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Unveiling Deforestation and Exploring Underlying Drivers: Insights from Jhargram District of West Bengal, India

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Abstract
Deforestation is a pressing global issue with profound ecological, social, and economic implications. This study investigates the nature of deforestation and drivers in Jhargram district, West Bengal, India, a region characterized by significant forest cover and indigenous communities. The study identifies key anthropogenic and natural factors contributing to forest loss and fragmentation through an integrated analysis of relevant literature, field surveys, and secondary data. The findings reveal that agricultural expansion, mining, industrial and infrastructural development, commercial plantations, and forest fires are the primary drivers of deforestation in the district. Additionally, the study highlights the socio-economic impact on forest-dependent tribal communities, emphasizing the need for inclusive and sustainable forest management policies. The insights gained from this study provide a crucial foundation for future policy-making and conservation efforts aimed at mitigating deforestation and promoting sustainability in Jhargram and similar forested regions.
Key Words: *Jhargram, Forest fragmentation, deforestation, sustainable management, anthropogenic drivers, indigenous knowledge*

1. INTRODUCTION:

Deforestation is a complex and dynamic phenomenon occurring worldwide at varying rates and scales, reshaping landscapes and ecosystems with profound environmental and socio-economic consequences (Farrokhi et al., 2024). Its global repercussions include the disruption of forest ecosystems, habitat fragmentation, loss of biodiversity, and depletion of invaluable gene pools. This relentless destruction not only accelerates the extinction of countless species but also exacerbates climate change, altering weather patterns and threatening the very balance of life on Earth (Barraclough and Ghimire, 1990; Myers, 1994). The challenge is particularly profound in developing countries, especially in tropical regions where forest ecosystems are highly vulnerable (Myers,1994). Between 1990 and 2020, approximately 420 million hectares of forest land were lost due to deforestation, with an annual deforestation rate of 10 million hectares in 2020 (FAO, 2020). Tropical forests experience the highest deforestation rates, significantly reducing their spatial extent and posing a severe threat to global biodiversity (Jayathilake et al., 2021). The rate and drivers of tropical deforestation have not remained over time. Instead, they have evolved based on location, accessibility, the demand and valuation of existing species, resource availability, and political control. Geist & Lambin (2002) conducted a global study covering 152 countries across Asia, Africa, Sub-Saharan Africa, and Latin America, identifying land expansion as the most proximate cause of deforestation, followed by wood extraction and infrastructural development. Deforestation drivers can be categorized into two types: (i) direct drivers and (ii) indirect drivers. Forest land conversion for commercial and subsistence agriculture, mining activities, infrastructural development, and urban expansion are the major direct drivers of deforestation (Laurance et al. 2014; Lewis et al. 2015). On the other hand, forest fires, livestock grazing, illegal logging and timber extraction, and charcoal production are some indirect causes of deforestation. The expansion of cropland acts as a major driver of deforestation and causes permanent loss of forest cover in humid tropical areas (Kim et al., 2015; Wees et al., 2021). Between 1980 and 1990, nearly 80 percent of newly added agricultural land in tropical areas resulted from forest land conversion (Geist & Lambin, 2002).

This trend has intensified, with approximately 90 percent of new agricultural land between 1990 and 2020 replacing forest land (FAO, 2020). A village-level study of the entire India found that between 1985 and 2005, approximately 49580 sq. km. of forest area was lost. Globally, forest fires in 2015 affected 2.41 percent of existing forest cover (98 million ha) and accounted for one-third of total forest cover loss (FAO, 2022). Around 90 percent of forest fires occur due to anthropogenic causes (FAO, 2020). Tropical forests are more vulnerable to forest fire due to immense population pressure on land and unique climatic conditions. Shifting cultivation and slash burning are extremely vulnerable factors that cause huge forest cover loss, especially during the drought season in tropical and subtropical areas (Siegert et al., 2001). Fire can cause loss of vegetation cover in two ways: wildfire by friction of dry leaves and twigs naturally during summer and slash burning due to human-centric activities (Wees et al., 2021). Human influence of forest fire depends on several factors like population density (Bistinas et al., 2014), landscape fragmentation (Archibald et al., 2009), socio-economic development (Chuvieco et al., 2019), mining (Lopez et al., 2023), agriculture (Malmer et al., 2005) and land management, etc. (Andela et al., 2017). Approximately 90 percent of forest fires in India occur through human intervention in forests (Srivastava & Garg, 2013). According to the Forest Survey of India (2015), Tropical dry deciduous forests in India are vulnerable to fire-related activities; about 3.95 percent of heavy forest fires occurred in such forest areas, which is well above the national level (2.40 percent). Mining is another critical driver of deforestation and forest degradation in tropical and sub-tropical regions, particularly in developing countries (Edwards & Laurance, 2015; Seymour & Harris, 2019). A study on the Brazilian Amazon revealed that total deforestation is 12 times more beyond mining lease boundaries due to mining concessions between 2005 and 2015 (Sonter et al., 2017). The cumulative effect of mining activities appeared as a most devastating situation for existing forest land. Mining not only leads to deforestation, but it also has a wide impact on land degradation, defiles water bodies, and causes soil erosion. More extensive mining indirectly promotes the development of new settlements, infrastructural setup, transport, and communication networks, which can be devastating for the entire forest ecosystem. approximate 4947 sq. km. area has been cleared legally for mining activities in the last three decades in India (Ghosh, 2016). Modern infrastructure, road networks, urban exposition, and industrialization all are cumulatively impacted by forest deterioration. The development of transport and communication networks within the national boundary and beyond the countryside is a world trend of economic giants for reducing time, money, and cost-effective trade for national interest (Atkin and Donaldson, 2015; Jedwab and Storeygard, 2017; Fajgelbaum and Redding, 2022). Infrastructural and road network development in forest-rich tropical countries like Brazil and Indonesia has a long history of deforestation (Araujo et al., 2023). The opening of new road networks influences the establishment of new settlements, which further leads to infrastructural development and urbanization; most of the deforestation is found at the edges of road networks in tropical countries (Barber et al., 2014; Laurance et al., 2009). Past three decades India experienced significant forest cover loss due to several infrastructural developments; 23716 new industrial projects caused 14000 sq. km. of forest cover loss followed by defense projects (1539 sq. km.) hydro electrical projects (1350 sq. km.), irrigation (1330 sq. km.), road and railway network (757 sq. km.) (Ghosh, 2016; Ranjan, 2019). Illegal logging and trading of timber products contribute significantly to forest fragmentation and degradation across the tropics, leading to environmental degradation, biodiversity loss, and economic challenges (Franca et al., 2023). According to UNEP (2014), illegal logging accounts for up to 30 percent of the global logging trade. India ranks as the third-largest importer of illegally logged timber globally, following China and Vietnam, with nearly 10 percent of the global illegal wood trade and an annual import value exceeding ₹40 billion (Rathore, 2016).

Jhargram district has 30 percent forest coverage, primarily consisting of tropical dry deciduous forest with rich bio-diversity (DSHB, 2011). Jhargram district has long been adobe to several marginalized tribal communities, where the influence of modernization has remained limited. These communities rely heavily on forests for both their livelihood and cultural heritage, maintaining traditional ways of life despite socio-economic changes. Jhargram, an extension of the Chhotonagpur Plateau, is rich with minerals, with recent exploration identifying deposits of several rare minerals (Indian Mineral Yearbook, 2018). The continuous development of road networks, buildings, and industries severely impacted both the forest cover and its biodiversity (Annual Administrative Report, 2021). Edge fragmentation and legalized harvesting of valuable *sal* species in different parts is a frequent incident in this region. This kind of activity across the district appears as a threat to existing biodiversity. The continuous destruction of the natural habitat of different animals has led to human-animal conflict in the recent past (Mandal & Das Chatterjee, 2021). Some researchers have highlighted actionable insights into effective restoration and conservation strategies tailored to regions like Jhargram; the link between deforestation, habitat fragmentation, and human-wildlife conflict is acknowledged but not thoroughly investigated (Mandal & Das Chatterjee, 2021; Sahoo et al., 2023). The effectiveness of existing policies and legal frameworks in forest conservation is also underexplored. The present study raises several critical questions that require thorough examination: What is the current status of deforestation in Jhargram? What are the predominant anthropogenic drivers contributing to forest cover loss in the region? How do socio-economic factors such as land-use changes, population growth, and infrastructure development exacerbate deforestation in the Jhargram division? To address these questions, the study needs to unravel the complex interplay of ecological and human-induced forces shaping forest landscape changes. In this connection, the current study aims to investigate the implicit causes of deforestation and focus on valuable insights into effective policy-making to reduce deforestation and scientific regeneration of existing forest cover.

2. MATERIAL AND METHODS:

Investigating the underlying causes of deforestation is crucial for sustainable forest management and conservation. Recent studies and records show that the Jhargram division has experienced significant forest cover loss in the last few decades. To establish the statement, the present study is based on an exhaustive review of several articles from Academia, Directory of Open Access Journals, Google Scholar, ISI Web of Science, JSTOR, and Semantic Scholars as a comprehensive database to identify major causes of deforestation in the study area. In addition, a detailed field investigation was conducted to understand the nature and diversity of deforestation in different places across the Jhargram district. Google Earth imageries of different decades were verified and compared to find changing LULC patterns in the study area. Different statistical data sources and their uses are given below in table 1. The composition of extensive field investigations with wide ranges (variation) of data from different sources helps to critically identify the most relevant causes of deforestation, which would further help frame deforestation strategies by respective authorities and policy makers.

Table No. 1: Data sources and uses

Sl. No.	Source of Data	Data Used
1	District Census Handbook, Paschim Medinipur, 1981 to 2011	Demographic Data
2	District Statistical Handbook, Paschim Medinipur, 1981 to 2011	Forest area and Agricultural land
3	Annual Administrative Report, Department of Forest, West Bengal, 2015-16 to 2020-2021	No. of annual Fire occurrence, fire-affected area, Estimated loss due to fire, persons killed and injured due to fire, Livestock Injured/killed, location of forest fire, Total offense cases registered, No. of trees illicitly felled, Timber seized, Vehicle Seized, Area felled (ha), Outturn of timber (m^3), The outturn of firewood (m^3), Outturn of poles (No.), Registered Saw mill
4	District Industrial Profile, Jhargram, Ministry of MSME, Government of India, 2017-2018	Nature of industry, types of industry, number of registered units, investment amount, employment generation
5	District Survey Report, Jhargram, 2021	Length and density of roads
6	Indian Minerals Yearbook, Government of India, 2021	Mineral deposition sites

7	Directorate of Mines and Minerals, Government of West Bengal, 2015-16 to 2020-21	Mineral Estimated Area/ Estimated resource, Grade of Mineral, Mouza having mineral reserve,

3. RESULT AND DISCUSSION:

The forest area under the Jhargram district has undergone drastic changes in the last few decades (Annual Administrative Report, 2021b). A recent study revealed that forest cover in Jhargram decreased from 146.67 sq. km in 1990 to 72.76 sq. km. in 2020, marking a loss of over 50% in three decades (Goswami, 2024). This decline corresponds to an average annual deforestation rate of approximately 2.47 sq. km. The continuous loss of forest cover has resulted in increased fragmentation, leading to smaller and more isolated forest patches. However, human-induced activities led to forest degradation, resulting in the loss of unique plant species and associated ecological knowledge. The development of transport networks and agricultural expansion are both responsible for the fragmentation and edge effects of forests. Research highlights that deforestation in Jhargram is a major driver of biodiversity loss, with studies documenting a decline in avifauna diversity due to habitat destruction from deforestation and other anthropogenic activities (Das et al., 2021). Broader ecological disruptions affect various species, leading to the local extinction of keystone species (Mandal & Das Chatterjee, 2021). Furthermore, the proliferation of exotic invasive species like *Eucalyptus cinereal*, etc., has intensified ecological imbalances, further endangering native biodiversity (Mishra et al., 2023). Increased surface runoff and decreased groundwater recharge further degrade local hydrology, exacerbating issues like water scarcity and soil erosion. Higher temperatures and erratic rainfall patterns have been observed as key indicators of local climate shifts in Jhargram due to declining forest ecosystems. Deforestation and subsequent land cover changes have adversely affected groundwater recharge rates, contributing to the decline in groundwater levels (Kayet et al., 2019). Additionally, deforestation has altered traditional elephant migration routes, leading to increased human-elephant conflicts in rural areas (Chakraborty, 2024). These conflicts not only threaten human safety and livelihoods but also endanger elephant populations. The forest-dependent tribal communities in Jhargram, such as the Santhal and Lodha, face significant challenges due to deforestation. Their traditional livelihoods, including non-timber forest product (NTFPs) collection, shifting agriculture, and herbal medicine production, have been severely disrupted (Ray & Mukherjee, 2023). Reduced forest resources increase their socio-economic vulnerabilities, deepening poverty cycles. Cultural degradation also accompanies ecological losses, as sacred groves and other forest-associated cultural traditions are impacted. At this juncture, based on the cascading negative impacts of deforestation, it becomes crucial to identify the divers responsible for the deforestation in the Jhargram district.

3.1. Drivers of deforestation:

Deforestation and associated fragmentation both are serious threats, especially to the seasonally dry forest ecosystem (Rivas et al., 2021) in the Jhargram district, not only causing forest cover loss but also being responsible for physical and biological changes in the entire forest landscape across the region (Jha et al., 2005). Based on existing literature, statistical data, and extensive field visits, a distinguished set of drivers of both natural and human-induced activities have been identified that contributed to the significant loss of forest cover in the Jhargram district (Figure 1). In this section, seven drivers of deforestation and fragmentation have been identified and analyzed in a cause-effect relationship based on various evidence.

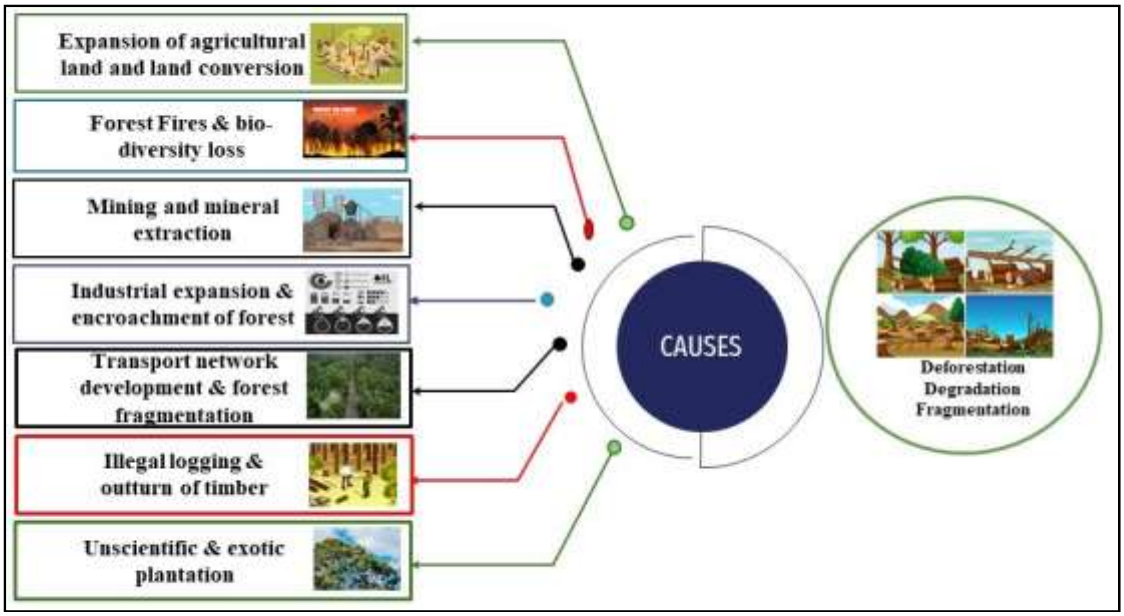


Figure 1: Drivers of deforestation

3.1.1 Expansion of agricultural land and land conversion:

The total forest cover in Jhargram district decreased from 109,460 hectares in 1990 to 97,271 hectares in 2010; decadal change shows a reduction of 7.08 percent forest in the 1990-2000 period and 4.36 percent in the 2000-2010 period. On the contrary, decadal change in agricultural land increased by 7.86 percent in the 1991-2001 period and 6.04 percent in the 2001-2011 period (Table 2). Agricultural land has been increasing, possibly due to a demographic shift towards an increase in population density and the conversion of forests to agricultural use (Barraclough and Ghimire, 2000). The trend suggests ongoing deforestation, primarily driven by agricultural land expansion with increasing urbanization and land abandonment. The above discussion reflected the conversion of forested land due to continuous human intervention, which created immense pressures on forested areas over the three decades.

Table No. 2: Decadal growth of population, forested land, and agricultural land

Year	Population & LULC					Decadal change (%)				
	Total Population	Rural population	Urban population	Forest land (ha)*	Agricultural land (ha)*	Total Population	Rural population	Urban population	Forest land	Agricultural land
1981	745118	718411	26707	NA	NA	-	-	-	-	-
1991	874745	832651	42094	109460	161580	17.4	15.9	57.61	-	-
2001	1008030	954885	53145	101708	174275	15.24	14.68	26.25	-7.08	7.86
2011	1136548	1069112	67436	97271	184799	12.75	11.96	26.89	-4.36	6.04

Source: *District Census Handbook, Paschim Medinipur; * District Statistical Handbook, Paschim Medinipur*
NA=Not Available

3.1.2 Forest fires and bio-diversity loss:

Forested areas within the district are highly susceptible to forest fires, increasing the frequency of such instances witnessing high vulnerability on canopy cover. A summary of all 107 forest fires that occurred between 2015 and 2021, causing 240.04 ha of forest burning with heavy monetary damage, is presented in Table 3. Jhargram, Binpur-I & II, and Nayagram blocks have the maximum area under forest coverage in the district; in most cases, forest fires occurred in these blocks (Figure 3a). The dry deciduous forest of the Jhargram division, characterized by shedding its leaves during late winter and early monsoon, became inaccessible for local communities to collect NTFPs and timber products as the floor of the forest is entirely covered with dry leaves, shrubs, and herbs (Sahoo et al., 2023). Typically, natural forest fires originate in the canopy layer and gradually spread toward the surface. However, in most instances, forest fires in the Jhargram forest are initiated at the ground by human-induced activities. Controlled burning is commonly practiced in relatively small areas, particularly in forest interaction zones, by local inhabitants as a preventive measure against poisonous and venomous animals. The local communities frequently set fire to dry leaves and thorny shrubs to avail smooth access to forest products and sustain their livelihood. Additionally, in some cases, forests are burned out of fear to protect themselves from wild animal attacks. Wild animals frequently venture into human settlements in search of food, leading to frequent human-animal conflict in the Jhargram division, and the report indicates 32 registered injuries as well as deaths of 53 livestock and 32 humans (Table 3). In controlled burning, targeted forest floors are burned without causing harm to trees (Figure 2c).

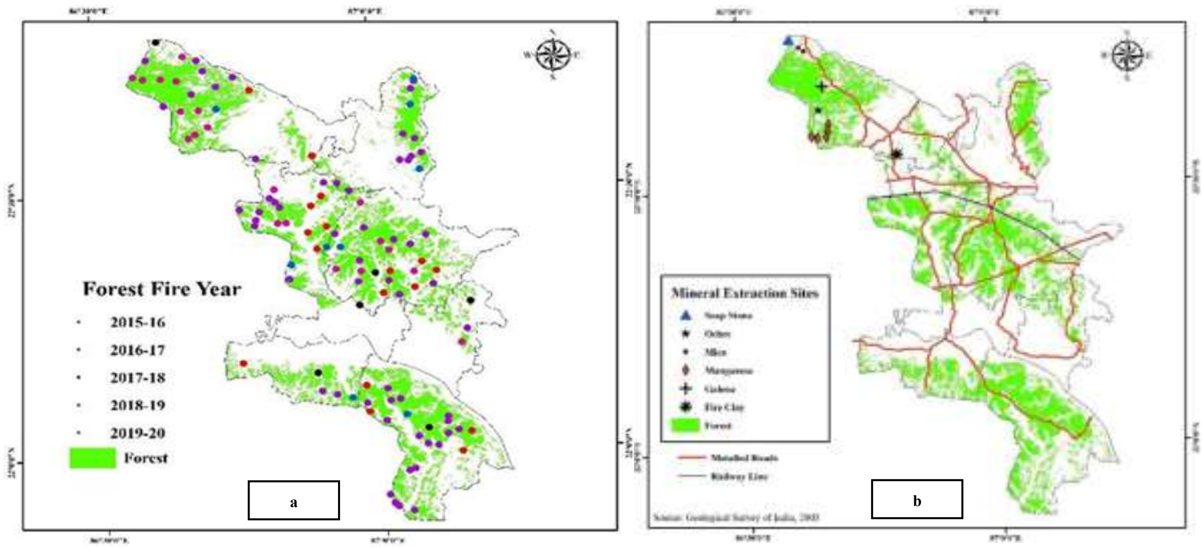
Table No. 3 Incidents of forest fire, the status of forest land encroachment, and person and livestock injured/killed by wild animal

Year	Forest Fire			Forest Land Encroachment	Human and Livestock Injured/Killed		
	No. of Occurrence	Affected Area (ha)	Estimated Loss (Rs)	Area in hectares (as of 31 March)	No. of Person Killed	No. of Person Injured	No. of Livestock Injured/Killed
2015-16	18	40.13		1545.42	5	2	
2016-17	18	40.13		1544.42	6	3	
2017-18	5	34.00	6800000	1544.42	4	4	
2018-19	16	39.60		1035.25	8	9	
2019-20	25	43.09		1502.92	13	7	
2020-21	25	43.09		1502.92	14	7	53
Total	**107**	**240.04**			**50**	**32**	
Source: Annual Administrative Report, Department of Forest West Bengal, 2015-16, 2016-2017, 2017-18, 2018-19, 2019-20, 2020-21							

Figure 2: Forest fire in Nayagram Range (a) **Uncontrolled burning**: Herbs, shrubs, and creepers have been completely burnt, leaving behind only black ashes on the forest floor. (b) The Sal stems have also been significantly impacted, with damage extending up to 1 meter from the base. (c) **Controlled burning**; Partially burnt forest floor cover.

However, uncontrolled burning predominantly occurred at unprotected forest edges without the presence of local dwellers, easily caught on fire and burnt extensive areas (Figure 2a). Lack of knowledge and precautionary measures contributed to the rapid spread of fires, particularly in the resin-enriched *Sal* forest, where flames quickly reached up to 2 meters from the ground (Figure 2b) and extended deeper into the forest. Such uncontrolled burning has some severe consequences for vegetation, soil, and ecosystems, ultimately accelerating environmental degradation. Intensive fire not only burns existing forest cover but is also responsible for changing the physical and chemical properties of soil (Verma & Jayakumar, 2012). Intense wildfires can reduce up to 50 percent of carbon and 25 percent of nitrogen in the soil, making it difficult to regenerate natural vegetation in that soil for a long time (Bormann et al., 2008).

Figure 3: (a) Year-wise location of forest fire and (b) Mineral extraction sites



3.1.3 Mining and mineral extraction:

The extended part of the Chhota Nagpur plateau is located northwest of the Jhargram district, considered one of the mineral-enriched districts of West Bengal after Purulia and Bankura. The Binpur-II block is located at a high altitude, with a 300m contour line passing through the Kakrajhore region, and contains a high concentration of various minerals within the densely forested area (Figure 3b). A survey conducted in the year 2020-21 by the Geological Survey of India (GSI), estimated the concentration of quartz, clay, laterite, limestone, sulfur, and manganese around Labani, Pahar Chakri, Odolchua, Balichua, and

Mahulbani region under Binpur-II block of the district (Indian Minerals Yearbook, 2021). Mineral excavation points are located deep inside the core forest, leading to rapid cutting down of vegetation for mining and industrial activities. Significant loss of forest cover found at the mineral reserve and extraction area, causing rapid fragmentation and isolation. Mouzas, having a high concentration of minerals, faced rapid and continuous destruction of forest cover in the previous three decades, which is evident that the loss of forest cover is directly linked with mineral extraction (Table 4). The largest forest patch is located in the Binpur-II block and faces a drastic reduction in its area. The absolute area of the largest patch has declined from 11392 hectares to 8415 hectares in the last three decades, and incidentally, huge laterite deposition was found near Belpahari under Binpur-II (Indian Mineral Yearbook, 2017). If further unscientific extraction process continues to maximize the economic potential, forest fragmentation will be aggravated and environmental degradation initiated. To preserve natural cover and maximize these natural resources' potential, planners must exercise caution when managing the mineral extraction process.

Table No.4 Mineral reserve and extractions

Mineral	Estimated Area/ Estimated resource ('000 tonnes)	Grade	Location	Name of Mouza having a mineral reserve	Forested Area (ha)#			
					1990	2000	2010	2020
Quartz	3.36 million tonne (upto 20 m depth)	SiO2: 97.5% to 99.61%	Binpur-II	Balichua	207	192	168	103
Clay	0.552 million tonne (upto 15 m depth)	Grade-I=18%, Grade-II=16% and Low=66%	Binpur-II	Banspahari	247	228	173	128
				Chirugora	96	90	69	51
Laterite	Area-2056.73 sq.m and depth-20m	yet to explore	Binpur-II	Kadamdiha	138	126	112	94
Phyllite	Area-620.41 sq.m and depth-20 to 25m	yet to explore	Binpur-II	Labani	281	255	212	167
Granite	Area-33.77 sq.m and depth-30m	yet to explore	Nayagram	Mahulbani	271	231	180	125
Sulfur	100	yet to explore	Jhargram	Odolchua	202	184	162	128
Manganese	200	yet to explore	Jhargram	Pahar Chakri	123	101	87	66
Source: Directorate of Mines and Minerals, Government of West Bengal, 2015-16 to 2020-21 # Area calculated from Google images.								

3.1.4 Industrial Expansion and encroachment of forest:

Expansion of the industry at the cost of the forest, experienced since the Industrial Revolution (Anderson, 1990; Pandya & Didwania, 2021), and Jhargram district is not an exception. The north-western part of the Jhargram district is covered with dense forest and also endowed with minerals; many raw material-based industries tend to set up in close proximity to the raw material sources, which is responsible for forest fragmentation (Nayak et al., 2020). Of the 3337 industries in the district, Jhargram has medium-scale 3 paper industries and small-scale 100 wood-based, 1000 *bidi*, and 1200 sal leaf plate industries (Table No. 5).

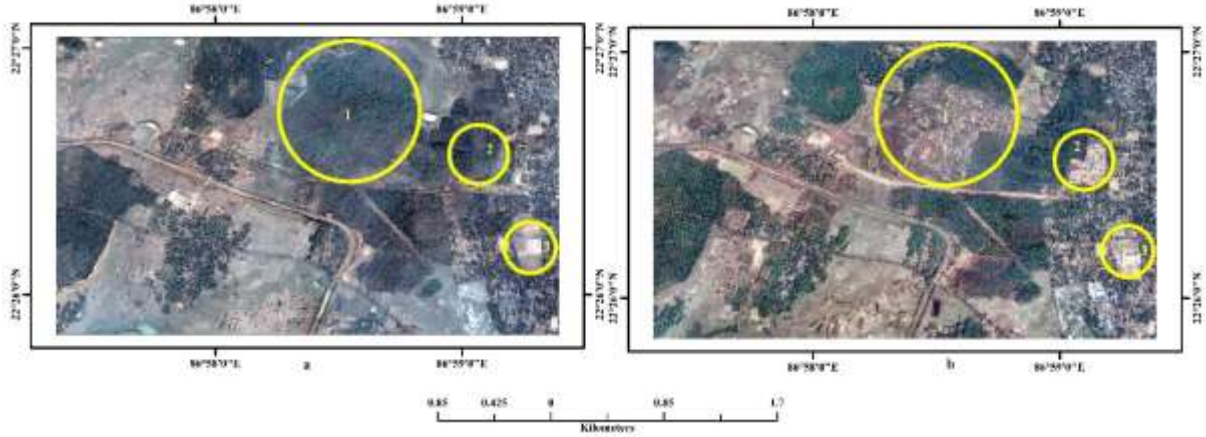


Figure 4: Google image 2014 (a) and 2022 (b). Urban expansion and settlement growth at the cost of forest cover in Jhargram municipality, e.g., (1) establishment of new settlement; (2) Jhargram Medical College; (3) Jhargram Raj College indicated in 2022, but in 2014, the area was mostly covered with forest.

These industries affect the forest in two ways: first, the paper and wood-based industries directly cause tree cutting, and second, the emergence of other industries has led to a decrease in the total area of forest cover. Satellite data showed that the initial development of the Jhargram municipality area proceeded with rapid encroachment in forested areas, which led to rapid deforestation and forest fragmentation (Figure 4). Increases in linear built-up into the forest area are responsible for the increase of forest patches, forest edges, and inter-patch distance which is considered the main reason for the loss of interconnectivity between two adjacent forest patches (Figure 5); further enhances rapid encroachment along the patch edges (Nayak et al., 2020).

Figure 5: Google image 2013 (a) and 2024 (b). Expansion of industrial units and establishment of the new university, replacing forest cover e.g. (1) Rashmi Udyog Pvt. Ltd. (2) Rashmi Parking side (3) Sadhu Ram Chand Murmu University (4) Expansion of Rashmi industrial unit found in 2024 image which area was mostly covered with forest in 2013. Under the CAMPA Act, new plantation patches are also found in 2024 (A, B, C).

Under the Compensatory Afforestation Fund Management and Planning Act (CAMPA) 1980, vulnerable forest areas can be used for various non-forestry purposes, such as farming, building roads, bridges, dams, and other infrastructure projects. Under the act, the further development of raw material-based industries (Figure 5) is established in the Jhargram district (Government of India, Ministry of

MSME, 2018). In 2013, 12.145 hectares of land were proposed to be diverted for setting up Jhargram Medical College in Jhargram, which was further extended to 20 hectares (Office of the District Collector, Jhargram, 2013). This proposed land came under protected forest (Calcutta Gazette, 1956) where several species of *Sal, Acacia*, and *Neem* are grown experimentally (Centre for Science and Environment). This kind of land diversion not only reduces the total forest area but is also responsible for the extinction of several vulnerable species. The exponential rate of industrial growth has resulted in the loss of vegetation, including NTFPs and timber, and continuously disturbed the livelihood practices of forest-dependent locals (Table 6). The quality of the forest has deteriorated because of air and soil pollution caused by industrial exhaustion. Moreover, the relationship between industrial development and deforestation in the Jhargram district is a complex and multifaceted issue that has been the subject of extensive research on the sustainable use of natural resources (especially forests).

Table No. 5 Number of registered industries in Jhargram district

Category	**Type of Industry**	**Registered Unit**
Large scale Industries	Steel	1
	Cement	2
	Asbestos	1
Medium Industries	Paper	3
	Oil	1
	Skincare	1
	Cement	1
Small industries	Agro based industries	53
	Wood/wooden based furniture	100
	Repairing & Servicing	544
	Pottery	112
	Handcraft	310
	Bidi*	1000
	Sal leaf plate	1200
	Cotton textile	1
	Paper & Paper Products	5
	Metal-based industries	2
Total		**3337**

*Bidi, a common Indian product prepared by crushing tobacco mixture into a small length roll.
Source: District Industrial Profile, 2016

Table No. 6 No. of registered industries, employment generation, and investment

Year	Registered Units (Yearly)	New Employment Generated ('000)	Fresh Investment (Million)
2006-07	206	2.47	218.3
2007-08	650	4.63	315.64
2008-09	462	3.73	360.11
2009-10	329	2.56	261.91
2010-11	499	3.78	389.51
2011-12	1174	4.67	243.39
Total	**3320**	**19.54**	**1782.87**

Source: *District Industrial Profile, 2017-18*

3.1.5 Transport network development and forest fragmentation:

Table 7 shows almost every block except Sankrail experienced significant expansion of the road network. Overall road density for the district increased by 64.50 percent while Nayagram registered the highest increase (202.78%) in road density, reflecting substantial development in transportation. The backward district (Nayagram) was also privileged with the rapid development of the transport network after Naxalite activities; the major objective of developing the transport network was establishing connectivity between remote places in this region. Currently, the entire district is connected with a good transportation network; a high concentration of road density is found in the surrounding areas of district headquarters. To establish connectivity between remote areas, roads have been constructed through forested land, leading to an increase in forest patches, causing large-scale habitat loss, increased vulnerability in breeding, and aggravated human-animal conflict. Road networks have been developed by cutting down dense forests to avail raw materials to industries as well as distribute products in the market; as a result, the total forest ecosystem has been disturbed and created barriers to the movement of wildlife.

Table No. 7: Transport network of Jhargram District (2021)

CD Block	Road density/km^2 (2011)	Road density/km^2 (2021)	Change (%)
Jhargram	1.41	2.44	73.05
Binpur-I	1.41	2.53	79.43
Binpur-II	1.08	1.29	19.44
Jamboni	1.86	2.51	34.95
Nayagram	0.72	2.18	202.78
Sankrail	2.75	2.85	3.64
Gopiballavpur-I	1.29	1.78	37.98
Gopiballavpur-II	1.67	3.32	98.8
District Total	**12.19**	**18.9**	**64.50**
Source: *District Survey Report, Jhargram, 2021*			

3.1.6 Illegal logging and legalized outturn of timber:

The legalised outturn of valuable premature *Sal* trees in the Jhargram forest is a frequent incident (Figure 6). The legalized harvesting of premature Sal trees by the members of the forest protection committee (FPC) under the supervision of local forest administration (age of the trees 12-15) for commercial interest found almost each FPCs under Jhargram district. Under CFC (Complete Felling Coupe), felling entire demarcated forested areas has been wiped out, this causes severe damage in the ecosystem balance as well as prevents the regeneration process. The CFC collected logs with a diameter exceeding 15 centimetres, while logs with a diameter below 15 centimetres are utilized by the FPCs for household purposes only, which causes severe damage to small and premature trees. Data from the Annual Administrative Report (2015-16 to 2020-21) shows that rapid urbanization and industrialization have triggered deforestation in Jhargram, with numerous forest offenses reported. The district has three medium-scale paper industries and 100 small-scale wood-based furniture and five paper industries (Table 8), directly dependent on forests. Government agreements related to the source of raw materials for these mills contribute to large-scale forest fragmentation and deforestation. From 2015 to 2021, 1270 offense cases were registered, 3050 trees were illicitly felled, and 267.848 m^3 of timber, valued at Indian rupees 14,91,079, was seized. A total of 26 vehicles were seized, carrying 66.645 m^3 of timber valued at rupees 3,95,587 (Table 9). Ineffective forest governance and management characterized by inadequate rule of law, transparency, accountability, participation, inclusiveness, equitability, efficiency, and effectiveness have exacerbated illegal logging in Jhargram (Basu & Basu, 2023). As of 2015, 484 Joint Forest Management Committees (JFMCs) and 64 Self-Help Groups (SHGs) were working to prevent illegal logging. Despite these efforts, 302 hectares of land were affected by unlawful felling during 2015-16, and 83.223 cubic meters of illegal logging of Sal, valued at 6,40,800 rupees, were seized (Table 8). Table 9 shows that from 2015-21, Jhargram experienced the felling of 3,711.02 hectares of forest, the outturn of 4,487.887 m³ of timber, the production of 77,063.354 m³ of firewood, and 1,316,600 poles by government or government-permitted agencies.

Table 8: Details of registered offense cases, timber seized, and vehicles seized

year	Total offense cases registered	Timber seized			Vehicle Seized		
		No. of trees illicitly felled	Volume (m^3)	Value (Rs.)	No. of vehicles seized	The volume of timber seized with the vehicle	Value (Rs.)
2015-16	409	857	83.221	6,40,800	4	28.78	2,21,600
2016-17	227	875	68.469	3,01,264	7	30.095	1,32,418
2017-18	174	610	34.714	132418	4	0	0
2018-19	190	411	22.172	1,38,510	2	1.128	9024
2019-20	167	297	24.694	1,08,655	5	0	0
2020-21	103	0	34.578	1,69,432	4	6.642	32545
Total	**1270**	**3050**	**267.848**	**1491079**	**26**	**66.645**	**395587**

Source: Annual Administrative Report,2015-16, 16-17, 17-18, 18-19, 19-20, 20-21

Table 9: Outturn of forest product and registered Sawmill

Year	Area felled (ha)	Outturn of timber (m^3)	The outturn of firewood (m^3)	Outturn of poles (No.)	Registered Saw mill	
					Licensed unit (General category)	Licensed unit (secondary non-pasting category)
2015-16	928.75	264.852	22598.227	248048	19	51
2016-17	706.1	637.501	12644.841	248048	19	51
2017-18	885.17	1011.928	20615.096	366546	20	51
2018-19	383	468.852	6209.253	91350	20	51
2019-20	392	1383	9797	158842	20	51
2020-21	416	721.754	5198.937	203766	21	7

Total	3711.02	4487.887	77063.354	1316600	119	262
Source: Annual Administrative Report, 2015-16, 16-17, 17-18, 18-19, 19-20, 20-21						

Figure 6: Legalized harvesting of premature *Sal* trees (a) measurement of Sal logs (b) measurement of firewood stacks (c) staking of firewood

3.1.7 Unscientific and exotic plantation:

The unscientific plantation is a common practice in the Jhargram forest division, causing forest degradation. National Forest Policy (1998) enlisted community participation for sustainable forest management; these communities are driven by respected authorities' governing principles and ignored knowledge of indigenous forest-dependent local people. Community-based scientific and sustainable forest management policies emphasize increasing cash flow from plantations (Sarangi, 2004); as a result, two crucial incidents occurred: (a) Those plant species are selected for plantations that have higher economic value and more forest produce. In many cases, selective plant species have an evil impact on existing forest species. (b) Interaction between local communities and the forest has been severely restricted, which has led to illegal logging to fulfill their economic needs.

The state afforestation scheme through the National Forest Policy (1988) aims to cover 33 percent of the total geographical land under forest. To execute this policy, state authorities have taken some extraneous decisions; they have quick-growing tree species for plantation, especially in lateritic soil (Department of Forest, 2017). Quick-growing exotic species like *Eucalyptus globulus* have adverse impacts on the ground: (a) The planting initiative has resulted in the replacement of the native *sal* dominated multi-species forest composition with single species (Figure 7). (b) Waxy coating and phenolic compounds of eucalyptus leaves take a long time to break down, as a result, existing species cannot survive under the circumstances and the forest floor remains without any vegetation growth inside its canopy range (Kabir et al., 2023). (c) The herbs, shrubs, and creepers were the main characteristics of an Indigenous forest but in plantation, the forest floor remains almost vegetation less and low productive in terms of forest products and more prone to soil erosion. (d) The planting of mono-species throughout the region prevents the expansion of naturally grown forests, and the proper development of the forest tier composite has stopped it from flourishing. As a result, the plantation maintained its prominence in the landscape while the fragmented sections of the forest came to symbolize the forest. It is very useful to engage local forest-dependent people in those organizations to use their traditional ecological knowledge to sustain forests and improve economic conditions.

Figure 7: (a & b) *Sal* species are replaced by *Eucalyptus sp*.

4. CONCLUSION

The study underscores the dynamic interplay between human activities and forest landscape changes in the Jhargram district, revealing the significant impact of agricultural expansion, mining, industrial growth, transport network development, and other anthropogenic factors on deforestation and fragmentation. The findings highlight the pressing need for balanced strategies that safeguard forests' ecological integrity while respecting Indigenous communities' socio-economic dependence. Effective policy interventions, such as stringent enforcement of environmental regulations, community-inclusive forest management practices, and scientific restoration measures, are vital. Additionally, addressing challenges like unscientific plantations, illegal logging, and human-wildlife conflict requires a nuanced approach that integrates ecological, economic, and social dimensions. The study advocates for a paradigm shift toward sustainable forest management that recognizes the rights and roles of indigenous communities, utilizes their traditional ecological knowledge, and ensures equitable resource distribution. Scientific forest restoration should replace exotic monocultures with native Sal forests to enhance resilience, while wildlife protection measures must establish safe corridors and buffer zones to reduce human-animal conflicts. A sustainable, participatory approach to forest management is essential to balancing ecological integrity with the socio-economic well-being of local communities, ensuring a resilient forest ecosystem in Jhargram.

REFERENCE

1.Andela, N., Morton, D. C., Giglio, L., Chen, Y., Van Der Werf, G. R., Kasibhatla, P. S., DeFries, R. S., Collatz, G. J., Hantson, S., Kloster, S., Bachelet, D., Forrest, M., Lasslop, G., Li, F., Mangeon, S., Melton, J. R., Yue, C., & Randerson, J. T. (2017). A human-driven decline in global burned area. *Science*, *356*(6345), 1356–1362. https://doi.org/10.1126/science.aal4108

2.Anderson, A. B. (1990). Smokestacks in the rainforest: Industrial development and deforestation in the Amazon basin. *World Development*, *18*(9), 1191–1205.

3.Araujo, R., Assunção, J., & Bragança, A. (2023). The Effects of Transportation Infrastructure on Deforestation in the Amazon: A General Equilibrium Approach. In *Policy Research Working Papers* (Issue April).

4.Atkin, D., & Donaldson, D., (2015). "Who's Getting Globalized? The Size and Implications of Intra-national Trade Costs", *NBER Working Papers*, 21439, National Bureau of Economic Research, Inc.

5.Barraclough, S.L., & Ghimire, K.B. (1990). *The social dynamics of deforestation in developing countries: principal issues and research priorities*. United Nations Research Institute for Social Development. USA.

6.Barraclough, S.L., & Ghimire, K.B. (2000). *Agricultural expansion and tropical deforestation: Poverty, international trade and Land use*. Earthscan Publications, London.

7.Barber, C. P., Cochrane, M. A., Souza, C. M., & Laurance, W. F. (2014). Roads, deforestation, and the mitigating effect of protected areas in the Amazon. *Biological Conservation*, *177*(2014), 203–209. https://doi.org/10.1016/j.biocon.2014.07.004

8.Bistinas, I., Harrison, S. P., Prentice, I. C., & Pereira, J. M. C. (2014). Causal relationships versus emergent patterns in the global controls of fire frequency. *Biogeosciences*, *11*(18), 5087–5101. https://doi.org/10.5194/bg-11-5087-2014

9.Bormann, B.T., Homann, P. S., Darbyshire, R.L., & Morrissette, B.A., (2008). Intense forest wildfire sharply reduces mineral soil C and N: the first direct evidence. *Canadian Journal of Forest Research*. *38*(11): 2771-2783. https://doi.org/10.1139/X08-136

10. Chakraborty, S. (2018). Perception and attitude of local people towards human-elephant conflicts around Mahananda Wildlife Sanctuary, West Bengal, India. *International Journal of Zoology Studies*, *3*(2), 93–95.

11. Chakraborty, S., Banerjee, S., Chatterjee, A., *et al.* (2024) People's perceptions and attitudes towards human-elephant conflicts and mitigation practices in the western part of southern West Bengal, India. *GeoJournal*, *89*(4).

https://doi.org/10.1007/s10708-024-11179-3
12. Chuvieco, E., Mouillot, F., Werf, G. R. Van Der, San, J., Tanasse, M., Koutsias, N., García, M., Yebra, M., Padilla, M., Gitas, I., Heil, A., Hawbaker, T. J., & Giglio, L. (2019). Historical background and current developments for mapping burned area from satellite Earth observation. *Remote Sensing of Environment*, *225*(2019), 45–64. https://doi.org/10.1016/j.rse.2019.02.013
13. Das, D., Patra, S., Jana, S., Bera, A., Jana, B., Giri, S., & Jana, R. (2021). Diversity of Birds Fauna in Jhargram, West Bengal, India. *Journal of Indian Association for Environmental Management*, *41*(4), 38–44. http://op.niscair.res.in/index/php/JIAEM/index
14. Department of Forest, Government of West Bengal (2016). *Annual Administrative Report 2015-2016*. https://doi.org/10.1097/00006199-196413040-00087
15. Department of Forest, Government of West Bengal (2017). *Annual Administrative Report 2016-2017*. https://www.westbengalforest.gov.in/publications_administrative_report_ banabithi.php
16. Department of Forest, Government of West Bengal (2018). *Annual Administrative Report 2017-18* (Vol. 01). https://www.westbengalforest.gov.in/notice/n23-03-2018-03.pdf
17. Department of Forest, Government of West Bengal (2019). *Annual Administrative Report 2018-2019*.https://www.westbengalforest.gov.in/upload/publication/Annual_ Administrative_Report 18-19.pdf
18. Department of Forest, Government of West Bengal (2020). *Annual Administrative Report 2019-2020*. https://www.westbengalforest.gov.in/upload/publication/AAR-2019-20.pdf
19. Department of Forest, Government of West Bengal (2021). Annual Administrative Report 2020-2021. https://www.westbengalforest.gov.in/upload/publication/ANNUAL%20 ADMINISTRATIVE%20REPORT%202020-2021.pdf
20. Edwards, D. P., & Laurance, W. F. (2015). Preventing tropical mining disasters. *Science*, *350*(6267), 1482–1483. https://doi.org/10.1126/science.350.6267.1482-d
21. Fajgelbaum, P., & Redding, S. J. (2022). Trade, Structural Transformation, and Development: Evidence from Argentina 1869–1914. *Journal of Political Economy*, *130*(5), 1249-1318. https://doi.org/10.1086/718915
22. Farrokhi, F., Kang, E., Pellegrina, H. S., & Sotelo, S. (2024). Deforestation: A global and dynamic perspective. Purdue University, University of Michigan
23. Food and Agriculture Organization of the United Nations. (2007). *Manual on Deforestation, Degradation, and Fragmentation using Remote Sensing and GIS*. https://www.fao.org/4/ap163e/ap163e.pdf
24. Food and Agriculture Organization of the United Nations. (2020). *The State of the World's Forests 2020. Forests, biodiversity, and people*. https://doi.org/https://doi.org/10.4060/ca8642en
25. Food and Agriculture Organization of the United Nations. (2022). The State of the World's Forests 2022. In *The State of the World's Forests 2022*. https://doi.org/10.4060/cb9360en
26. Forest Survey of India. (2015). India state of forest report 2015. Ministry of Environment, Forest and Climate Change, Government of India. https://fsi.nic.in
27. Forest Survey of India. (2017). India state of forest report 2017. Ministry of Environment, Forest and Climate Change, Government of India. https://fsi.nic.in
28. Franca, C. S. S., Persson, U. M., Carvalho, T., & Lentini, M. (2023). Quantifying timber illegality risk in the Brazilian forest frontier. *Nature Sustainability*, *6*(11), 1485–1495. https://doi.org/10.1038/s41893-023-01189-3
29. Geist, H. J., & Lambin, E. F. (2002). Proximate causes and underlying driving forces of tropical deforestation. *BioScience*, *52*(2), 143–150. https://doi.org/10.1641/0006-3568(2002)052[0143:PCAUDF]2.0.CO;2
30. Ghosh, H. (2016). In just 30 years, India has lost large forests to 23,716 industrial projects. *Scroll. in*. Retrieved July 10, 2018, from https://scroll.in/article/809286/in-just-30-years-india-has-lost-large-forests-to-23716-industrial-projects
31. Goswami, B. (2024). Rampant tree felling in Jhargram, urgent need for land restoration. *The Statements*. https://www.thestatesman.com/bengal/rampant-tree-felling-in-jhargram-urgent-need-for-land-restoration-1503311063.html
32. Government of India. (1980). Compensatory Afforestation Fund Act, 1980. Ministry of Environment, Forest and Climate Change.
33. Government of India. (1988). National Forest Policy, 1988. Ministry of Environment & Forests. https://moef.gov.in
34. Government of India. (1998). National Forest Policy, 1998. Ministry of Environment & Forests. https://moef.gov.in
35. Government of West Bengal. (2013). FORM-I (for linear projects): Diversion of forest land for non-forest purposes in Jhargram district. Office of the District Collector, Jhargram.
36. Government of India, Ministry of Micro, Small and Medium Enterprises (2018). *District Industrial Profile, Jhargram (2017-2018)* (Vol. 1, Issue 033). http://www.dcmsme.gov.in/dips/2016-17/Bengaluru Urban.pdf
37. Government of India, Ministry of Minning (2018). *Indian Minerals Yearbook 2016 (West Bengal)*. https://ibm.gov.in/writereaddata/files/02202018153245Westbengal2016.pdf
38. Government of India, Ministry of Minning. (2021). *Indian Minerals Yearbook 2021*. https://ibm.gov.in/IBMPortal/pages/Indian_Minerals_Yearbook__2021
39. Guha, R., & Gadgil, M. (1992). This fissured land: An ecological history of India. Berkeley: University of California Press
40. Jayathilake, H. M., Prescott, G. W., Carrasco, L.R., Rao, M., Symes, W.S., (2021). Drivers of deforestation and degradation for 28 tropical conservation landscapes. *Ambio, 50*(1):215-228. https://doi.org/10.1007/s13280-020-01325-9
41. Jedwab, R., & Storeygard, A., (2022). The Average and Heterogeneous Effects of Transportation Investments: Evidence from Sub-Saharan Africa 1960–2010, *Journal of the European Economic Association*, *European Economic Association*, *20*(1), 1-38.
42. Kabir, M. G., Wang, Y., Abuhena, M., Azim, M. F., Al-Rashid, J., Rasul, N. M., Mandal, D., & Maitra, P. (2023). A bio-sustainable approach for reducing Eucalyptus tree-caused agricultural ecosystem hazards employing Trichoderma bio-sustained

spores and mycorrhizal networks. *Frontiers in Microbiology*, *13*(January), 1–15. https://doi.org/10.3389/fmicb.2022.1071392
43. Kayet, N., Chakrabarty, A., Pathak, K., Sahoo, S., Mandal, S. P., Fatema, S., Tripathy, S., Garai, U., & Das, T. (2019). Spatiotemporal LULC change impacts on groundwater table in Jhargram, West Bengal, India. *Sustainable Water Resources Management*, *5*(3), 1189–1200. https://doi.org/10.1007/s40899-018-0294-9
44. Kim, D., Sexton, J. O., & Townshend, J. R. (2015). Tropics From the 1990S To the 2000S. *Geophysical Research Letters*, *42*, 3495–3501. https://doi.org/10.1002/2014GL062777.Received
45. Laurance, W. F., Goosem, M., & Laurance, S. G. W. (2009). Impacts of roads and linear clearings on tropical forests. *Trends in Ecology and Evolution*, *24*(12), 659–669. https://doi.org/10.1016/j.tree.2009.06.009
46. Lewis, S. L., Edwards, D. P., & Galbraith, D., (2015). Increasing human dominance of tropical forests. *Science, 349*(2015), 827-832. DOI:10.1126/science.aaa9932
47. Malmer, A., Van Noordwijk, M., & Bruijnzeel, L. A. (2005). Effects of shifting cultivation and forest fire. In M. Bonell, And, & L. A. Bruijnzeel (Eds.), *Forests, Water and People in the Humid Tropics: Past, Present and Future Hydrological Research for Integrated Land and Water Management.* (pp. 533–560). Cambridge University Press. https://doi.org/10.1017/CBO9780511535666.028
48. Mandal, M., & Das Chatterjee, N. (2021). Forest landscape and its ecological quality: A stepwise spatiotemporal evaluation through patch-matrix model in Jhargram District, West Bengal State, India. *Regional Sustainability*, *2*(2), 164–176. https://doi.org/10.1016/j.regsus.2021.06.002
49. Myers, N. (1994). Tropical deforestation: rates and patterns. In Brown, K. and Pearce D (Eds.), *The Causes of Tropical Deforestation* (pp 27-40). UCL Press
50. Mishra, S. N., Mukherjee, P., & Kumar, R. (2023). *Invasion of Exotic Plants Species in Rural-urban Gradient in Jharkhand, India: Their Harmful Effects and Beneficial Uses*. https://doi.org/10.21203/rs.3.rs-2627894/v1
51. Nayak, R., Karanth, K. K., Dutta, T., Defries, R., Karanth, K. U., & Vaidyanathan, S. (2020). Bits and pieces: Forest fragmentation by linear intrusions in India. *Land Use Policy*, *99*(March), 104619. https://doi.org/10.1016/j.landusepol.2020.104619
52. Pandya, M., & Didwania, K. (2021). Existential Repercussions of Development: Deforestation Caused by Haphazard Urbanisation and Rapid Industrialisation. *International Journal of Policy Sciences and Law*, *1*(3), 1372-1397.
53. Ranjan, R. (2019). Assessing the impact of mining on deforestation in India. *Resources Policy*, *60*(July 2018), 23–35. https://doi.org/10.1016/j.resourpol.2018.11.022
54. Rathore, V. (2016). India is the third largest importer of illegally-logged wood: IUFRO. *DownToEarth*.
55. Rivas, C. A., Guerrero-Casado, J., & Navarro-Cerillo, R. M. (2021). Deforestation and fragmentation trends of seasonally dry tropical forest in Ecuador: impact on conservation. *Forest Ecosystems*, *8*(1), 1-13. https://doi.org/10.1186/s40663-021-00329-5
56. Ray, B., & Mukherjee, P. (2023). Forest Income and Rural Livelihoods in West Bengal, India. *Studies in Microeconomics*, *11*(1), 10–35. https://doi.org/10.1177/23210222211024389
57. Sahoo, K. P., Ghosh, S., Allarakha, S., & Siddique, G. (2023). Socio-ecological impact of forest legislations on forest and forest-people of Jhargram District, West Bengal. *Land Use Policy*, *135*(106940), 1-16. https://doi.org/10.1016/j.landusepol.2023.106940
58. Sarangi, S. (2004). Unlocking the Scientific and Unscientific Debate in Community Forestry. *The Commons in an Age of Global Transition: Challenges, Risks and Opportunities*. https://hdl.handle.net/10535/1711
59. Seymour, F., & Harris, N. L. (2019). Reducing tropical deforestation. *Science*, *365*(6455), 756–757. https://doi.org/10.1126/science.aax8546
60. Shiva, V. (1986). Ecology Movements in India. Alternatives: *Global, Local, Political*, *11*(2), 255–273. doi:10.1177/030437548601100204
61. Siegert, F., Ruecker, G., Hinrichs, A., & Hoffmann, A. A. (2001). Increased damage from fires in logged forests during droughts caused by El Niño. *Nature*, *414*(6862), 437–440. https://doi.org/10.1038/35106547
62. Sonter, L. J., Herrera, D., Barrett, D. J., Galford, G. L., Moran, C. J., & Soares-Filho, B. S. (2017). Mining drives extensive deforestation in the Brazilian Amazon. *Nature Communications*, *8*(1), 1–7. https://doi.org/10.1038/s41467-017-00557-w
63. Srivastava, P., & Garg, A. (2013). Forest fires in India: Regional and temporal analyses. *Journal of Tropical Forest Science*, *25*(2), 228–239. https://jtfs.frim.gov.my/jtfs/article/view/386
64. United Nations Environment Programme. (2012). Illegal Trade in Wildlife and Timber Products Finances Criminal and Militia Groups, Threatening Security and Sustainable Development, UNEP. https://www.unep.org/news-and-stories/press-release/illegal-trade-wildlife-and-timber-products-finances-criminal
65. Verma, S., & Jayakumar, S. (2012). Impact of forest fire on physical, chemical and biological properties of soil: A. *Proceedings of the International Academy of Ecology and Environmental Sciences*, *2*(3), 168–176. http://www.iaees.org/publications/journals/piaees/articles/2012-2(3)/impact-of-forest-fire.pdf
66. Wees, D., van der Werf, G. R., Randerson, J. T., Andela, N., Chen, Y., & Morton, D. C. (2021). The role of fire in global forest loss dynamics. *Global Change Biology*, *27*(11), 2377–2391. https://doi.org/10.1111/gcb.15591