

A Systematic Literature Review on AI-Based Forest Vegetation Loss Detection and Blockchain-Enabled Traceability System

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Abstract – From past few years, There has been an advancement of Artificial Intelligence and Blockchain technology and all those technologies could be used to make the monitoring and tracking of deforestation and forest product tracing easy. But the problem is that past literature always had different focuses for solving different purposes like detecting deforestation, forest monitoring, real time detection of forest disturbances and forest products monitoring as separate topics. For this purpose the present literature review evaluates current approaches for detecting deforestation analyzing satellite data and remotely sensed data, conducting time series analysis applying machine learning and deep learning, using multiple sources of observation and detecting forest disturbance. Similarly assessing the use of blockchain technology in ensuring the traceability of the forest products and managing the geospatial data. From the literature there have been improvements made regarding multitemporal data analysis using satellite imagery SAR imagery, deep learning approaches. The use of blockchain for managing the Forest product production and a minimal steps of supply chain has been recorded. However resolution, generalizability, verification automation, driver identification and separation of detecting disturbances from traceability remains as limitation. The literature makes a strong case for the requirement of integration of these processes. That is why we have proposed a study named as ECO-sentinels in this regard.

Key Words: Deforestation detection, remote sensing, satellite image processing, forest monitoring, change detection, deep learning, blockchain, geospatial intelligence, forest product traceability.

I. INTRODUCTION

Forests are important in keeping the ecological balance, in supporting biodiversity, in regulating the climate, and in supplying resources for human activities. Yet deforestation and forest degradation still have an impact

on forest ecosystems in many areas. Traditional methods of forest monitoring, which rely greatly on field surveys, are expensive and hard to apply on a large scale over vast and remote regions. As a result, the use of satellite remote sensing has become a significant means of observing forest conditions and detecting changes over large geographic areas. In recent studies, optical satellite imagery, Synthetic Aperture Radar (SAR), and multi-temporal observations have been employed in order to improve the spatial and temporal assessment of forest disturbances [11], [12], [18], [19].

The greater availability of satellite observations has also led to the development of time-series methods for detecting changes in forests. Instead of comparing observations from different times, traditional change detection techniques rely on comparing observations from different time periods, while more recent approaches seek to use longer temporal sequences in order to tell the difference between real forest disturbances and variations that are due to the seasons and environmental factors. For instance, the Sub-Annual Scale LandTrendr (SSLT) combines data from Landsat and Sentinel-2 to increase the temporal frequency of the imagery and to enhance the ability to detect deforestation on a sub-annual basis [19]. In a similar way, the use of Sentinel-1 SAR time-series analysis has been studied as a means of detecting deforestation in the Brazilian Amazon, a region where persistent cloud cover can limit the value of optical observations [18]. Near-real-time systems such as DETER-RT also show the promise of SAR-based monitoring in issuing earlier warnings of deforestation, especially in cases affected by clouds and smoke [12]. Together with advances in satellite monitoring, artificial intelligence and machine learning have become ever more widely used in the detection of changes in forests. Methods based on machine learning, such as Random Forest, have been applied to landcover classification, to the mapping of forest change, and to the prediction of spatial forest dynamics [2], [11]. Deep learning techniques have also increased the capacity to extract complex spatial and temporal patterns from remote sensing images. For instance, DLCD combines

machine-learning classification with change mapping based on deep learning in order to detect changes in forest areas [13]. Some other studies have looked into the use of U-Net for the detection of selective logging [5], transformer-based change detection for very-high-resolution imagery [8], and deep learning systems developed for the purpose of detecting large-scale deforestation [15]. These developments show a move from traditional image comparison to more automated methods that are capable of learning complex representations from remote-sensed data.

A major area of focus is the combination of various remote sensing data sources. Optical imagery gives spectral data, whereas SAR is able to provide observations in situations when optical sensors are hindered by clouds. Furthermore, LiDAR observations can offer information on the vertical structure of forests. In order to improve forest change mapping, the integration of data from Sentinel-1, Sentinel2, GEDI, and ICESat-2 has therefore been studied by including canopy height information together with the usual spectral and backscatter features [11]. Multi-source methods can enhance the capacity to identify forest changes that cannot be adequately captured by two-dimensional spectral information alone. However, problems arising from sensor availability, spatial resolution, temporal coverage, and the sparsity of certain observations are still significant challenges [11], [19]. Even though there have been these advances, current forest monitoring methods still have a number of limitations. Some of the techniques work in a retrospective manner and are therefore unable to give out timely warnings, while others still rely on human interpretation for verification. Just because a forest disturbance can be identified does not mean that it tells us what the cause was, for example whether it was due to logging, fire, agricultural expansion, or infrastructure development. Moreover, various studies also mention problems relating to false detections, spatial resolution, the difficulty of generalizing to different environments, and temporal delays [5], [11]-[13], [18], [19]. As a result, improving the accuracy of detection by itself does not fully meet the wider needs of forest monitoring and decision-making. There is now a different and unique area of research focusing on the use of blockchain for tracking forest products. The application of blockchain and smart contract technologies has been studied with a view to enhancing the transparency, integrity, and ability to verify timber supply chains. It has been suggested that blockchain-based traceability should be applied to teak, recording details from the time of felling through to manufacturing and thus offering a more transparent substitute for paper documentation [6]. Likewise, blockchain-enabled smart contracts have been proposed for the registration of timber felling, for the transfer of ownership, for certification, and for allowing consumers

to verify products [4]. Some other research has looked into cryptographic methods such as zero-knowledge proofs in order to verify the relationships between physical pieces of wood while at the same time lowering the chance of false claims regarding their origin [20]. Research into smart forestry has also examined decentralized identities, verifiable credentials, and data registries supported by blockchain in order to enable trusted communication between forestry stakeholders and machinery [7]. The use of Artificial intelligence in detection layer plays an important role, hence the different methods & techniques of using artificial intelligence in deforestation.

Blockchain has also been looked into as a means of protecting and controlling access to geospatial information. It has been suggested that attribute-based access control, together with blockchain and smart contracts, could be used for the Decentralized and finely-grained management of geographic spatial data [3]. These methods mainly concentrate on data security, access control, auditability, and resistance to tampering rather than on the direct detection of forest disturbances. It is important to note that remote sensing systems and blockchain traceability systems generally deal with different stages of the overall forest management process. The literature surveyed shows that considerable advances have been achieved in various areas such as satellite-based forest monitoring, time-series change detection, artificial intelligence, multi-source remote sensing, near-real-time alert generation, blockchain based timber traceability, and secure geospatial data management. Yet these capabilities are usually examined as separate issues. Studies in the field of forest monitoring mainly aim at detecting and mapping changes, whereas those concerning blockchain focus on securing and tracing forest products after they have been harvested. There is still a relatively limited degree of integration among the detection of forest events by remote means, reliable geospatial evidence, and the subsequent traceability of forest products in the studies that have been reviewed. In this situation, the literature review critically looks at recent research concerning deforestation detection, remote sensing-based forest monitoring, AI-based change detection, the use of multiple satellite observation sources, near-real-time monitoring, blockchain-based forest-product traceability, and blockchain-enabled geospatial data security. It compares the methods, data sources, contributions, limitations and research gaps found in the various studies and examines how these different research areas have developed. The findings are then used to identify the need for a more integrated area of research and to place the proposed ECO-SENTINEL system within the existing body of work.

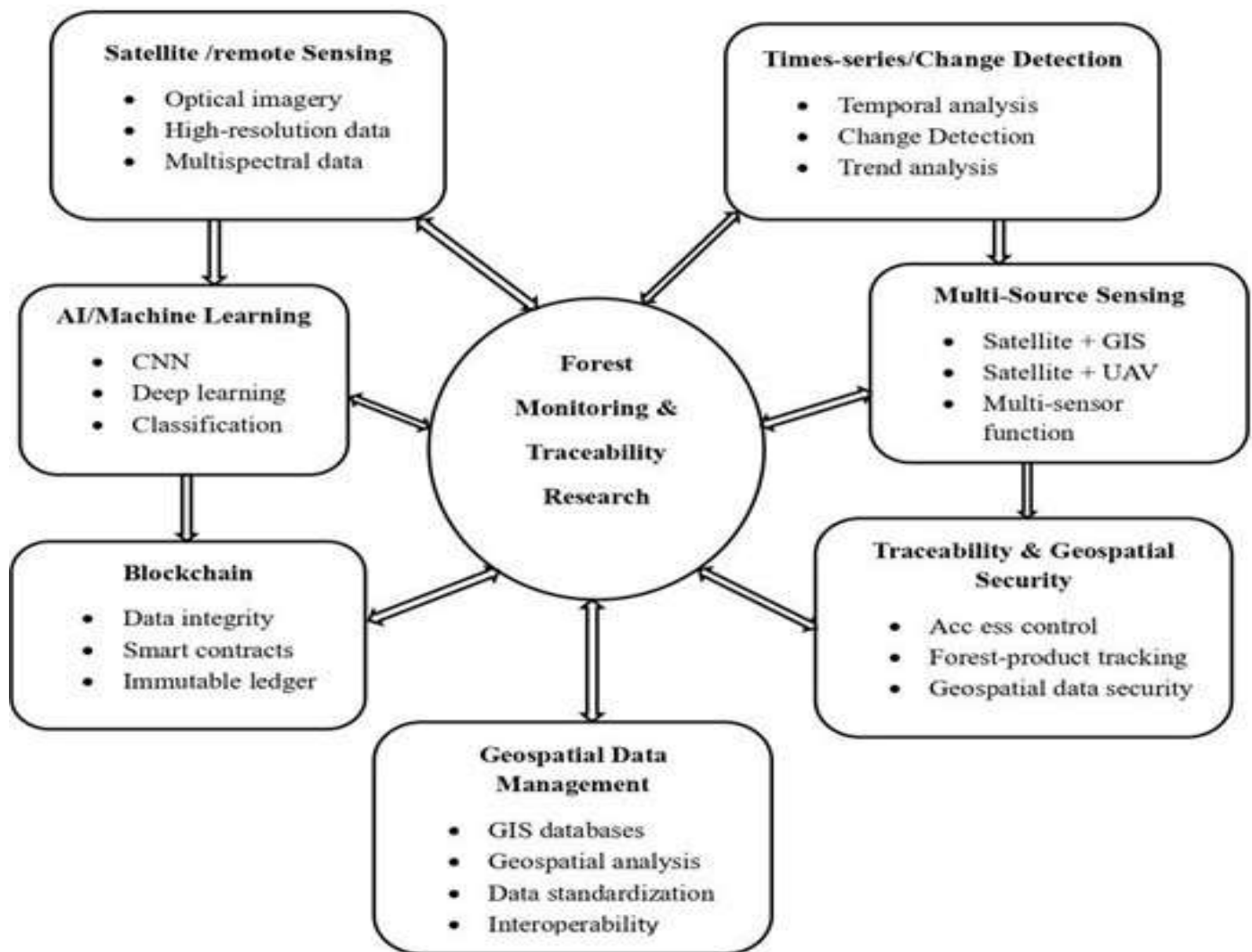


Fig 1. Taxonomy with the main themes and sub-themes.

The rest of this paper is arranged as follows.

Section II includes a review of the relevant literature thematically, covering satellite-based forest monitoring, time-series change detection, AI and deep learning, multi-source remote sensing, near-real-time monitoring, blockchain-based forest-product traceability, and blockchain-based geospatial data security.

Section III gives a critical comparative analysis of the methods reviewed.

Section IV examines the major research gaps that have been identified in the literature. Section V places the ECO-SENTINEL research approach in relation to these gaps.

Section VI concludes the review and sums up the main findings as well as the future directions for research. The diagram shows the taxonomy of the themes and sub-themes.

II. LITERATURE REVIEW METHODOLOGY

A. Literature Search and Selection

Our literature survey aims to traceback recent development and evolution in satellite-images based deforestation monitoring, forest change detection, artificial intelligence, multi-source remote sensing, near-real-time monitoring, and use of blockchain for forest-product traceability as mentioned in the title. The review focuses on research published from 2022 to 2026, paying special attention to recent approaches combining remote sensing, intelligent change detection, geospatial technologies, and decentralized systems.

The papers selected in this literature survey were recognized because of their connection to the objectives of this review . Particular attention was given to studies addressing forest-cover change detection, deforestation monitoring, time-series satellite analysis, artificial intelligence-based image interpretation, and blockchain-enabled timber traceability. Studies focusing on related applications of blockchain for geospatial data security

were also considered where they provide techniques applicable to secure forest-monitoring data.

The final literature set consists of 20 research papers covering different aspects of forest monitoring and forest-product traceability. These studies include approaches based on Sentinel-1, Sentinel-2, Landsat, LiDAR, high-resolution remote sensing imagery, machine learning, deep learning, Transformer architectures, time-series analysis, blockchain, smart contracts, and zero-knowledge proofs.

B. Inclusion And Exclusion Criteria

The literature was selected according to its relevance to one or more of the major research areas considered in this study. Papers were included when they contributed substantially to at least one of the following:

- Satellite-based forest or deforestation monitoring.
- Forest disturbance and land-cover change detection.
- Time-series analysis for identifying forest changes.
- Machine learning or deep learning is used for doing analysis of remote sensing data on satellite images.
- Multi-source satellite or remote sensing data fusion.
- Monitoring of deforestation in real-time.
- Use of Blockchain for forest-product traceability.
- Use of Blockchain for evidence generation, security purpose, verification, or for accessing of the geospatial data.

The Research papers which did not contribute to any module of this research themes were removed and are not included in this final analysis of our literature survey paper.

C. Thematic Classification of the included Research Papers

TABLE-1 A SUMMARY OF THE IDENTIFIED STUDIES

Objectives	Studies
Detect monitor deforestation and changes in forest cover using satellite images.	[1], [2], [5], [9], [11], [12], [13], [15], [18], [19]
Identify forest changes by comparing satellite images taken at different time periods.	[8], [10], [13], [16], [17], [18], [19]
Improve the forest-change detection using AI, ML and deep-learning methods.	[1], [5], [8], [9], [10], [11], [13], [14], [15], [17], [18]
Combining different types of remote-sensing data to improve forest monitoring.	[2], [11], [16], [19]

Detecting forest changes earlier and generating timely deforestation alerts.	[12], [15], [19]
Identifying selective logging and other forest disturbances.	[5], [14]
Tracking timber and forest products from their origin thru the supply chain using blockchain.	[4], [6], [7], [20]
Verifying the origin and movement of timber using blockchain and cryptographic methods.	[6], [20]
Protecting geospatial data thru blockchain-based access control and secure data sharing.	[3], [4]
Connecting forest monitoring with secure verification and timber traceability.	[4], [6], [7], [20]

The above table summarizes the objectives that are gathered from this study and they are mentioned with the related paper for that particular objective or focus of that paper.

To make comparative analysis, the selected studies were classified according to their primary technological contribution. The literature broadly falls into six interconnected themes:

- satellite-based forest monitoring.
- time-series and change detection.
- AI/ML/DL-based detection.
- multi-source and near-real-time monitoring.
- blockchain-based forest-product traceability.
- blockchain-based geospatial data security.

This classification enables the review to move beyond individual paper summaries and examine how existing approaches address different stages of the proposed forest-monitoring and traceability framework. The reviewed studies are subsequently compared in terms of their data sources, methodologies, detection capabilities, limitations, and research gaps.

TABLE 2. THEMES AND THEIR RELATION TO THE RELEVANT PAPERS

Theme	Studies
Data Acquisition and Remote Sensing	[2], [11], [14], [16], [18], [19]
AI-Based Deforestation and Change Detection	[1], [5], [8], [9], [10], [13], [15]
Time-Series and Forest Change Monitoring	[11], [12], [16], [17], [18], [19]

Blockchain-Based Forest-Product Traceability	[4], [6], [7], [20]
Blockchain-Based Geospatial Security and Data Management	[3], [4], [6]

III. CRITICAL ANALYSIS OF THE PAPERS

A. THEME I – DATA ACQUISITION AND REMOTE SENSING

Recent studies have shown that the type of remote sensing data used can influence the accuracy of detecting changes in forest cover. Mukomberanwa et al.[2] studied change in forest cover for a period of ten years using Landsat 7 and Landsat 8 images. This provides consistent data for long term monitoring but the 30 m spatial resolution makes identification of gradual forest degradation and smaller changes difficult [2]. Hosseiny et al. [11] combined the Sentinel-1 SAR data, Sentinel-2 optical data and LiDAR data to overcome some of these limitations. They found that canopy height information from GEDI and ICESat-2 can be combined with spectral and SAR features to improve detection of forest change [11].

Other research have concentrated on increasing the amount of usable satellite data over time. Dong et al.[16] worked on image fusion between Sentinel-2 and high resolution images at different time intervals, showing the usefulness of fusing different observations when proper images are not always available. SAR data also is useful in areas where cloud cover makes optical images difficult to use. Karaman et al. [18] used Sentinel-1 SAR time series data to detect deforestation in the Amazon, and Yang et al. [19] used a combination of Landsat and Sentinel-2 images to create a denser time series for detecting forest disturbances on a sub-annual scale. These studies indicate that the use of observations from different sources can help to reduce delays in the detection of forest changes.

But there are some limitations to the current methods. Cloud cover and seasonal variations affect optical images while LiDAR data provides valuable information on the height of the canopy but is only available at sparse locations [11], [16], [18], [19]. Some methods also rely on specific sources of satellite data or on sufficient observations in time. Therefore, there is a need for a monitoring approach that can integrate different types of satellite data, detect forest changes effectively, and provide timely results without being totally dependent on one data source or suffering from long time gaps between observations.

B. THEME II – AI BASED DEFORESTATION AND CHANGE DETECTION

More recent work has used AI and deep learning techniques to improve forest change detection from satellite images. CNN-RF Hybrid Approach [1] This method is a hybrid of CNN and Random Forest methods for detection of deforestation using satellite imagery. Srivastava and Ahmed [13] also proposed the DLCD methodology whereby forest and non-forest areas are initially classified and then the changes in forest areas are analyzed. This helps the system focus on where forest changes are really happening.

Forest disturbances of certain types have been detected using deep learning. A U-Net based study on selective logging [5] is concerned with detection of the logging infrastructure such as roads, skid trails and storage areas that can be difficult to detect from regular forest cover maps. Wang et al.[15] created a web-based system called OpenForestMonitor that can use different deep learning models to detect deforestation from high-resolution images. This makes the detection process more accessible as the users do not need to work directly with complex model implementations.

Other works have investigated newer deep learning architectures for change detection. Lin et al. [8] proposed an unsupervised Transformer-based method for fusing CNN features with Transformer features. The CNN is used to detect local features and the Transformer is used to understand the relationships between different parts of the image. Alshehri et al. [9] also used a deep Transformer-based network for the detection of deforestation in the Brazilian Amazon with Sentinel-2 images. Xu et al. [10] investigated a General Deep Forest approach for remote sensing image change detection. They showed that different deep learning approaches can be applied according to the type of change detection problem.

But these methods are still not without some limitations. Some of the approaches require labeled training data and unsupervised methods can be based on the quality of the samples generated during the initial detection stage [8]. The performance of models can also be dependent on the study area, image resolution and type of forest disturbance [5], [15]. Therefore, while AI-based approaches may improve the automation and accuracy of forest-change detection, a system that can operate reliably under different conditions, reduce the dependence on labeled data and provide timely forest-change information is still needed.

C. THEME III – TIME-SERIES AND FOREST CHANGE MONITORING

Forest monitoring is more efficient when using satellite images from different dates, rather than relying on a single image. Sentinel-1 SAR time-series data were used by Karaman et al. [18] to detect deforestation in the Amazon. In their study, they found that using images from a longer time period can improve the detection of forest changes

compared with just before-and-after images. However, this approach requires a long sequence of observations and is not capable to provide near real-time detection or detect the exact date of the deforestation event [18].

To reduce the time lag of forest disturbance detection, Yang et al. [19] proposed the Sub-Annual Scale LandTrendr (SSLT) method. The Landsat and Sentinel-2 images are fused to create a denser time series and spatial normalization is performed to minimize the influence of seasonal variations. The method performed better than the traditional LandTrendr in terms of spatial accuracy and was also able to more accurately detect the disturbance date as well [19]. But it cannot see disturbances smaller than 30 m. It can also have errors due to mountain shadows and variability in forest conditions.

Ortega et al. [17] used Sentinel-2 images from different time periods to improve the generalization of a CNN for deforestation detection. The model is fed more information about how a forest area changes over time by using images from different dates, not just the appearance of one image. This implies that time-series information can contribute to the improvement of forest-change detection [17].

D. THEME IV – BLOCKCHAIN-BASED FOREST PRODUCT TRACEABILITY

The majority of the forest monitoring studies focus on monitoring forest changes from satellite images but some studies focus on what happens to the forest products after harvesting. In the studies, blockchain was used for storing and tracing information about timber during the supply chain.

Sheng and Wicha [6] developed a traceability system for teak by using a blockchain-based decentralized application on the Ethereum platform. The system collects data from farmers, forestry officials, and manufacturers and links the physical teakwood with digital data using QR codes and GPS information [6]. The study also showed that blockchain can cut down the time needed for verification, as opposed to the traditional process.

Shibano et al. [20] proposed a wood traceability system based on blockchain and zero-knowledge proof. The system provides a digital identity to a tree or wood object and verifies the relationship between the original tree and the resulting wood product by means of cryptographic proofs [20]. This helps prevent false claims about the origin of timber, without revealing the private information used to verify it. However, the system has high transaction costs and additional information like the GPS coordinates, photographs and tree species was planned to be stored outside the blockchain [20].

Based on digital twins, IoT and decentralized identities, Hoppen et al. [7] proposed a broader digital forestry system. The system is also based on Decentralized Identifiers (DIDs), Verifiable Credentials (VCs) and Hyperledger Indy to enable trusted communication between various participants involved in timber harvesting [7]. Unlike systems mainly based on

blockchain for storage of records, this work connects the digital system with machines, forest workers and other participants. However, physical activities like harvesting, transport and manual checking of wood are still outside of the digital system [7].

Damaševičius and Maskeliūnas [4] developed a blockchain based smart contract framework for registration of timber harvest, transfer of ownership, certification and verification by the consumer. The framework uses IPFS, oracles and role based access control to store and verify timber information [4].

E. THEME V – BLOCKCHAIN-BASED GEOSPATIAL SECURITY AND DATA MANAGEMENT

In addition, blockchain has been explored for geospatial data security and access control. Li et al. [3] presented a blockchain and smart contract-based attribute-based access control scheme for sharing geographic data. The system manages access to various types of geographic data thru a private blockchain with Proof-of-Authority consensus. Access rules are enforced thru intelligent contracts and the UBK optimization algorithm is used to reduce unnecessary rules and policy conflicts [3].

Verification in some blockchain timber traceability systems also relies on geospatial information. Sheng and Wicha [6] embed GPS coordinates into the teak metadata and link this information to the digital identity of timber [6]. This helps in keeping information on the origin of the teak as part of the traceability record. Similarly, Damaševičius and Maskeliūnas [4] combine geolocation information with external data sources to verify if a reported harvesting location is within an approved area [4]. The studies show that blockchain can be used not only to maintain traceability records, but also to store, verify and audit geospatial information. However, in these studies, blockchain is mainly used for security, verification, access control, and traceability. It is not used to directly analyze satellite images or detect deforestation [3], [4], [6]. The actual detection of forest changes is handled separately by remote sensing or other monitoring methods. Therefore, there is still a gap in connecting AI-based satellite detection, geospatial verification, and blockchain-based traceability in the same system. Bringing these parts together could provide a continuous record starting from the detection of forest change and continuing through its verification and the later movement of forest products.

IV. CRITICAL ANALYSIS OF RESEARCH PAPERS

A. COMPARATIVE ANALYSIS

Different research have employed different satellite sources for data collecting, depending on the type of forest change they sought to monitor. Karaman et al. [18] used Sentinel-1 SAR time series data for deforestation identification. Yang et al. [19] used a combination of Landsat and Sentinel-2 photos to obtain more useable

observations over time. Hosseiny et al. [11] employed a combination of Sentinel-1, Sentinel-2, GEDI and ICESat-2 data which allowed the analysis to include both surface and canopy-height information. These studies demonstrate that merging several remote sensing methods can provide additional information on forest change. However, the availability of the data, the geographical resolution and the pre-processing required for each source might still influence the outcomes.

In AI-based research multiple models are used for the sort of forest change to be identified. Souza Filho et al. [5] employed a U-Net model for selective logging detection while Wang et al. [15] built a web-based system using deep learning models for high resolution deforestation identification. For example, Alshehri et al. [9] applied a deep transformer-based technique to detect deforestation in Amazon, and Lin et al. [8] fused features from CNN and Transformer for unsupervised change detection. In contrast, the CNN- RF method [1] uses integration of machine learning algorithms instead of using one deep learning architecture. These investigations show that standard artificial intelligence can potentially reduce the need for manual interpretation and enhance the ability to detect complicated forest change, though training data, generalization and computational needs are still key limits. Time-series techniques generally strive to improve the timing of a forest change detection. Longer observation periods in traditional methodologies can offer information about forest dynamics but also delay the discovery of a disturbance. Yang et al. [19] tackled this using sub-annual LandTrendr. Doblas et al. [12] took a more direct approach with SAR data to enable near-real-time detection. The DETER-RT system was able to give earlier warnings than the optical DETER-B system, especially in periods influenced by clouds and smoke. But these technologies still have problems with timing gaps, false detections and confirmation by experts.

The studies based on blockchain address a distinct aspect of the problem. Sheng and Wicha [6], Shibano et al. [20], Hoppen et al. [7], & Damaševičius and Maskeliūnas [4] are interested in the preservation of trusted record of timber, and the enhancement of traceability along the supply chain. These ideas vary in their execution from Ethereum based smart contracts to zero-knowledge proofs, decentralized identities & multi-blockchain frameworks. However, the blockchain systems rely on information provided by forest stakeholders and do not themselves perform the initial detection of forest loss. Study by Li et al. [3] reveals another usage of blockchain by employing it in access control and security of spatial data. Its major objective is to regulate access and keep safe data, not to trace physical forest products, unlike the timber traceability research. The comparison reveals that, in general, none of the approaches covers all stages of forest monitoring and forest-product management. Remote sensing technologies are useful in monitoring forest changes; AI methods increase automatic detection; time series methods improve understanding about when changes occur; and blockchain approaches improve

traceability and data security. But these functions are, in their implementation, largely different systems. This suggests a paradigm for linking forest-change detection, geographical information, verification and forest product traceability rather than handling these processes independently.

B. IDENTIFIED RESEARCH GAPS

From the results presented in the reviewed studies, it is obvious that considerable advances have been made in satellite-based forest monitoring, AI-based change detection, and blockchain-based timber traceability. Nevertheless, these issues are researched independently from each other. Based on the comparison of the reviewed articles, several research gaps can be identified. There are mainly 5 limitations or gaps identified:

1. Lack of integrated monitoring and traceability system: Although most of the remote sensing studies concentrate on the detection of forest changes, the blockchain-based papers concentrate mainly on tracking and authenticating timber after harvest. Existing researches do not combine satellite-based detection of forest changes and subsequent tracking and authentication of forest products [4], [6], [7], [20]. Thus, it would be desirable to develop a system for integration of all the above stages into one single framework.

2. Limited near-real-time detection and automated verification: Although some time-series approaches have helped to improve the detection of forest changes, they still require repeating observations in order to detect changes [12], [18], [19]. In addition, in some systems, detected alerts have to be verified manually by the expert [12]. Thus, there is a need in the system which would enable near-real-time detection of forest changes and automate the verification process.

3. Limited identification of the cause of forest change: Although most of the reviewed studies help to recognize the presence of the change in the forest area, they cannot automatically identify the reason for this change. For instance, they cannot automatically define whether the forest change occurred due to logging, forest fire, agriculture or road construction [11], [12], [13], [19]. Identification of the cause of the change could help to increase the effectiveness of alerts.

4. Separation between forest monitoring and geospatial security: The findings obtained using the blockchain technology indicate that the geospatial information could be employed for verification, access control, and auditing [3], [4], [6]. At the same time, the systems mentioned above are designed not to perform the analysis of satellite images and detection of forest losses [3], [4], [6]. Thus, there is still a separation between the AI-based approach to forest change detection and the secure management of the results received.

5. Lack of direct connection between forest loss and timber traceability: Although the blockchain systems could be used to register the origin, owner and history of timber transportation [4], [6], [7], [20], this information is manually introduced into the system. Thus, there is no way to directly correlate the detected forest loss with the physical product of the forest that will later enter the supply chain. Thus, there is a need for a system that will establish the link from detection to verification of forest loss and traceability of the forest product.

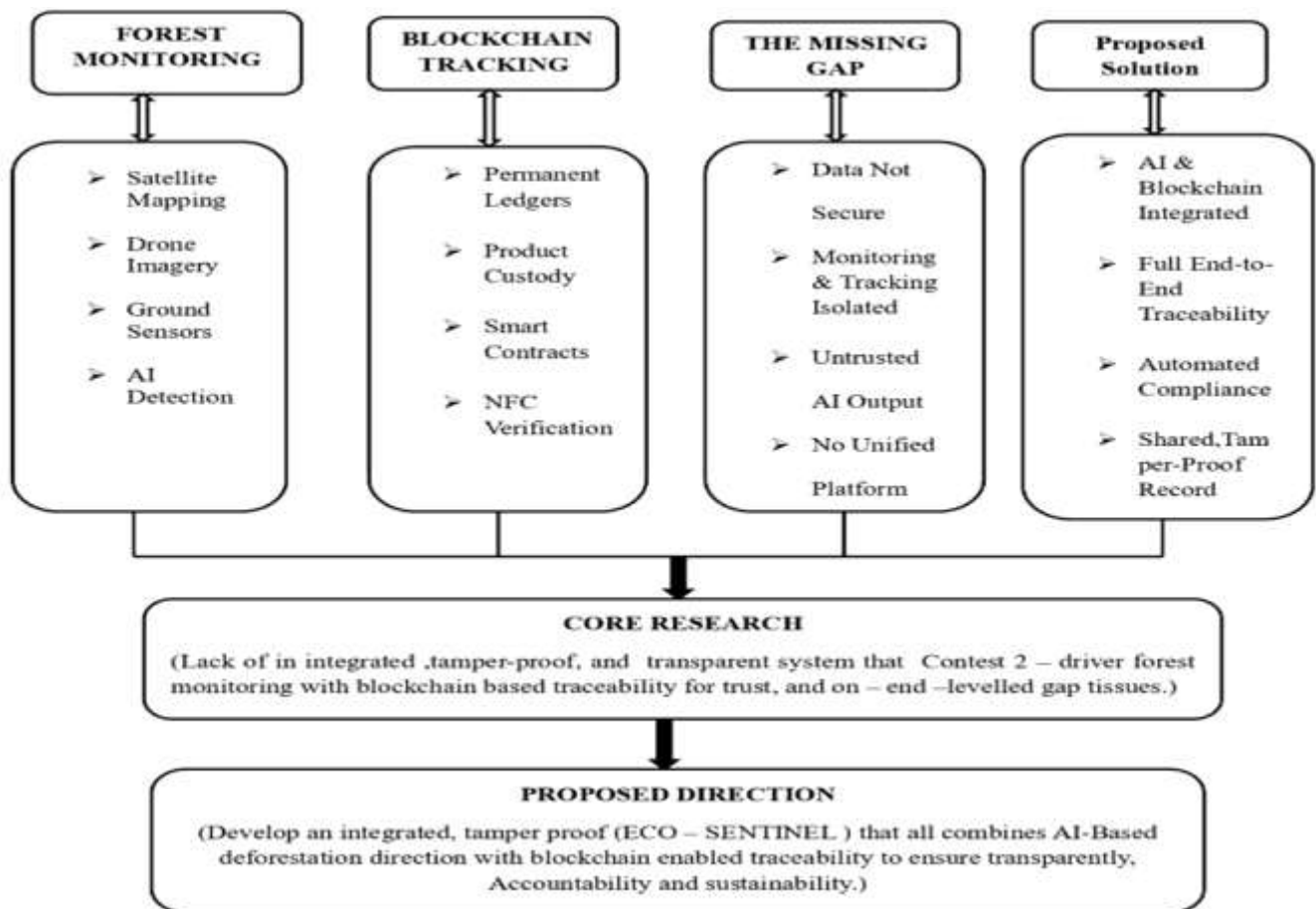


Fig 2. Research gap Framework

6. Limitations in satellite data availability: Even though different researches use different satellite sources, each of the sources has its limitations due to the coverage by clouds, spatial resolution, availability and preprocessing [11], [16], [18], [19]. While LiDAR data are helpful in providing canopy height, they have spatial limitations; optical data can suffer from clouds and seasonality [11], [16]. At the same time, smaller disturbances can be missed when the spatial resolution is insufficient [19]. It demonstrates the need in the system which can effectively use different satellite data depending on their availability.

V. FUTURE RESEARCH AND ADVANCEMENT

In my opinion future research may be done about forest monitoring system that includes Satellite based forest monitoring, Artificial Intelligence Based Detection System, Geospatial Verification and Blockchain Technology for Traceability of Forest Products. This process would allow us to detect the changes quickly with satellite monitoring and artificial intelligence technology. Without doing much effort manually we could easily detect such forest changes and give alert signals regarding it. Furthermore geospatial verification would ensure whether there was any manipulation done in detecting the changes of forest location. With respect to blockchain technology it could provide an authentic record about forest detection and its further traces.

VI. CONCLUSION

The studies discussed in this paper show that satellite remote sensing is extensively utilized for monitoring and detection of deforestation and forest changes. The data from Landsat, Sentinel-1, Sentinel-2, LiDAR and other satellite observations are used in several studies to better understand forest changes [11], [18], [19]. In addition, different AI methods (e.g., CNN, Random Forest, U-Net, transformer-based model, and others) are applied for automation of the detection process [1], [8], [13], [15]. The review also demonstrates the utility of images of different dates for early detection of changes in forest cover. SAR images are very useful in areas where clouds or smoke make optical images inaccurate [12], [18], [19]. In addition, the current detection approaches are limited by some factors such as low spatial resolution, availability of relevant images, delay in detection and manual intervention. The majority of the approaches can only detect the existence of change in the forest but cannot clearly specify the cause of the change and how the change relates to the movement of forest products.

The review on blockchain has shown that it is possible to record, verify and trace information on timber at different stages of the supply chain [4], [6], [7], [20]. It is to be noted that most of these approaches are independent of the satellite based forest detection approaches. Therefore, as discussed in this paper, it can be said that there is need to integrate satellite based forest detection, AI analysis, geospatial verification and blockchain based traceability.

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