

## Remote Sensing Studies in the Defense World Seen from a Mathematical Perspective

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### ABSTRACT

Remote sensing is a technology that can help humans in solving various problems faced. The use of remote sensing especially related to defense in a mathematical perspective is still little used. The purpose of this research is to provide information about remote sensing that is associated with mathematics and has uses in the field of defense. The method used in this research is a literature study. The application of this research can be used at any time, depending on the needs of the defense itself. The results obtained in this study are the use of remote sensing in defense seen from a mathematical perspective is still lacking so that there needs to be sustainable activities and innovation in its use.

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## INTRODUCTION

Remote sensing is one of the technologies that can help humans solve various problems. Problems that can be solved with remote sensing are very diverse, ranging from health, economic activities, to the field of defense and security. This paper will discuss remote sensing in maintaining national security and defense. In particular, it will discuss defense satellites and aerial photography systems. The use of remote sensing in the defense sector has long been used. This is because with the use of remote sensing, locations that initially look vast can be captured in detail. With such uses, the use of remote sensing is very useful in the field of defense.

It is no secret that remote sensing has many benefits in human life (Wayan Gede Krisna Arimjaya & Dimiyati, 2022; Krichen et al., 2024; Van & Celik, 2021). Remote sensing has many benefits in various fields of life. For example, in the health sector which has uses for health checks, then in the economic sector in mapping the economic welfare of the community, to the defense sector which has many benefits. There are many studies that explain remote sensing in the field of defense, which is not only used by developed countries, but many developing countries use remote sensing in maintaining the defense and security of their country.

Based on the data obtained, the number of citations in research with the theme of remote sensing in defense obtained data that there is an increase in the number of studies each year (Figure 1). The highest number of citations was in 2021, with more than 25000 citations in one year.

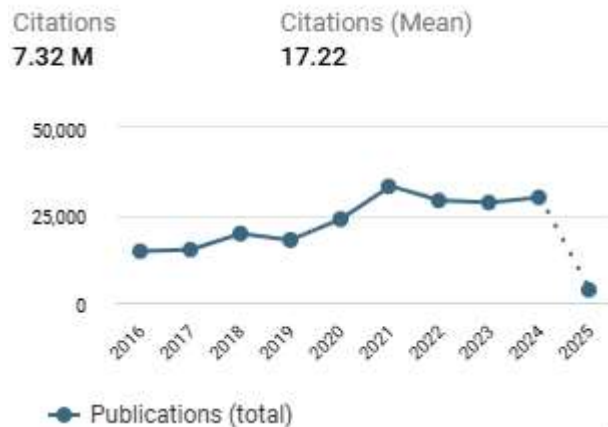


Figure 1. Publications about Remote Sensing for Defense from 2016 until 2025

Source:

[https://app.dimensions.ai/discover/publication?search\\_mode=content&search\\_text=remote%20sensing%20for%20defense&search\\_type=kws&search\\_field=full\\_search](https://app.dimensions.ai/discover/publication?search_mode=content&search_text=remote%20sensing%20for%20defense&search_type=kws&search_field=full_search)

Based on these data, research on remote sensing in the field of defense is increasing every year, both in terms of technology, application and use, science data management, information and computational knowledge, to technical communication. However, there are still not many specific studies on remote sensing in the field of defense when viewed from a mathematical perspective.

So the purpose of this research is to examine the use of remote sensing in the field of defense from a mathematical perspective.

## LITERATURE REVIEW

### *Remote Sensing*

Remote Sensing is a technology used to help human work in solving a problem. The problem can be seen from various aspects ranging from economic, political, social, health, to defense issues. The use of remote sensing in solving these problems is carried out according to the needs of the research object. The following is the use of remote sensing in humans or conceptual framework in this research (figure 2).

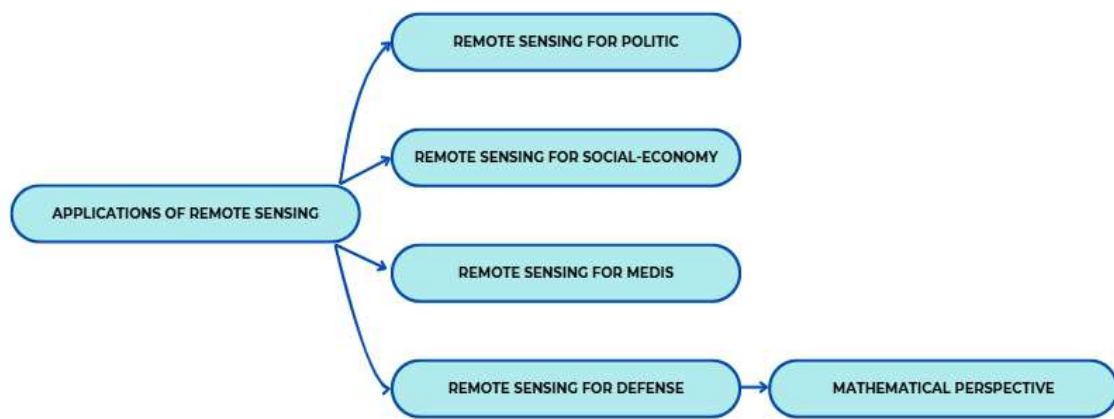


Figure 2. Conceptual Framework

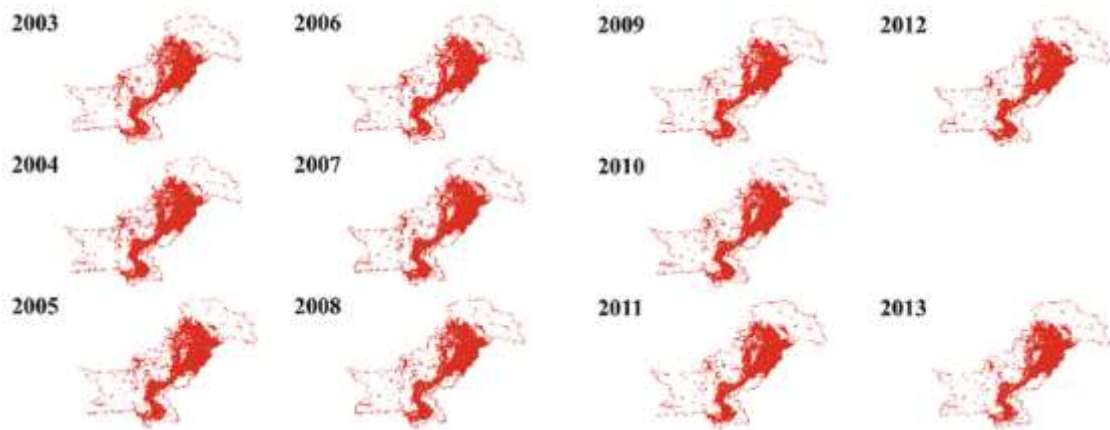
## METHODOLOGY

In this research, the method used is a literature study related to research that discusses remote sensing in the range of 2017-2024. The remote sensing research is divided into several aspects such as politics, socio-economics, medical, and defense which will be associated with a mathematical perspective as in Figure 2.

## RESULT AND DISCUSSION

### *Applications Remote Sensing for Politic*

The use of remote sensing in politics is widely used, especially in determining further policies regarding a problem. For example, research conducted by Shoaib Ahmad Anees which discusses the dynamics of fractional land cover using remote sensing (Anees et al., 2022). In this study, the results obtained were that the land cover that occurred between 2003 and 2013 had significant results. The remote sensing used in this study is the Moderate Resolution Imaging Spectroradiometer-Normalized Difference Vegetation Index (MODIS-NDVI). The following is the image data generated in the study.

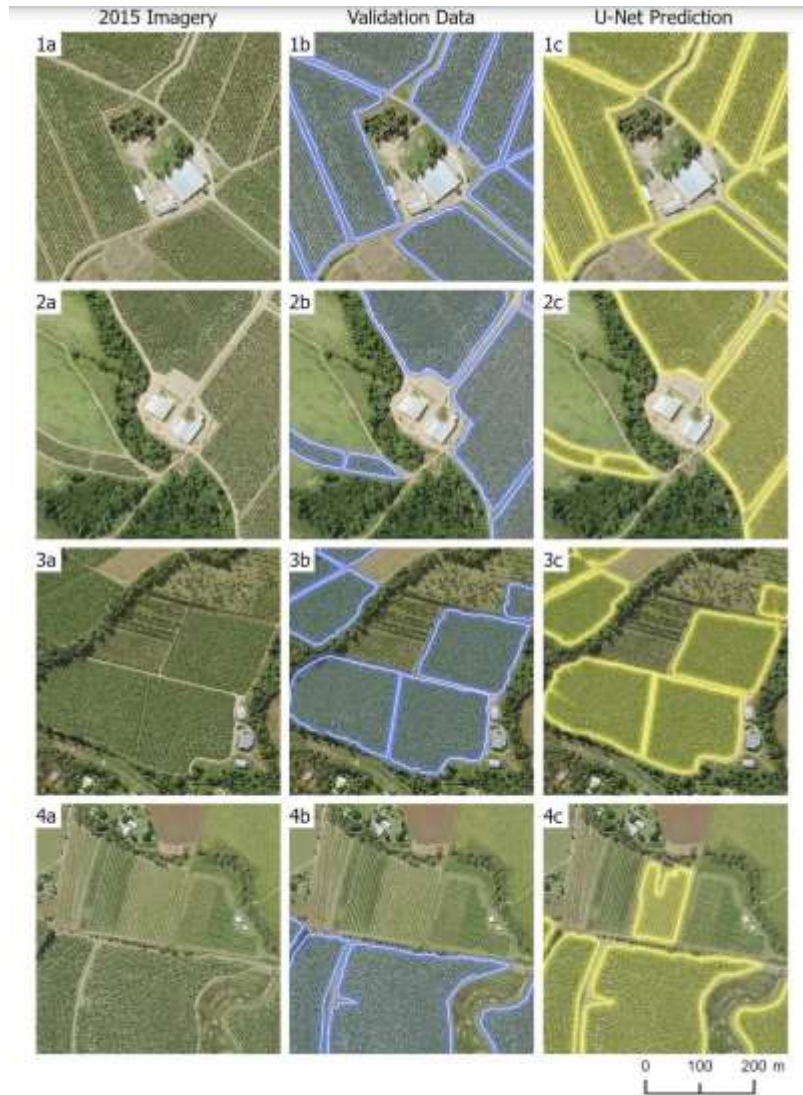


**Figure 3.** Data Citra MODIS-NDVI  
Source: (Anees et al., 2022)

From the image data, it can be seen that the land cover in 2003-2013 in Pakistan fluctuated significantly. This can indicate that areas with high change or industrialization have low FVC values. So from this it can be said that regional changes in the area change the land vegetation cover caused by human activities. The impact on politics in this case is that changes in land cover can determine the direction of policies that can be taken by the government. This can also be used as a reference for the Indonesian government in dealing with similar events, so that policies can be made that anticipate in advance.

#### *Applications Remote Sensing for Social-Economy*

The use of remote sensing in the socio-economic field is widely used, both in machine learning and deep learning. Usually the use of remote sensing is used in seeing the potential of economic growth of a business, as well as things that can help human social activities. Research conducted by Andrew Clark on the use of aerial photography in detecting banana plantations in Australia (Clark & McKechnie, 2020). In this study, the use of remote sensing was carried out because of the losses received by banana farmers from the Panama TR45 pest. This causes the use of remote sensing, especially aerial photography in its monitoring.



**Figure 4.** Aerial Photography Image Data using U-Net  
 Source: (Clark & McKechnie, 2020)

In the study, in addition to using aerial photography in remote sensing data collection, the use of U-net was also used. The results obtained in this study are the use of aerial photographs in detecting banana plantations has a higher accuracy compared to manual calculations. The accuracy generated by using U-Net is 98% and the accuracy of the manufacturer is 96%.

**Table 1.** Accuracy Assessment Result of QLUMP and U-Net Banana Plantations

Classification	Total Accuracy	User's Accuracy	Producer Accuracy	Jaccard Index
QLUMP Banana Palntations	0.996	0.862	0.921	0.341
U-Net Banana Palntations	0.999	0.983	0.959	0.943

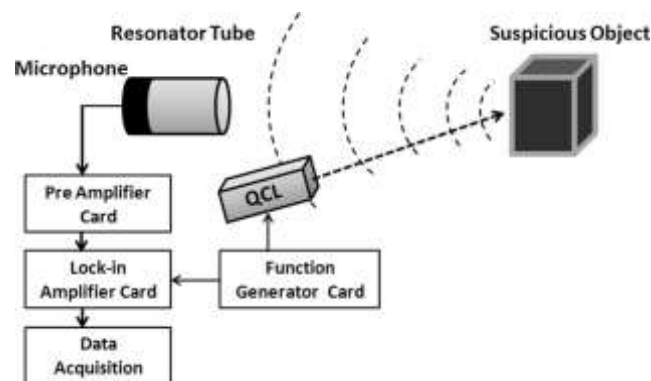
Source: Source: (Clark & McKechnie, 2020)

These percentages indicate that the mapping process using U-Net is faster and more accurate than manual mapping. These results have a good

impact on the socio-economics of the community, especially banana farmers. Accurate mapping can make activities more effective, especially in terms of time and cost which will have an impact on the amount of national banana yield in Australia can be maintained. This can also be implemented in Indonesia, especially for areas with high productivity.

### *Applications Remote Sensing for Medical*

The use of remote sensing in the medical field is widely used, especially in assisting with surgery, forensic and facial recognition activities. For example, research conducted by Rames C Sharma regarding the use of remote sensing in the creation of forensic applications (Sharma et al., 2020). In the study, it was found that using photoacoustic spectrum techniques can be used in filtering suspicious objects. The following is the system used in the photoacoustic spectrum technique in this study.

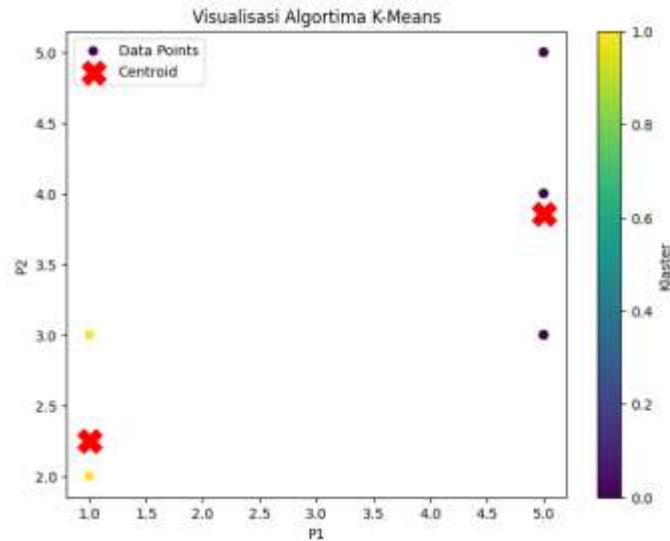


**Figure 5.** Technology Spectrum Photoacoustics  
Source: (Sharma et al., 2020)

In figure 5, it is explained that the way this technology works is by creating waves by a function generator which will then be directed to the object through a resonator. Then it will interact with two types of interactions, namely reflected or absorbed. If reflected, it will be absorbed by the microphone, which is amplified and processed from the information received. The end of the process is the analysis process which is used to determine the distinctive nature of the indicated threat. This system is very useful in determining the form of the threat from the forensics performed. Even in its use, this technique can still be developed further, seeing the times are getting better in terms of technology.

### *Applications Remote Sensing for Defense*

The use of remote sensing in the field of defense is increasingly being used. Many studies discuss remote sensing used in defense. Research relevant to remote sensing for defense is research written by Mahmud Badarudin (Badarudin. M, et all 2022). In his research, remote sensing in the field of defense has benefits as a form of data grouping in determining the potential spread of terrorism. In the study, it was found that there are two clusters that have great potential in the spread of terrorism.



**Figure 6.** Output Mapping Potential Terrorism Threats  
Source: (Badarudin. M, et all 2022)

The visualization explains that remote sensing can determine the number of clusters formed from all available samples in this study. In this case there are two large clusters formed, which have seven and four samples in them respectively. Based on this research, the samples in the first cluster have great potential in the spread of terrorism against IKN Nusantara.

Then based on Su explained that the role of remote sensing is to conduct dynamic surveillance related to military facilities, target tracking using motion trajectories so that defense strategies are more effective, then it can also detect threats both maritime and air (Su, et all, 2024). The research also describes the object detection path in maritime and air using the detection pipeline (TDNet), namely with object detection (R-FCN), multi-target tracking (MT-KCF), detection-assisted tracking (DAT), and new target recognition (NTR). The resulting visualizations are:



**Figure 7.** Visualization of tracking result

In the study there are several results obtained, first in terms of accuracy the use of TDNet has a high mean precision indicating that the detection performance is very good. secondly, the MOTA and MOTP values are high so that it shows high effectiveness in tracking multiple objects. Third in tracking speed, although TDNet is not the fastest tracking, it has a high average value of frames per second (fps) which reaches 82.84 fps.

### *Applications Remote Sensing for Defense with Mathematical Perspective*

Based on the four remote sensing applications above, especially in the field of defense, it will be seen from a mathematical perspective. Remote sensing applications in the field of defense seen from a mathematical perspective are closely related. This can be seen from remote sensing itself which uses mathematical analysis in solving its problems. There are many mathematical approaches used in solving remote sensing. For example, the use of algorithms in data analysis, mathematical models in data interpretation, strategic location optimization, to prediction and monitoring.

First in the use of algorithms in data analysis. Just like before the use of algorithms in data analysis on remote sensing for defense is research conducted by Badarudin, M regarding the analysis of the potential spread of terrorism (Badarudin. M, et all 2022). Based on the Google Semantic website, in the last five years there have only been 43 studies.

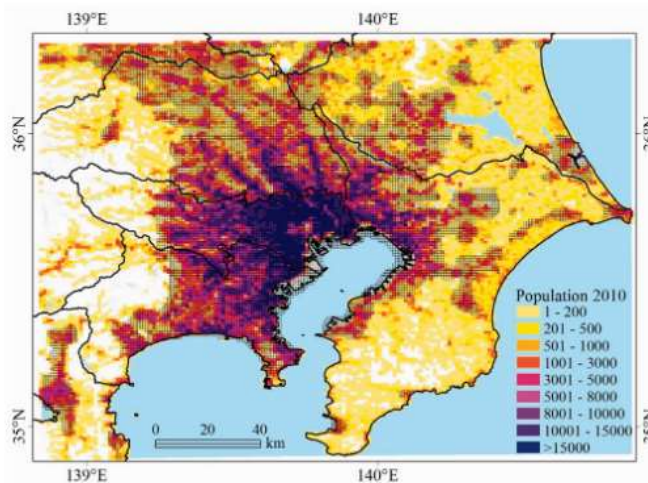


**Figure 8.** Publication of Remote Sensing with Application Algorithm for Defense

Source: Semantic Scholar, 2025

<https://www.semanticscholar.org/search?year%5B0%5D=2020&year%5B1%5D=2024&q=Remote%20Sensing%20for%20Defense%20with%20Application%20Algorithm&sort=relevance>

Research that discusses defense satellites is research conducted by Hasi Bagan. In this study he conducted research on defense satellites at night in urban development areas (Bagan et al., 2019). It was found that the use of linear regression in this problem is difficult to use. Especially when calibrating between satellites with linescan and urban development areas at night.



**Figure 9.** Spatial Distribution of High DN Value of nighttime light pixels in Tokyo  
Source: (Bagan et al., 2019)

The latest is research conducted by Min Zhao on the development of nighttime light in Southeast Asia from 1992 to 2018 (M. Zhao et al., 2020). The study used the Defense Meteorological Satellite Program's Operational Linescan System (DMSP-OLS) satellite and the Suomi National Polar-orbiting Partnership Visible Infrared Imaging Radiometer Suite (NPP-VIIRS) satellite. It was found that according to evaluations based on profile curves, spatial patterns, scatter correlations, and NTL histograms, our method can achieve good agreement between DMSP data and simulated DMSP data of the same year. Our method makes it possible to generate a time series of global DMSP NTL data from 1992 to the present. This will make it possible to make a greater contribution to more continuous and consistent monitoring of human activities.

## CONCLUSIONS AND RECOMMENDATIONS

The use of remote sensing in the field of defense can be used in various perspectives. One of them is in a mathematical perspective. Remote sensing for defense in a mathematical perspective has advantages and a close relationship. This is because in applying remote sensing, it is closely related to mathematics. There are many studies that use mathematics in solving problems with remote sensing. However, when discussing the field of defense, the scale used is even smaller, meaning that its use is still minimal. Therefore, there needs to be a lot of research on the use of remote sensing for the defense sector in a mathematical perspective, so that the results obtained have high accuracy.

## FURTHER STUDY

In this study, there are several limitations, including this research using the literature review method of research that has been done. So it is necessary to do more in-depth research using other methods.

## ACKNOWLEDGMENTS

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