Multitemporal landsat image utilization for spatial prediction of built up area in Tasikmalaya city, Indonesia

R Ridwana*, D Sugandi, R Arrasyid, S Himayah, T D Pamungkas

Department of Geography Education, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi 229, Bandung 40154, Indonesia

*rikiridwana@upi.edu

Abstract. Changes in built up area which are increasingly rapid consequence of the latest data requirements for urban planning. On the other side the process of expansion of built up area without control can impact the destruction of lands that have ecological functions so that they have an effect on the onset of social and environmental disasters. Of the many cities in Indonesia, the City of Tasikmalaya is one of the most significant cities that develops the built-up area. Effective technology that can be used to predict the development of built up area in the City of Tasikmalaya is to utilize multitemporal landsat imagery. This study aims are 1) Identify changes in built up area in Tasikmalaya City and its surroundings based on multitemporal landsat imagery, 2) Predict the development of built up area in Tasikmalaya City. The research method uses remote sensing technology, multitemporal recording landsat imagery in 2002 and 2019, through landuse change modeler modeling. The results of this study indicate an increase in built up area from 2002 to 2019, predicted results of the development land built up in 2034 produce a probability of expansion 0.229 with the direction development from northeast to southwest.

1. Introduction

The human need for land has an increasing trend as a consequence of economic development and population growth. Land issues are closely related to almost all aspects of life and development, this is in line with regional growth, especially the growth of urban areas. Cities are synonymous with the dynamics of living systems that have a strong appeal for most residents to live and settle in them so that it will have an impact on land cover changes [1]. The magnitude of the effect of changes in land cover is related to global issues such as decreasing biodiversity, global warming, and other negative impacts on humans both directly and indirectly [2]. In terms of availability, land area is not increasing at all and is limited, but on the other hand the need for land is increasing, especially the need for built up area [3].

The built-up area is the appearance of the earth's surface which has experienced human intervention and has a certain function for human life. The limitation can be seen in the appearance of physical construction such as houses, buildings, factories and asphalt. The
development of a city is often associated with the development of built up area because one of the physical characteristics of a city's development is that it is increasing and expanding land is being built up. This is relevant to the theory which states that the existence of urban development can be viewed from various aspects, including in terms of urban morphology which emphasizes the physical aspects of urban areas reflected in the road network system and building blocks [4].

The process of expansion of built up area without control can impact the destruction of lands that have ecological functions, protection and cultivation functions, which were originally non-developed land to be built up so that it has an effect on the onset of social and environmental disasters. Departing from this, it is necessary to take preventive measures through accurate city planning in order to prevent future disasters. One effort that can be done to prevent the adverse effects of the development of built up area is to monitor and predict the development of the land so that solutions can be traced before the disaster occurs [4].

Monitoring and predicting the development of built up area can be started by identifying the morphology of the city through the use of remote sensing technology to find trends in the direction of urban development and regional development. Arronof and Jensen include technology in the definition of remote sensing [5] [6], whereas according to Lillesand et al., sensing is much more emphasized in science and art [7]. Then from the three opinions of the experts was reaffirmed by Sutanto, that remote sensing is a science, technology and art in obtaining object information through its recordings [8]. Referring to the opinions of the experts above, it can be concluded that remote sensing is a science, technology, and art to obtain information on some properties of objects, areas, or phenomena through sensors carried by vehicles (aircraft, satellites, etc.) which are then analyzed without direct contact [9].

Visual interpretation of imagery is one of the remote sensing data extraction information which includes detection and identification of objects on the surface of the earth through interpretation elements. One way that can be done to obtain information from remote sensing images is through visual interpretation [10] [11]. While multitemporal analysis with remote sensing imagery can help in the ongoing monitoring of urban development so that it can be directed to the purposes of predicting the development of built up area. The availability of up-to-date information on the prediction of the development of built up area can be utilized for the purpose of consideration in planning an area/ city.

Many cities in Indonesia, the City of Tasikmalaya is one of the cities that has significantly experienced the development of built up area from year to year. Based on the Tasikmalaya City National Spatial Plan (RTRWN) included in the East Priangan development area (WP), while based on the West Java Province Spatial Plan (RTRWN), Tasikmalaya City is directed as part of the regional activity center (PKW) with facilities and infrastructure integrated, as well as a center for the development of the craft, trade and service industries. Starting from this background, Tasikmalaya City is very interesting to be selected as a study area entitled "Multitemporal Landsat Imagery Utilization for Spatial Built up area Prediction in Tasikmalaya City, Indonesia".

2. Methods
The method used in this study is a digital analysis of multitemporal Landsat imagery to detect changes in land cover with a classification of maximum likelihood in 2002 and 2019. Remote sensing image has a temporal resolution that is the ability to communicate the same area at different times. Phenomena that can be used to study various spatial changes, so from phenomena that can change that will benefit or cause harm [12]. Landuse change modeler is carried out on land cover data in 2002 and 2019. This modeling aims to
determine changes and predictions of development of built up area in a certain year. Generally detection of change includes the application of a number of multitemporal images for quantitative analysis of the temporal influence of a phenomenon. Ideally, to detect changes must meet the criteria including data from similar sensor systems, in terms of number of channels, geometric, radiometric, recording time, and spatial resolution [13]. Often recording dates are used to minimize the influence of sun angles and seasonal changes [14] [15]. As for this study determined in 2034 to predict the development of built up area in the City of Tasikmalaya and surrounding areas. More details can be seen in Figure 1 research flow diagram.

Figure 1. Research Flow Diagram
2.1 Study Area
The location of the study is in Tasikmalaya city and covers the area that surrounds it. The scope of the study was chosen to see the direction of urban development which was assessed based on the development of built up area. Geographically, Tasikmalaya city is at 7°10’ - 7°26’32” South Latitude and 108°08’38” - 108°24’02” East Longitude. Whereas administratively, Tasikmalaya City in West Java Province, Indonesia is bordered by Ciamis Regency in the North and East, Tasikmalaya Regency in the West and South. More details can be seen in Figure 2 of the study area.

Figure 2. Study Area (Landsat 7 ETM+)

2.2 Tools and Material
Supporting tools and materials in this study are as follows:
1) Laptop with AMD A10-7300 Radeon R6 specifications, 4.00GB, 64-bit Operating System
2) Windows-10 64-bit operating system, Microsoft Office 2010 software
3) GPS (global positioning system) Garmin GPSmap 62stc
4) Image processing software (ENVI Classic/ 5.0)
5) Image processing software (IDRISI Selva)
6) Geographical information system software (ArcGIS 10.1)
7) Landsat Image 7 ETM + recording in 2002 and Landsat Image 8 OLI/ TIRS recording in 2019 research areas
8) Digital Globe Image Spatial Resolution 1.1 meter research area
9) Map of Indonesian Digital Rupabumi Edition 1 - 2001
3. Results and Discussion

3.1 Atmospheric Correction

The aim of doing atmospheric correction is to produce surface reflectance values that are converted from landsat digital data [16]. In this research, atmospheric correction utilizes the dark object subtraction. The principle of dark object subtraction atmospheric effect is relatively uniform on the value of energy reflected from the visible channel. To eliminate the effects of the atmosphere on images is to use reflected values that are close to zero in an area, including a clear deep sea and dark cloud shadows.

3.2 Geometric Correction

Landsat 7 ETM+ and 8 OLI/TIRS images have 1G level criteria, meaning that they have passed systematic geometric improvements. This means that errors arising from the sensor have been resolved properly. However, these conditions still require non-systematic geometric corrections to correct image shifts due to sensor height dynamics and earth's rotational motion [16]. This study uses image to image correction.

3.3 Built up area Changes in Tasikmalaya City

The built up area very rapid development in the City of Tasikmalaya because of the relatively flat topography. Besides that, the availability of sufficient water is another supporting factor besides the regulation that sets Tasikmalaya city as the Regional Activity Center in East Priangan, especially the center of the development of new educational areas in West Java. So it is natural that land expansion in the City of Tasikmalaya continues to increase every year. This phenomenon can be proven through multitemporal remote sensing image. Classification of multispectral image of land cover that has been done resulted in the class of built up and non-built up area based on Landsat 7 ETM+ 2002 and Landsat 8 OLI/TIRS in 2019. Based on the multitemporal imagery, it appears that the developed land continues to expand compared to non-built up area. More details can be seen in (Figure 3. land cover classification Tasikmalaya City in 2002) and (Figure 4. land cover classification Tasikmalaya City in 2019).

![Figure 3. Land Cover Classification Tasikmalaya City in 2002](image_url)
Figure 4. Land Cover Classification Tasikmalaya City in 2019

Analysis development of built up area can be done with factor analysis through modeling. These factors are factors that can influence the development of an area, such as the main road, non-main road, the central business district analyzed from public facilities, and the slope of an area. Road factors and public facilities are influenced by distance factors, so it can be assumed that the closer to these factors, the greater the potential for urban development [4].

Statistically, it can be seen that the change in land cover that was originally non-developed land changed significantly to built up area from 2002 to 2019. Based on Figure 5, the percentage of non-developed land that was (in 2002) an area of 60.5% decreased to 25.7% (in 2019) and vice versa built up area experienced an increase in area which was originally (in 2002) 24.2% increasing in size to 65.6%. Statistics on land cover changes in square meters can be seen in Figure 6.

The change of non-built up area into built up area from 2002 - 2019 can be seen in Figure 7 below. The map of changes in non-built up area to being built up in 2002 - 2019 in Tasikmalaya city and its surroundings shows that the developed land continues to increase (+) and is distributed to almost all study areas and conversely the non-built up area decreases (-) in its area.

Figure 5. Change Detection Statistic Land Cover 2002 – 2019 (Percentage)
3.4 Built up area Development Prediction in Tasikmalaya City

Changes in built up area can be modeled through cubic trends to find out the direction of the development Tasikmalaya city. The higher value of the cubic trend, which is shown in red, the greater development of built up area, so direction of city development can be seen. More details can be seen in Figure 8 below.
Cubic trend results show that the direction of development non-built up area into built up area has a tendency from northeast to southwest with expansion probability of 0.229. The direction of development built up area is influenced by the relatively flat relief condition, besides supporting road access and previously available public facilities.

The results of the predicted land cover map from 2019 to 2034, the expansion of built up area is increasing every year. Expansion that is considered slow in its development is in the south direction of the City of Tasikmalaya. This can occur due to the undulating relief conditions compared to other regions. Prediction of the development of built up area can be used for monitoring and development planning in the City of Tasikmalaya. Information on the direction development of built up area as monitoring material so that development still pays attention to the carrying capacity of environment. The government as a policy maker can firmly defend any area that has a protected area function so that it does not pose a risk of future disasters. Supervision and enforcement of protected area regulations is also a limitation for the expansion of developed land so as to maintain environmental quality.

4. Conclusions
Multitemporal Landsat imagery is able to detect changes in non-built up area into built up area in Tasikmalaya City in 2002 to 2019 which continues to increase. The predicted results of the development of land built up in 2034 produce a probability of expansion of 0.229 with the direction of development from northeast to southwest of Tasikmalaya city.
References

[1] Ratnasari, D. S., Suharyadi, R., 2014. Pemanfaatan Citra Resolusi Spasial Tinggi Multitemporal untuk Analisis Karakteristik Perkembangan Permukiman Kota Bogor Tahun 2005 – 2014 Menggunakan Spatial Statistics.

[2] Dharturedjasa, I., Hartono. 2012. Analisis Citra Satelit Multitemporal untuk Kajian Perubahan Penggunaan Lahan di Kota Surabaya, Kabupaten Gresik dan Sidoarjo Tahun 1994 – 2012.

[3] Pangestu, S. A., Retnadi, H. J. 2014. Analisis Citra Satelit Multitemporal untuk Deteksi Perubahan Penggunaan Lahan dengan Menggunakan Metode Post-Classification Comparisson di Sebagian DKI Jakarta.

[4] Zahrotunisa, S., Prama, W. 2017. Prediksi Spasial Perkembangan Lahan Terbangan Melalui Pemanfaatan Citra Landsat Multitemporal di Kota Bogor. JOIN Volume 2 No. 1.

[5] Aronoff, Stan., 2005. Geographic Information Systems - a management perspective, Ottawa: WDLPublications.

[6] Jensen, J. R., 2007, Introductory Digital Image Processing: An Earth Resource Perspective (2nd ed), Englewood Cliffs, N.J: Prentice Hall.

[7] Lillesand, T. M., R. W. Kiefer., and J. W. Chipman., 2008. Remote Sensing and Image Interpretation. 6th edition, New York: John Wiley and Sons, Inc.

[8] Sutanto. 2011 Penginderaan Jauh Jilid I. Gadjah Mada University Press. Yogyakarta.

[9] Ridwana, R. 2014. Analisis Campuran Spektral Secara Linier untuk Kajian Perubahan Penutup Lahan pada Tingkat Subpiksel. Tesis.

[10] Howard, J. A. 1996, Penginderaan Jauh Untuk Sumberdaya Hutan (terjemahan). Gadjah Mada University Press. Yogyakarta.

[11] Janssen, L. L. F., Bakker, W. H., Weir, M. J. C., et al. 2000, Principle of Remote Sensing. ITC, Endschede. Netherlands.

[12] S Himayah et al 2019 IOP Conf. Ser.: Earth Environ. Sci. 286 012043

[13] Lu, D. S., Mausel, P., Brondi’zio, E. S. and Moran, E. 2004. Change Detection Techniques. International Journal of Remote Sensing, 12, 2365–2407.

[14] Lillesand, T. M., R. W. Kiefer., and J. W. Chipman., 2004. Remote Sensing and Image Interpretation.5th edition, New York: John Wiley and Sons, Inc.

[15] Jensen, J. R., 1986, Introductory Digital Image Processing: A Remote Sensing Perspectiv, New Jersey: Pearson Prentice Hall.

[16] R Ridwana et al 2019 IOP Conf. Ser.: Earth Environ. Sci. 286 012042