improve the understanding of surface-atmosphere exchange processes at global and regional scales and provide valuable surface state metrics for various applications so that LST has been recognized as a key parameter in studying climate change.

LST image coverage of large areas and periodic revisits, satellite observations provide the only way to perform worldwide LST measurements at a spatially averaged pixel scale (Li et al., 2013). Since the 1960s, evolving thermal modeling of infrared instruments (TIR, atmospheric window wavelength region 8–14 μm) has been carried out on different satellites, such as the National Oceanic and Atmospheric Administration (NOAA) satellite series, the Landsat satellite series, the Earth Observing System Terra and Aqua satellites, the Second Generation Meteosat (MSG) satellite series, and the Chinese Fengyun (FY) satellite series. Currently there are various methods for extracting LST from TIR remote sensing data in the literature (Rozenstein et al., 2014) including LST Moderate Resolution Imaging Spectroradiometer (MODIS) (Wan & Dozier, 1996), Landsat Collection 2 surface temperature product (Malakar et al., 2018), Advanced Thermal Emission and Reflection Radiometer (ASTER) Surface Kinetic Temperature (AST_08) product (Gillespie et al., 1998), Spinning Enhanced Visible and InfraRed Imager (SEVIRI) LST product (Trigo et al., 2011), and Copernicus Global Land LST product Operations (Koetz et al., 2018).

Various methods for obtaining LST data, these methods focus on discussing atmospheric effects, geometric effects, and emissivity effects (Prata et.al., 1995) complemented by Li et al. (2013) provide a more systematic and comprehensive review than stated by clarifying the assumptions, advantages, limitations, and requirements of ESG retrieval and validation methods and presents topics for further research.

3. RESEARCH METHOD

Study Area

The research was carried out in the Ciliwung watershed, especially the DKI Jakarta area, with a watershed area of 13,995 ha. The watershed covers parts of North Jakarta, Central Jakarta, West Jakarta, South Jakarta, and East Jakarta. The Ciliwung watershed in this study borders several sub-district administrative areas, including Penjaringan and Tanjung Priok sub-districts in North Jakarta, Taman Sari and Tambora sub-districts in West Jakarta, Gambir and Tanah Abang sub-districts in Central Jakarta, Setia Budi sub-districts, Mampang Prapatan, Pancoran, Pasar Minggu, and Jagakarsa in South Jakarta, as well as the sub-districts of Matraman, Jatinegara, Kramatjati, and Ciracas in East Jakarta.

Figure 1. Location map of the study area

Data acquisition

This research uses secondary data which includes satellite image data, administrative data and land cover classification data. The digital satellite image data used includes Landsat 5 for 1990, 2000, 2010 and Landsat 8 for 2021, where this data was obtained from the Earth explorer USGS and Earth Angine Data Catalog. The second data about shapefile map Ciliwung Watershed with the classification land cover, was obtained from River Basin Organization / Balai Besar Wilayah Sungai (BBWS) Ciliwung-Cisadane and The Ministry of Environment and Forestry.

Data Processing

d. Image processing

Image processing in this research went through three stages, including geometric and radiometric correction, image cropping, and image processing. For geometric and radiometric correction, Landsat 8 imagery with OLI type is used, where the data has been corrected both radiometrically and geometrically. In the image cutting section, it is carried out using digital data on the administrative boundaries of the Jakarta area and the Landsat image of Jakarta, so that the image that previously covered the area of Jakarta becomes an image with the area coverage of only the Jakarta area, which is within the Ciliwung watershed. At the image processing stage, it is divided into several stages, which include image classification and land surface temperature extraction.

Image classification is used to obtain land cover in the Jakarta area. Classification was carried out using digital image classification using ENVI 5.0 digital image processing software using the maximum likelihood method. Land cover classification uses ROI (Regions of Interest). ROI is needed as a representative for each different land cover so that the computer can recognize it based on its pixel value.

The land cover that will be used in image classification can be seen in Table 4, which is the land cover classification class, but in this table, the land cover is modified to suit the research area, namely the Jakarta area in the Ciliwung watershed. The basic classification used refers to the provisions of the Indonesian National Standard (SNI) 7645:2010, the River Basin Organization Ciliwung-Cisadane, and the Ministry of Environment and Forestry. Each land cover class is detailed with its original form in the field, which can be seen in Table 1 below.

Tabel 1. Land cover classification in the ciliwung watershed

Classification	Landcover
Build up land	Settlements, road networks, railway networks, airports, ports
Field land	Badlands
Waters body	Lakes or reservoirs, swamps, rivers, shipping lines, coral reefs.
Vegetation 1	wetland forest, grass marsh. rice fields, swamp bushes
Vegetation 2	Residential gardens, grasslands, savannas, reeds, dry land farming

e. Land surface temperature extraction

Convert DN (Digital Number) values to TOA values

TOA correction is carried out using ENVI 5.0 software using bands 10 and 11 on Landsat images, the aim is to eliminate the influence of atmospheric disturbances on the absolute temperature between objects on the ground and the satellite.

$$L_\gamma = M_L Q_{Cal} + A9_L$$

where:

$L\gamma$: TOA spectral radiance (watts / (m2 * srad * μm))

ML : Band-specific (RADIANCE_MULT_BAND_x, x = band number)

$A9L$: Band-specific (RADIANCE_MULT_BAND_x, x = band number)

$QCal$: Image pixel value DN (Digital Number)

Convert the Radiance value into a brightness temperature value

$$BT = \frac{K2}{ln\,(\frac{K1}{L\lambda} + 1)} - 273{,}15$$

where:
BT : Top Of Atmosfer (TOA) brightness temperature (°C)
Lλ : Top Of Atmosfer (TOA) Radiance
K1 : thermal constant band 10 or 11 (found in metadata)
K2 : thermal constant band 10 or 11 (found in metadata)

Normalized Different Vegetation Index (NDVI)

NDVI functions to determine the level of vegetation density that makes up an area by looking for the fraction value of the area covered by vegetation which will later become a value to obtain information on land surface temperature. In the process, two bands from Landsat imagery are used, namely band 4 (red) and band 5 (near infrared).

$$\text{NDVI} = \frac{(NIR-RED)}{(NIR+RED)}$$

Where:
NDVI : Normalized Differential Vegetation Index
RED : Digital Number value (DN) dari RED band
NIR : Digital Number value (DN) dari Near-Infrared band

Fractional Vegetation Cover, The FVC value is estimated using the previously obtained NDVI value as well as the NDVI (soil) and NDVI (vegetation) values. Functions to estimate the fraction of an area covered by vegetation.

$$FVC = \frac{NDVI - NDVI_{soil}}{NDVI_{veg} - NDVI_{soil}}$$

$where$:
FVC : Fractional Vegetation Cover
NDVI : Normalized Differential Vegetation Index
$NDVI_{veg}$: NDVI for soil = 0.2 (Latif, 2014)
$NDVI_{soil}$: NDVI value for vegetation = maximum value NDVI

Land Surface Emissity (LSE)

To measure the inherent characteristics of the earth's surface and measure its ability to convert thermal energy or heat into radiation energy. The LSE value calculation can be estimated using the FVC value from previous calculations. LSE estimation requires soil emissivity values and vegetation emissivity values from both TIRS bands (band 10 and band 11).

$$LSE = \varepsilon_s * (1 - FVC) + \varepsilon_v * FVC$$

Where:
LSE : Land Surface Emissity
FVC : FVC value
εs : Band 10 and band 11 soil emissivity
εv : Band 10 and band 11 soil emissivity

Land Surface Temperature (LST)

Calculated by applying a structured mathematical algorithm, namely the Split Window Algorithm (SWA). This algorithm uses brightness temperature values from two bands on the Landsat 8 image TIRS sensor, the average value and the LSE (land surface emissivity) difference value to estimate LST.

$$LST = TB10 + C1(TB10 - TB11) + C2(TB10 - TB11)2 + C0 + (C3 + C4W)(1 - M) + (C5 + C6W)\Delta m$$

Where:
LST : Land Surface Temperature (K)
C0 – C6 : Split Window Coefficient
TB10, TB11 : Brightness Temperature (K) band 10 abd band 11
m : average LSE value band 10 and band 11
W : Atmospheric Water Vapour Content = 0,013
Δ m : difference between LSE band 10 and band 11 values

Analysis Data

The data analysis method contains stages in analyzing research results, which consist of spatial descriptive analysis. Spatial descriptive analysis is used to explain and describe the spatial distribution of land cover and the results of extracting surface temperatures (Normalized Different Vegetation Index (NDVI), Top of Atmosphere (TOA), Temperature Brightness, and Land Surface Temperature). To find out the relationship between the two, an overlay is carried out to combine the land cover data and surface temperature data so that the two data become one and overlap each other, so that later the surface temperature can be known for each land cover. Then the assumption is made that the more vegetation, the lower the land surface temperature will be, and if there is little vegetation, the land surface temperature will be high.

4. RESULT AND DISCUSSION

Land cover changes using supervised classification of 1990, 2000, 2010 and 2021

Land cover in the Ciliwung watershed, DKI Jakarta province, is divided into five categories: built-up land, open land, water, vegetation 1, and vegetation 2. Land cover in the Ciliwung watershed (DKI Jakarta) is experiencing changes. Built-up land has increased without decreasing from 1990 (7932.26 ha) to 2021 (11498.92 ha), open land has decreased without increasing from 1990 (358.35 ha) to 2021 (58.31 ha), waters or water bodies decreased from 1990 (393.51 ha) to 2000 (236.93 ha) then increased until 2021 (485.62 ha), vegetation 1 experienced a decrease from 1990 (2581.91 ha) to 2000 (637.31 ha) then increased until 2021 (1284.06 ha), vegetation 2 experienced an increase from 1990 (2728.97 ha) to 2000 (2803.68 ha) then decreased until 2021 (668.09 ha).

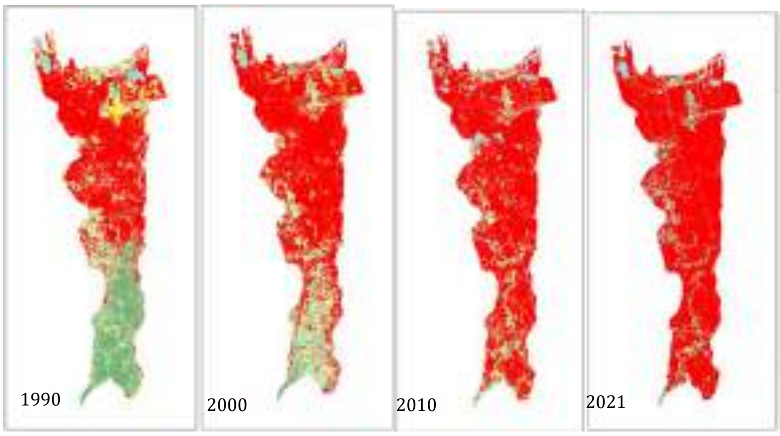

Figure 2. Land cover changes 1990-2021

Based on the image above Figure 3, in the period 1990-2000 there was a change in land cover of 14.85% for built-up land. This can be assumed that every year development progress is 1.4%. Based on Figure 4 above, in the period 2010-2021, there was a change in land cover in vegetation classification 2 of 15.26%. It can be assumed that each year there will be a reduction in vegetation due to development of 1.5%. Of the five existing land classes, it can be seen that from 1990 to 2021, built-up land has experienced a significant increase, filling from 56.68% (1990) to 82.16% (2021), while water has experienced a less significant increase, from 2.81% (1990) to 3.47% (2021). Open land along with vegetation 1 and 2 experienced a decline, where open land decreased from 2.56% (1990) to 0.42% (2021), vegetation 1 decreased from 18.45% (1990) to 9.18% (2021), and vegetation 2 decreased from 19.5% (1990) to 4.77% (2021). From these data, it can be seen that the composition of built-up land is increasing or expanding, and vegetation land is decreasing.

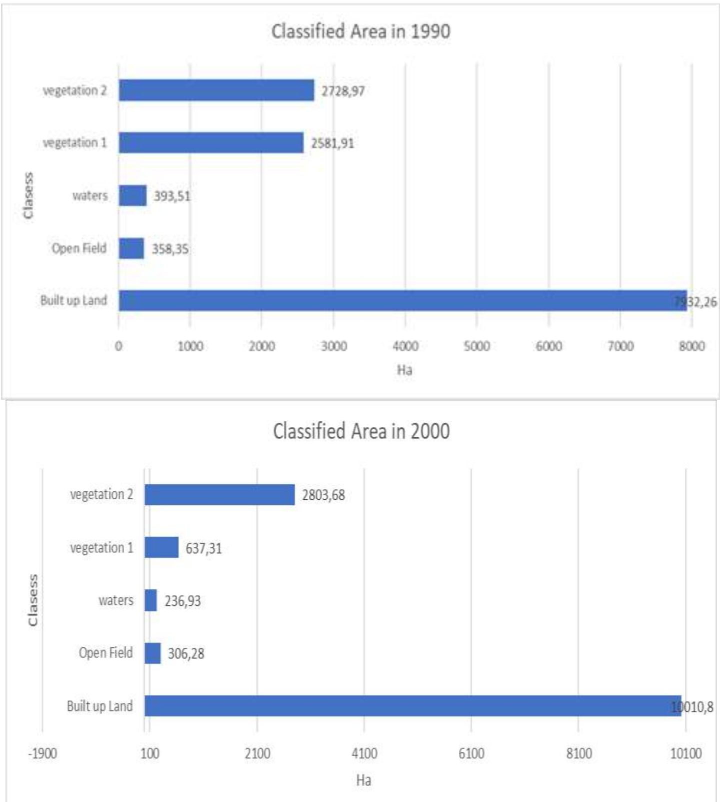

Figure 3. Change in area size 1990-2000

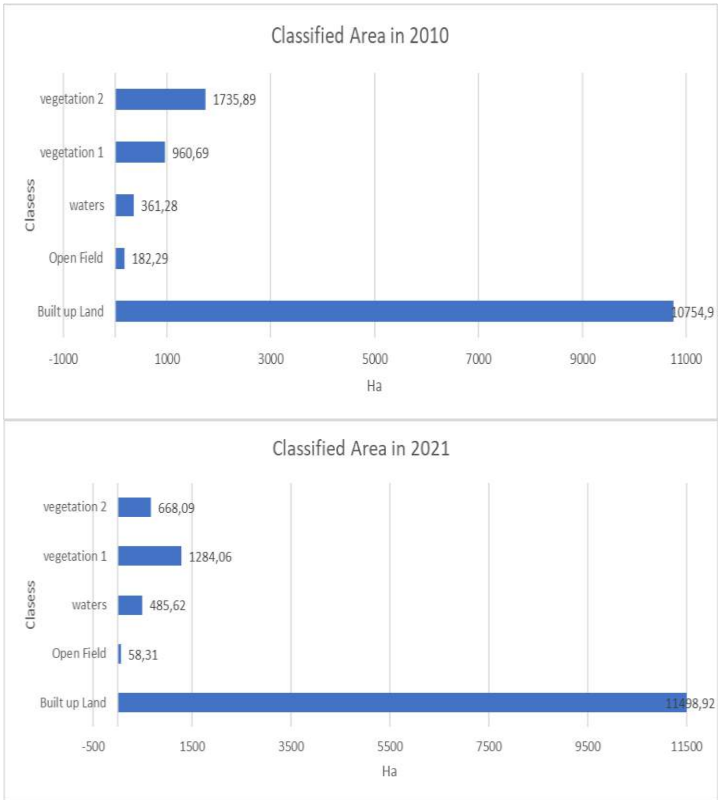

Figure 4. Change in area size 2010-2021

The composition of built-up land increased while vegetated land decreased, reflecting significant changes in the land use of the region. Overall, the vegetation cover in the study area is under the serious threats of floods, drought and seawater intrusion.

Land surface temperature of 1990, 2000, 2010 and 2021

The classification of land surface temperature analysis is divided into 5 classes, namely very low (15^0C-20^0C)-Light blue, low (20^0C-25^0C)-blue, moderate (25^0C-30^0C)-yellow, high (30^0C-35^0C)-brown and very high (35^0C-40^0C)- red.

LST of 1990: Figure 6 and Table 2 are showing the LST ranged from 21°C to 35,2°C with a mean of 27°C. Based on the results of analysis in 1990, land surface temperature conditions in the low category had an area of 9.27% (20^0C-25^0C), the medium category was 90.56% (25^0C-30^0C) and the high category was 0.18% (30^0C-35^0C). This is because in 1990 it had an area with a vegetation distribution of 37.95%.

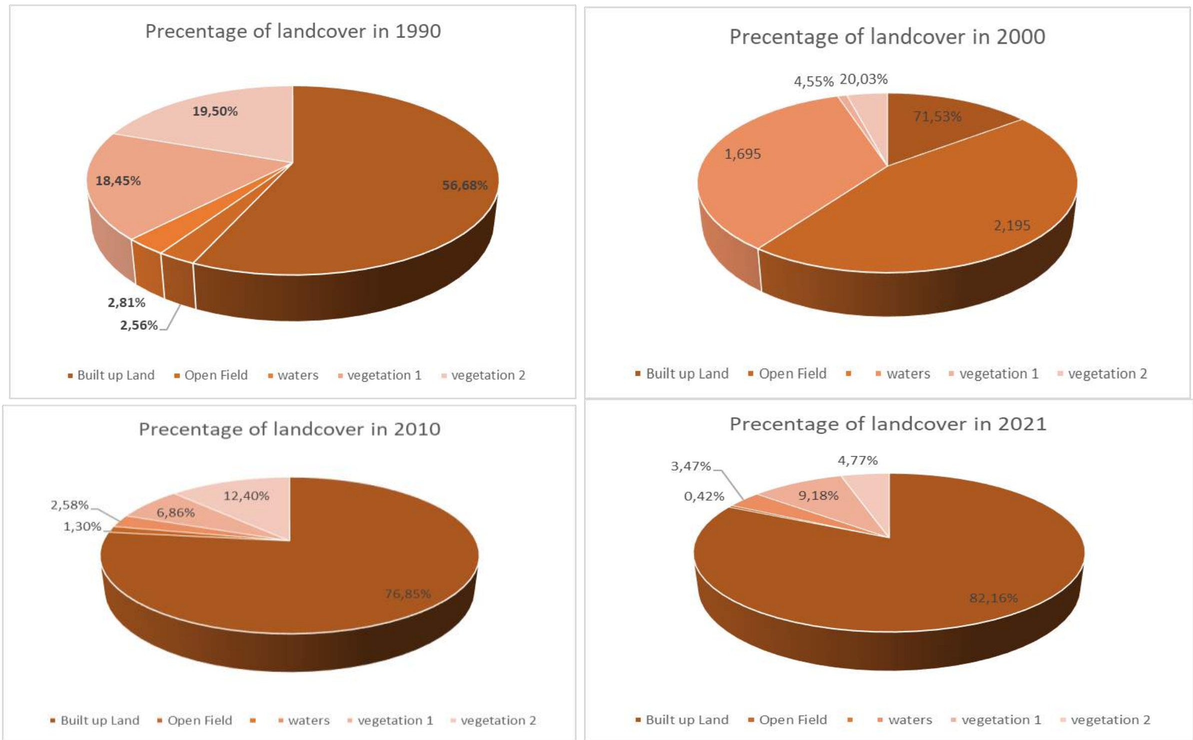

Figure 5. Precentage of landcover in 1990-2021

LST of 2000: Figure 6 and Table 2 are showing the LST ranged from 22°C to 35,5°C with a mean of 27°C. Based on the results of analysis in 2000, land surface temperature conditions in the low category had an area of 0.84% (20^{0}C-25^{0}C), the medium category was 45.39% (25^{0}C-30^{0}C) and the high category was 53.77% (30^{0}C-35^{0}C). This is because in 2000 it had an area with a vegetation distribution of 24.58% and built up land of 1.4% per year.

LST of 2010: Figure 6 and Table 2 are showing the LST ranged from 21,6°C to 35,6°C with a mean of 27,4°C. Based on the results of analysis in 2010, land surface temperature conditions in very low category had an area of 0.20% (15^{0}C-20^{0}C) ,the low category had an area of 10.96% (20^{0}C-25^{0}C), the medium category was 88.82% (25^{0}C-30^{0}C) and the high category was 0.01% (30^{0}C-35^{0}C). This is because in 2000 it had an area with a vegetation distribution of 19.26% and built up land of 0.53% per year. However, this year's LST data has a low level of accuracy. This is because the map used is mostly still covered by clouds so that the resulting analysis has a low category for land surface temperature.

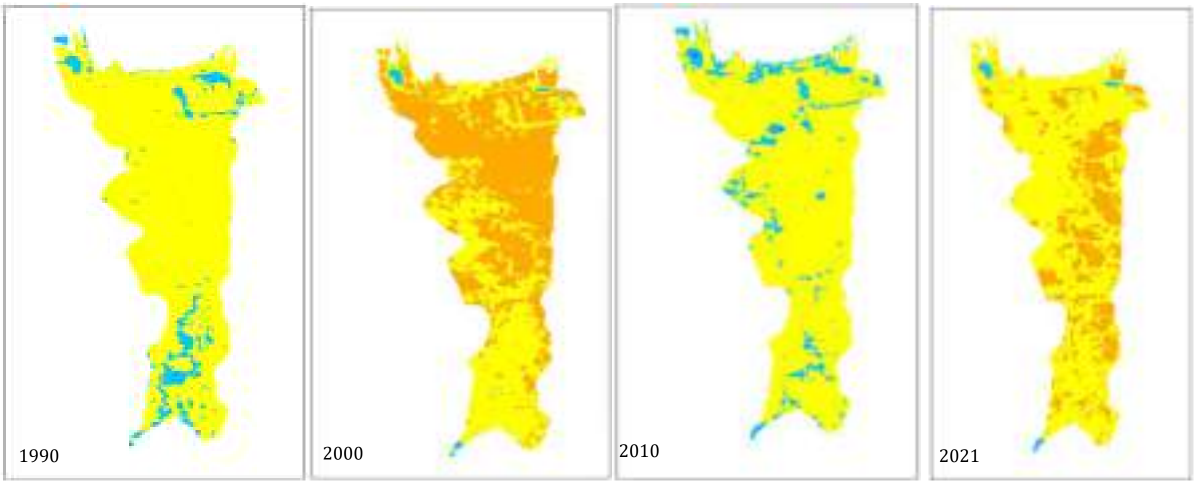

Figure 6. Land surface temperature in 1990-2021

Table 2. LST values of 1990, 2000, 2010 and 2021

No	Year	Minimum Temperature (^{0}C)	Maximum Temperature (^{0}C)	Mean Temperature (^{0}C)
1	1990	21,0	35,2	27,0
2	2000	22,0	35,5	27,0
3	2010	21,6	35,6	27,4
4	2021	19,2	38,0	27,6

LST of 2021: Figure 6 and Table 2 are showing the LST ranged from 19,0°C to 38,0°C with a mean of 27,6°C. Based on the results of analysis in 2021, land surface temperature conditions in very low category had an area of 0.20% (15^{0}C-20^{0}C), the low category had an area of 0.77% (20^{0}C-25^{0}C), the medium category was 73.64% (25^{0}C-30^{0}C) and the high category was 25.39% (30^{0}C-35^{0}C). This is because in 2021 it had an area with a vegetation distribution of 13.95% and built up land of 0.53% per year.

Climatic factors affecting land cover changes

Cyclone: Satellite imageries provide extensive information about extreme weather patterns like Tropical cyclones. These are part of climate of tropical region of Asia, which affect various countries in the region including Indonesia. The intensity and frequency of these cyclones are increased in the end of 19th century. It goes more destructive with the sea level rise, high tides and motions of waves. It even raised the loss of infrastructure and erotion the land area. This usually occurs due to negative coastal development, tectonic plate movements, climate patterns, as well as increased tidal and wave movements due to rising sea levels, affect land.

Flood/ Rain: The devastating floods that occurred in Jakarta occurred in 1872, 1918, 1979, 1996, 2002, 2007, 2013, 2015 and 2021. Floods are an overflow of water that extends to submerge the land. Jakarta occasionally experiences slow and fast types of river flooding in the rainy season.

Figure 7. Sinking area at Muara Baru (source: google, 2022)

Figure 8. Sinking area at Muara Baru (source: Kompas 2007; 2021)

5. CONCLUSION AND RECOMMENDATIONS

The surface temperature classification in Jakarta from 1990 to 2021 includes two classes: medium (25–30°C) and high (30–35°C). The increase in built-up land cover reached 25.48%, while the decrease in vegetation 1 and vegetation 2 was 9.26% and 14.73% respectively, so it is predicted that it has the potential to influence the hydrological cycle. Higher vegetation density generally leads to lower land surface temperatures, while lower vegetation density is associated with higher surface temperatures. Jakarta is prone to significant flooding, with historical events highlighting risks. Satellite data, especially Landsat imagery, reveals key threats and land degradation, particularly on the north coast due to both human and natural factors. Temporal datasets show changing land cover in the Ciliwung watershed, including shifts in vegetation and coastal erosion. Continuous monitoring and mitigation can address these issues. This research is a foundation for future studies on climate change and water resource resilience. In planning for mitigation and adaptation due to climate change, it is necessary to add parameters, such as rainfall based on satellite imagery, climatological data, and condition of vegetation types. This aims to strengthen the resulting influence, thereby allowing a deeper understanding of the relationship between variables.

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Dr. Muhammad Ali Tarar joined University of Agriculture, Faisalabad- Pakistan as Teaching Assistant in 2005, later as, Lecturer Rural Sociology in November 2007 and presently serving the Department of Sociology, Ghazi University, Dera Ghazi Khan-Pakistan as Associate Professor / Chairman Sociology along with serving as Director Purchase & Store at GU. Additionally, he has also served as Director Financial Assistance & Development (FAD) w.e.f 05-07-2023 to 31-12-2023 as well as Director office of Research, Innovation & Commercialization (ORIC) from 18-11-2015 to 24-10-2022 and awarded a "Certificate of Appreciation" from Vice Chancellor, Ghazi University, Dera Ghazi Khan for excellent services (15-09-2022). As Chief Editor, Kisht-e-Nau (student Magazine, University of Agriculture, Faisalabad) published Centennial Number in 2006 and was awarded UNIVERSITY GOLD MEDAL from Chancellor of University/ Governor of Punjab-Pakistan as-well-as UNIVERSITY ROLE OF HONOR, UNIVERSITY COLOUR & UNIVERSITY CERTIFICATE OF EXCELLENCE was awarded from Worthy Vice Chancellor for publishing the Centennial Number of " Kisht-e-Nau " as Chief Editor on the eve of centenary celebrations of University of Agriculture, Faisalabad (14th to 16th March 2006). He has vast experience in teaching & research. Being Researcher published more than 45 research articles on different social & behavioral issues in National & International high-quality indexes/ impact factor journals that are recognized by Higher Education of Pakistan and at postgraduate level supervised more than one hundred research students and completed their Research Thesis/ Projects. He is also coauthor/ Editor of books (i)"Introduction to Sociology; (ii) "Accounting Inquiries with New Approaches in the Post-Pandemic Era Volume I"; (iii) "Accounting Inquiries with New Approaches in the Post-Pandemic Era Volume II"; (iv) "Abstract E-Book" 5th International CEO Social Sciences Congress (CEOSSC 2022)"; (v) 5th CEO Proceedings Book. 5th International CEO Social Sciences Congress E-Proceeding Book 9-11-December CEOSSC 2022); (vi) CEO Abstract E-Book. 8th International CEO Social Sciences Congress Abstract E-Book 16-17 December, 2023- Portugal; (vii) CEO Proceedings E-Book. 8th International CEO Social Sciences Congress E-Proceeding Book 16-17 December, 2023-Portugal; (viii) Contemporary Exploration of Social Sciences in the Post Pandemic Era-1; (ix) Contemporary Exploration of Social Sciences in the Post Pandemic Era-2; (x) Global Digital Era, Social, Peace & Business Perspectives in Society; (xi) Social Behaviour, Leadership, Sales, Communication, Organization, Branding, Feasibility Analysis for Business Management Inquiries with New Approaches in the Post-Pandemic Era-1; (xii) Social Behaviour, Leadership, Sales, Communication, Organization, Branding, Feasibility Analysis for Business Management Inquiries with New Approaches in the Post-Pandemic Era; (xiii) Social Behaviour, Leadership, Sales, Communication, Organization, Branding, Feasibility Analysis for Business Management Inquiries with New Approaches in the Post-Pandemic Era; and (xiv) Social Green Behaviour, Artificial Intelligence and Business Strategies & Perspectives in Global Digital Society. He is also external examiner of research / paper setter of many universities for postgraduate level as well as examination supervisor of Punjab Public Service Commission, Pakistan. Being Director ORIC made collaboration with sister universities and industries to develop academia to academia

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T.C.
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9th International CEO Communication, Economics, Organization & Social Sciences Congress

The Relationship Between Land Surface Temperature and Water Availability: a Preliminary study

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ABSTRACT

Land Surface Temperature (LST) is an indicator of climate change, which can influence urban climatological conditions, global environmental changes, and human-environment interactions. In the field of water resources, it is closely related to the hydrological cycle, which has an impact on water security. This research is an initial study of the relationship between surface temperature and water security as climate change mitigation in the Java Island region. The methods used include Supervised Machine Learning with the Random Forest algorithm, Cook's method, and remote sensing using Land Surface Temperature (LST) parameters and Temperature Vegetation Dryness Index (TVDI). The research results show that an increase in built-up land and a decrease in vegetation result in an increase in surface temperature. The surface temperature classification in Jakarta from 1990 to 2021 includes two classes: medium (25–30°C) and high (30–35°C). The increase in built-up land cover reached 25.48%, while the decrease in vegetation 1 and vegetation 2 was 9.26% and 14.73% respectively, so it is predicted that it has the potential to influence the hydrological cycle

Keywords: Land Surface Covering, Land Surface Temperature, Vegetation, Water security, Climate Change

1. INTRODUCTION

Satellite remote sensing is a method of observing environmental changes due to human activities physical activities and phenomena. This method can address extraordinary changes in land use/cover, sea level rise, especially in monitoring environmental protection, river deltas, biodiversity and the sustainability of coastal development. Remote sensing systems provide extensive coverage the range of acquisition of spatial data to assess an area using Geographic Information Systems (GIS). In recent years, satellite remote sensing data has been used in research, especially regarding climate change.

Climate change has 5 indicators, including atmospheric composition, temperature and energy, rainfall, ocean conditions and the cryosphere. Understanding changes in these indicators such as CO_2 concentrations, land and sea surface temperatures, rainfall patterns, sea level rise, ocean acidification, and glacier changes is critical to understanding the impacts of climate change and responding effectively.

Based on IPCC data in 2023, global climate change is caused by human activities where air temperatures have increased up to 1.45 and there have been several heat waves in certain countries including the United States, Bolivia, Nepal, Thailand, Japan, Italy, Greece, Morocco, Africa and Indonesia. So 2023 is certain to be the hottest year ever recorded. Heat waves occurred simultaneously in many regions on an unprecedented scale.

The development of climate change is the fundamental reason why problems occur. One of the causes of climate change in Indonesia is that increasing temperatures cause water to evaporate more quickly from land, so that heat waves, droughts and severe forest fires due to climate change become more frequent and intense. This research will discuss the relationship between surface temperature and the condition of water resources in a watershed (Ciliwung Watershed, Jakarta-Indonesia). This research will continue because Indonesia is an archipelagic country which has different characteristics on each island and watershed.

2. LITERATURE REVIEW

Global Climate Change

Climate change (CC) has an influence on the ecological, environmental, socio-political and socio-economic components of the discipline (Adger et al. 2005; Leal Filho et al. 2021; Feliciano et al. 2022). Climatic conditions uncertainty involves increasing temperatures across the world (Battisti and Naylor, 2009; Schuurmans, 2021; Weisheimer and Palmer, 2005; Yadav et al. 2015). Some signs of climate change include the presence of comprehensive long-term trends in temperature and precipitation and other components such as pressure and humidity levels in the surrounding environment. Besides irregular weather patterns and intensity, shrinking global ice sheets and rising sea levels are among the most well-known international and domestic effects of climate change (Lipczynska-Kochany, 2018; Michel et al. 2021; Murshed and Dao, 2020).

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Sources of green house gases (GHG) include natural resources, including volcanoes, forest fires, and seismic activity which contain compounds such as CO2, CH4, N2O, and H2O into the atmosphere (Murshed et al. 2020; Hussain et al. 2020; Sovacool et al. 2021; Usman and Balsalobre-Lorente 2022; Murshed 2022). At the PBB level regarding climate Change (UNFCCC) reached a major agreement that must be addressed climate change and accelerate and intensify action and the investments needed to achieve a sustainable low carbon future at the Conference of the Parties (COP-21) in Paris on 12 December 2015 at which the Paris Agreement was expanded. Aims and objectives of the Paris Agreement is to increase the global response to the threat of climate change by controlling the rise in global temperatures century well below 2 °C compared to pre-industrial levels and up to make efforts to limit the temperature rise to 1.5° C (Sharma et al. 2020; Sharif et al. 2020; Chien et al. 2021).

Along with the acceleration of infrastructure development in Indonesia, the need for concrete is increasing. Minimizing environmental, energy and CO2 impacts is very important in anticipating the effects of greenhouse gases that cause climate change. In the world of construction, the intensity of concrete used for construction plays an important role because it is directly proportional to the decline in natural resources and the increase in the greenhouse effect. Cement is the main ingredient in conventional concrete which is important for society and the construction industry, but in the process it emits greenhouse gases, including carbon dioxide (CO2), which contributes to global warming (Nelfia, LO., et.al., 2024).

Land Surface Temperature

Land surface temperature (LST) is an indicator of climate change (Dash et al., 2002; Li et al., 2014). This is an indicator of energy and water exchange between the land surface and the atmosphere which influences the rate and timing of growth and plant density (Myneni et al., 1997; Peng et al., 2014; Zhang et al., 2007) , LST is widely used in analyzing balance surface energy (Friedl, 2002; Tajfar et al., 2020; Vancutsem et al., 2010; Xu, Guo, et al., 2019; Xu, He, et al., 2019), the urban heat island effect (Alexander, 2020; Fu & Weng, 2016; Estimated surface soil moisture (SM) and evapotranspiration (ET) (Colliander et al., 2017; Gallego-Elvira et al., 2019; Kalma et al., 2008; Karnieli et al., 2010). The development of LST knowledge can improve the understanding of surface-atmosphere exchange processes at global and regional scales and provide valuable surface state metrics for various applications so that LST has been recognized as a key parameter in studying climate change.

LST image coverage of large areas and periodic revisits, satellite observations provide the only way to perform worldwide LST measurements at a spatially averaged pixel scale (Li et al., 2013). Since the 1960s, evolving thermal modeling of infrared instruments (TIR, atmospheric window wavelength region 8–14 μm) has been carried out on different satellites, such as the National Oceanic and Atmospheric Administration (NOAA) satellite series, the Landsat satellite series, the Earth Observing System Terra and Aqua satellites, the Second Generation Meteosat (MSG) satellite series, and the Chinese Fengyun (FY) satellite series. Currently there are various methods for extracting LST from TIR remote sensing data in the literature (Rozenstein et al., 2014) including LST Moderate Resolution Imaging Spectroradiometer (MODIS) (Wan & Dozier, 1996), Landsat Collection 2 surface temperature product (Malakar et al., 2018), Advanced Thermal Emission and Reflection Radiometer (ASTER) Surface Kinetic Temperature (AST_08) product (Gillespie et al., 1998), Spinning Enhanced Visible and InfraRed Imager (SEVIRI) LST product (Trigo et al., 2011), and Copernicus Global Land LST product Operations (Koetz et al., 2018).

Various methods for obtaining LST data, these methods focus on discussing atmospheric effects, geometric effects, and emissivity effects (Prata et.al., 1995) complemented by Li et al. (2013) provide a more systematic and comprehensive review than stated by clarifying the assumptions, advantages, limitations, and requirements of ESG retrieval and validation methods and presents topics for further research.

3. RESEARCH METHOD

Study Area

The research was carried out in the Ciliwung watershed, especially the DKI Jakarta area, with a watershed area of 13,995 ha. The watershed covers parts of North Jakarta, Central Jakarta, West Jakarta, South Jakarta, and East Jakarta. The Ciliwung watershed in this study borders several sub-district administrative areas, including Penjaringan and Tanjung Priok sub-districts in North Jakarta, Taman Sari and Tambora sub-districts in West Jakarta, Gambir and Tanah Abang sub-districts in Central Jakarta, Setia Budi sub-districts, Mampang Prapatan, Pancoran, Pasar Minggu, and Jagakarsa in South Jakarta, as well as the sub-districts of Matraman, Jatinegara, Kramatjati, and Ciracas in East Jakarta.

Figure 1. Location map of the study area

Data acquisition

This research uses secondary data which includes satellite image data, administrative data and land cover classification data. The digital satellite image data used includes Landsat 5 for 1990, 2000, 2010 and Landsat 8 for 2021, where this data was obtained from the Earth explorer USGS and Earth Angine Data Catalog. The second data about shapefile map Ciliwung Watershed with the classification land cover, was obtained from River Basin Organization / Balai Besar Wilayah Sungai (BBWS) Ciliwung-Cisadane and The Ministry of Environment and Forestry.

Data Processing

1. Image processing

Image processing in this research went through three stages, including geometric and radiometric correction, image cropping, and image processing. For geometric and radiometric correction, Landsat 8 imagery with OLI type is used, where the data has been corrected both radiometrically and geometrically. In the image cutting section, it is carried out using digital data on the administrative boundaries of the Jakarta area and the Landsat image of Jakarta, so that the image that previously covered the area of Jakarta becomes an image with the area coverage of only the Jakarta area, which is within the Ciliwung watershed. At the image processing stage, it is divided into several stages, which include image classification and land surface temperature extraction.

Image classification is used to obtain land cover in the Jakarta area. Classification was carried out using digital image classification using ENVI 5.0 digital image processing software using the maximum likelihood method. Land cover classification uses ROI (Regions of Interest). ROI is needed as a representative for each different land cover so that the computer can recognize it based on its pixel value.

The land cover that will be used in image classification can be seen in Table 4, which is the land cover classification class, but in this table, the land cover is modified to suit the research area, namely the Jakarta area in the Ciliwung watershed. The basic classification used refers to the provisions of the Indonesian National Standard (SNI) 7645:2010, the River Basin Organization Ciliwung-Cisadane, and the Ministry of Environment and Forestry. Each land cover class is detailed with its original form in the field, which can be seen in Table 1 below.

Tabel 1. Land Cover Classification in the Ciliwung Watershed

Classification	Landcover
Build up land	Settlements, road networks, railway networks, airports, ports
Field land	Badlands
Waters body	Lakes or reservoirs, swamps, rivers, shipping lines, coral reefs.
Vegetation 1	wetland forest, grass marsh. rice fields, swamp bushes
Vegetation 2	Residential gardens, grasslands, savannas, reeds, dry land farming

2. **Land surface temperature extraction**

Convert DN (Digital Number) values to TOA values, TOA correction is carried out using ENVI 5.0 software using bands 10 and 11 on Landsat images, the aim is to eliminate the influence of atmospheric disturbances on the absolute temperature between objects on the ground and the satellite.

$$L_{\gamma} = M_L Q_{Cal} + A9_L$$

where:

$L\gamma$: TOA spectral radiance (watts / (m2 * srad * μm))

ML : Band-specific (RADIANCE_MULT_BAND_x, x = band number)

$A9L$: Band-specific (RADIANCE_MULT_BAND_x, x = band number)

$QCal$: Image pixel value DN (Digital Number)

Convert the Radiance value into a brightness temperature value

$$BT = \frac{K2}{ln(\frac{K1}{L\lambda}+1)} - 273{,}15$$

where:

BT : Top Of Atmosfer (TOA) brightness temperature (°C)

Lλ : Top Of Atmosfer (TOA) Radiance

K1 : thermal constant band 10 or 11 (found in metadata)

K2 : thermal constant band 10 or 11 (found in metadata)

Normalized Different Vegetation Index (NDVI), NDVI functions to determine the level of vegetation density that makes up an area by looking for the fraction value of the area covered by vegetation which will later become a value to obtain information on land surface temperature. In the process, two bands from Landsat imagery are used, namely band 4 (red) and band 5 (near infrared).

$$\text{NDVI} = \frac{(NIR-RED)}{(NIR+RED)}$$

Where:

NDVI : Normalized Differential Vegetation Index

RED : Digital Number value (DN) dari RED band

NIR : Digital Number value (DN) dari Near-Infrared band

Fractional Vegetation Cover, The FVC value is estimated using the previously obtained NDVI value as well as the NDVI (soil) and NDVI (vegetation) values. Functions to estimate the fraction of an area covered by vegetation.

$$FVC = \frac{NDVI - NDVI_{soil}}{NDVI_{veg} - NDVI_{soil}}$$

where:

FVC : Fractional Vegetation Cover

NDVI : Normalized Differential Vegetation Index

$NDVI_{veg}$: NDVI for soil = 0.2 (Latif, 2014)

$NDVI_{soil}$: NDVI value for vegetation = maximum value NDVI

Land Surface Emissity (LSE), to measure the inherent characteristics of the earth's surface and measure its ability to convert thermal energy or heat into radiation energy. The LSE value calculation can be estimated using the FVC value from previous calculations. LSE estimation requires soil emissivity values and vegetation emissivity values from both TIRS bands (band 10 and band 11).

$$LSE = \varepsilon_s * (1 - FVC) + \varepsilon_v * FVC$$

Where:

LSE : Land Surface Emissity

FVC : FVC value

εs : Band 10 and band 11 soil emissivity

εv : Band 10 and band 11 soil emissivity

Land Surface Temperature (LST), calculated by applying a structured mathematical algorithm, namely the Split Window Algorithm (SWA). This algorithm uses brightness temperature values from two bands on the Landsat 8 image TIRS sensor, the average value and the LSE (land surface emissivity) difference value to estimate LST.

$$LST = TB10 + C1(TB10 - TB11) + C2(TB10 - TB11)2 + C0 + (C3 + C4W)(1 - M) + (C5 + C6W)\Delta m$$

Where:

LST : Land Surface Temperature (K)

C0 – C6 : Split Window Coefficient

TB10, TB11 : Brightness Temperature (K) band 10 abd band 11

m : average LSE value band 10 and band 11

W : Atmospheric Water Vapour Content = 0,013

Δ m : difference between LSE band 10 and band 11 values

Analysis Data

The data analysis method contains stages in analyzing research results, which consist of spatial descriptive analysis. Spatial descriptive analysis is used to explain and describe the spatial distribution of land cover and the results of extracting surface temperatures (Normalized Different Vegetation Index (NDVI), Top of Atmosphere (TOA), Temperature Brightness, and Land Surface Temperature). To find out the relationship between the two, an overlay is carried out to combine the land cover data and surface temperature data so that the two data become one and overlap each other, so that later the surface temperature can be known for each land cover. Then the assumption is made that the more vegetation, the lower the land surface temperature will be, and if there is little vegetation, the land surface temperature will be high.

4. RESULT AND DISCUSSION

Land cover changes using supervised classification of 1990, 2000, 2010 and 2021

Land cover in the Ciliwung watershed, DKI Jakarta province, is divided into five categories: built-up land, open land, water, vegetation 1, and vegetation 2. Land cover in the Ciliwung watershed (DKI Jakarta) is experiencing changes. Built-up land has increased without decreasing from 1990 (7932.26 ha) to 2021 (11498.92 ha), open land has decreased without increasing from 1990 (358.35 ha) to 2021 (58.31 ha), waters or water bodies decreased from 1990 (393.51 ha) to 2000 (236.93 ha) then increased until 2021 (485.62 ha), vegetation 1 experienced a decrease from 1990 (2581.91 ha) to 2000 (637.31 ha) then increased until 2021 (1284.06 ha), vegetation 2 experienced an increase from 1990 (2728.97 ha) to 2000 (2803.68 ha) then decreased until 2021 (668.09 ha).

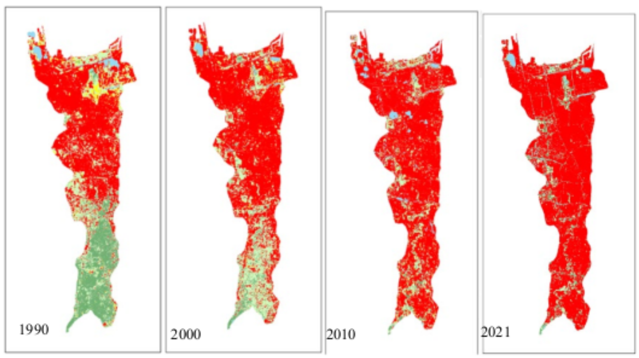


Figure 2. Land cover changes 1990-2021

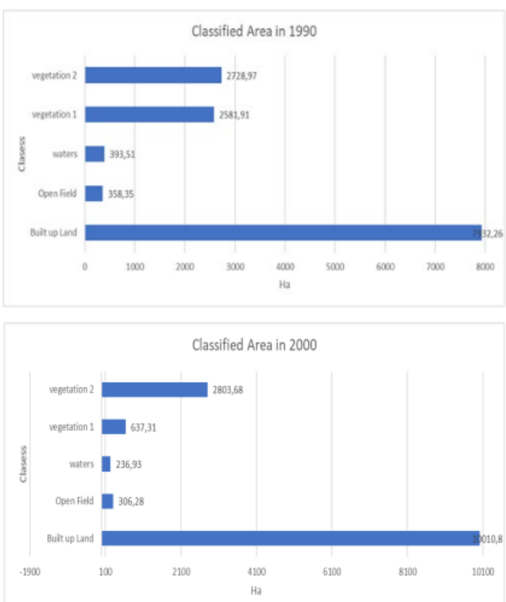


Figure 3. change in area size 1990-2000

Based on the image above Figure 3, in the period 1990-2000 there was a change in land cover of 14.85% for built-up land. This can be assumed that every year development progress is 1.4%.

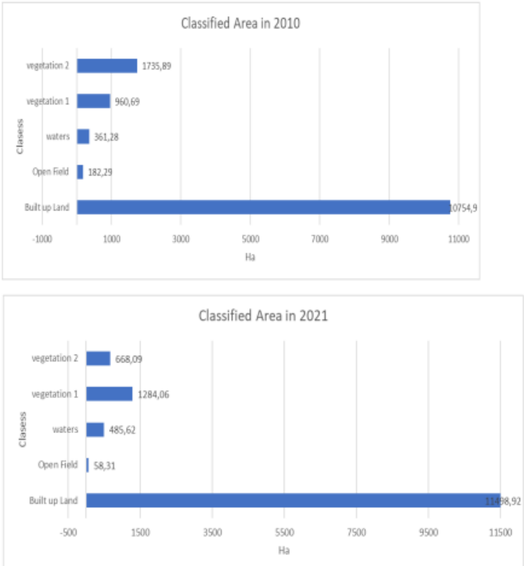
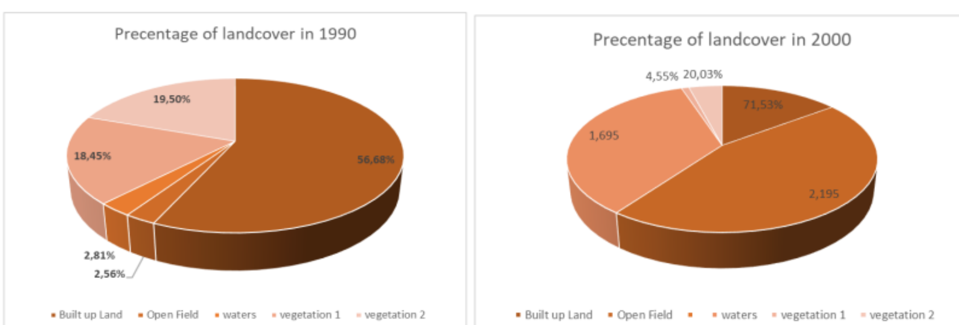


Figure 4. change in area size 2010-2021

Based on Figure 4 above, in the period 2010-2021, there was a change in land cover in vegetation classification 2 of 15.26%. It can be assumed that each year there will be a reduction in vegetation due to development of 1.5%. Of the five existing land classes, it can be seen that from 1990 to 2021, built-up land has experienced a significant increase, filling from 56.68% (1990) to 82.16% (2021), while water has experienced a less significant increase, from 2.81% (1990) to 3.47% (2021). Open land along with vegetation 1 and 2 experienced a decline, where open land decreased from 2.56% (1990) to 0.42% (2021), vegetation 1 decreased from 18.45% (1990) to 9.18% (2021), and vegetation 2 decreased from 19.5% (1990) to 4.77% (2021). From these data, it can be seen that the composition of built-up land is increasing or expanding, and vegetation land is decreasing.



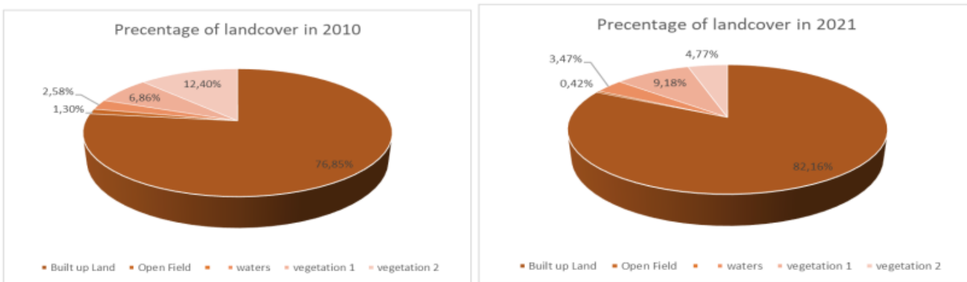


Figure 5. Precentage of landcover in 1990-2021

The composition of built-up land increased while vegetated land decreased, reflecting significant changes in the land use of the region. Overall, the vegetation cover in the study area is under the serious threats of floods, drought and seawater intrusion.

Land surface temperature of 1990, 2000, 2010 and 2021

The classification of land surface temperature analysis is divided into 5 classes, namely very low (15^{0}C-20^{0}C)-Light blue, low (20^{0}C-25^{0}C)-blue, moderate (25^{0}C-30^{0}C)-yellow, high (30^{0}C-35^{0}C)-brown and very high (35^{0}C-40^{0}C)- red.

LST of 1990: Figure 6 and Table 2 are showing the LST ranged from 21°C to 35,2°C with a mean of 27°C. Based on the results of analysis in 1990, land surface temperature conditions in the low category had an area of 9.27% (20^{0}C-25^{0}C), the medium category was 90.56% (25^{0}C-30^{0}C) and the high category was 0.18% (30^{0}C-35^{0}C). This is because in 1990 it had an area with a vegetation distribution of 37.95%.

LST of 2000: Figure 6 and Table 2 are showing the LST ranged from 22°C to 35,5°C with a mean of 27°C. Based on the results of analysis in 2000, land surface temperature conditions in the low category had an area of 0.84% (20^{0}C-25^{0}C), the medium category was 45.39% (25^{0}C-30^{0}C) and the high category was 53.77% (30^{0}C-35^{0}C). This is because in 2000 it had an area with a vegetation distribution of 24.58% and built up land of 1.4% per year.

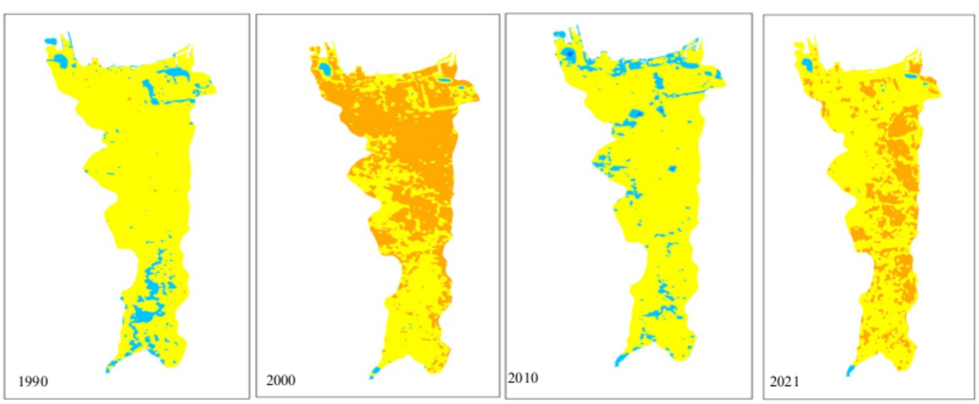


Figure 6. Land Surface Temperature in 1990-2021

Table 2. LST values of 1990, 2000, 2010 and 2021

No	Year	Minimum Temperature (^{0}C)	Maximum Temperature (^{0}C)	Mean Temperature (^{0}C)
1	1990	21,0	35,2	27,0
2	2000	22,0	35,5	27,0
3	2010	21,6	35,6	27,4
4	2021	19,2	38,0	27,6

LST of 2010: Figure 6 and Table 2 are showing the LST ranged from 21,6°C to 35,6°C with a mean of 27,4°C. Based on the results of analysis in 2010, land surface temperature conditions in very low category had an area of 0.20% (15^{0}C-20^{0}C) ,the low category had an area of 10.96% (20^{0}C-25^{0}C), the medium category was 88.82% (25^{0}C-30^{0}C) and the high category was 0.01% (30^{0}C-35^{0}C). This is because in 2000 it had an area with a vegetation distribution of 19.26% and built up land of 0.53% per year. However, this year's LST data has a low level of accuracy. This is because the map used is mostly still covered by clouds so that the resulting analysis has a low category for land surface temperature.

LST of 2021: Figure 6 and Table 2 are showing the LST ranged from 19,0°C to 38,0°C with a mean of 27,6°C. Based on the results of analysis in 2021, land surface temperature conditions in very low category had an area of 0.20% (15^{0}C-20^{0}C), the low category had an area of 0.77% (20^{0}C-25^{0}C), the medium category was 73.64% (25^{0}C-30^{0}C) and the high category was 25.39% (30^{0}C-35^{0}C). This is because in 2021 it had an area with a vegetation distribution of 13.95% and built up land of 0.53% per year.

Climatic factors affecting land cover changes

Cyclone: Satellite imageries provide extensive information about extreme weather patterns like Tropical cyclones. These are part of climate of tropical region of Asia, which affect various countries in the region including Indonesia. The intensity and frequency of these cyclones are increased in the end of 19th century. It goes more destructive with the sea level rise, high tides and motions of waves. It even raised the loss of infrastructure and erotion the land area. This usually occurs due to negative coastal development, tectonic plate movements, climate patterns, as well as increased tidal and wave movements due to rising sea levels, affect land.

Figure 7. Sinking area at Muara Baru (source: google, 2022)

Flood/ Rain: The devastating floods that occurred in Jakarta occurred in 1872, 1918, 1979, 1996, 2002, 2007, 2013, 2015 and 2021. Floods are an overflow of water that extends to submerge the land. Jakarta occasionally experiences slow and fast types of river flooding in the rainy season.

Figure 8. Sinking area at Muara Baru (source: Kompas 2007; 2021)

5. CONCLUSION AND RECOMMENDATIONS

The surface temperature classification in Jakarta from 1990 to 2021 includes two classes: medium (25–30°C) and high (30–35°C). The increase in built-up land cover reached 25.48%, while the decrease in vegetation 1 and vegetation 2 was 9.26% and 14.73% respectively, so it is predicted that it has the potential to influence the hydrological cycle. Higher vegetation density generally leads to lower land surface temperatures, while lower vegetation density is associated with higher surface temperatures. Jakarta is prone to significant flooding, with historical events highlighting risks. Satellite data, especially Landsat imagery, reveals key threats and land degradation, particularly on the north coast due to both human and natural factors. Temporal datasets show changing land cover in the Ciliwung watershed, including shifts in vegetation and coastal erosion. Continuous monitoring and mitigation can address these issues. This research is a foundation for future studies on climate change and water resource resilience. In planning for mitigation and adaptation due to climate change, it is necessary to add parameters, such as rainfall based on satellite imagery, climatological data, and condition of vegetation types. This aims to strengthen the resulting influence, thereby allowing a deeper understanding of the relationship between variables.

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16