Chapter-I: Introduction

1. Introduction

The French word "environner," which means to encircle or surround, is where the term "environment" originates. The entirety of factors that impact a living organism throughout its existence is commonly referred to as its environment in the tangible realm. In Hindi, the environment means **'paryavaran,'** which means **'parya' and 'avaron,'** i.e., surrounded by all four sides. Thus, the environment includes organic and inorganic elements such as soil, water, air, plants, birds, and other living creatures. The environment is treated as the embodiment of the earth's physical elements, of which man is a significant component influencing and being influenced". According to the **Oxford Dictionary,** the environment is the surrounding objects, circumstances of a person's life, or society. Therefore, the environment constitutes land, the atmosphere, and water. **Professor M.V.V. Rao (Cited by Y. Anjaneyulu, 2005)** says that the environment comprises all physical, chemical, biological, and sociological factors that compose man's surroundings. From a broad perspective, the environment includes both physical and cultural aspects.

Human societies produce culture, and man is largely a product of his cultural environment. The cultural environment includes human beings related to education, technology, health, agriculture, industry, etc. Anthropologists view customs and ingrained principles as a "cultural mosaic" that makes up the world **(Nanda and Warms, 2007).** Therefore, "development" (in the sense of financial advancement) includes culture, or rather "culture" is the ultimate goal of "development" **(UNESCO, 1995).**

The idea of sustainability is to raise human well-being while respecting the limits of the environment. It entails enhancing human welfare in a way that doesn't harm the environment or the welfare of others **(Shivalinga and Chandrashekar, 2017).** The degree of Sustainability in the environment is the capacity of renewable resources to replenish themselves and maintain a stable state. Environmental sustainability depends on human activities' extraction and destruction of the environment. Environmental sustainability is linked with the carrying capacity of land and maintaining a fair distribution of natural resources and opportunities.

Therefore, a proper perception of the natural environment is essential for achieving sustainability. Economic expansion has historically been associated with the natural resources' depletion and increasing strain on the planet's ability to absorb new information. So, the tribal people's perception of the natural environment is one of the important factors in protecting against environmental degradation and maintaining their sustainable livelihood. Programmes

for maintaining the life support system were started to safeguard, reclaim, and manage the biological resources—land, water, and plants—necessary for animal husbandry and agriculture. Land, water, and biological resources are intricately linked, and their proper management is vital to sustaining the Indian tribal life support system. It is essential to build capacity among the tribal people of the Jhargram district to promote sustainable livelihoods.

Approximately 104 million people, or 8.6% of India's total population, are members of the 698 Scheduled Tribes **(Ministry of tribal affairs, 2013).** Scheduled Tribes are defined in Articles 342 (i) and 342 (ii) of the Indian Constitution as tribes or tribal communities, or sections or groups within tribal communities that the Indian President may designate by way of a notice to the public. These orders cannot be changed in the future other than by an Act of Parliament. The preceding article also includes scheduled tribes by state/union territory rather than by India. Groups that meet certain requirements—such as scheduled tribes—are identified by traits like primitive appearance, unique culture, remote location, reluctance to interact with the outside world, and backwardness. Although the aforementioned conditions are generally acknowledged, they are not expressly addressed in the Constitution.

The tribal people have exotic customs, traditions, and practices. For centuries, they lived far away from civilized society in geographical isolation. The tribal people reside in a specific cultural landscape with diversified social, cultural, and psychological systems and patterns. Tribal people are not defined in any particular way. Together, subjective and objective criteria are provided by the ILO (1989) to identify these individuals.

Table 1.1 Definition of Tribal People

Type	Subjective criteria	Objective Criteria
Tribal people	People from tribes Identification of oneself as a member of a tribe	1. They are distinct from other groups within the national community due to their social, cultural, and economic conditions. 2. Their habits, traditions, or unique rules or regulations either entirely or largely govern their status.

Source: ILO (1989)

A tribe is defined as a group of families or communal units with the same name, living in the same region, speaking the same language, and following certain taboos regarding marriage, career, or occupation. They have also created a solid reciprocity and mutual duties framework

(Majumdar, 1937). Tribal peoples are commonly categorised as mountain peoples, hill tribes, or hunter-gatherers, and various governments have made specialised registries of these groups.

Tribals have a traditional holistic view of land and other natural resources. The tribal people of Jhargram entirely depend on nature and the surrounding environment. Their living standards are also strongly influenced by the environment. In this connection, knowing the environmental sustainability level of the Jhargram district is essential. It will help draw the inference between environmental sustainability and the livelihood of the tribal people of the Jhargram. This helps us protect against environmental degradation and maintain environmental sustainability, which helps promote sustainable livelihoods and the living standard of indigenous people in the district of Jhargram.

The Random House dictionary defines livelihood as "a means of subsistence." It refers to people's skills, resources, and methods to sustain themselves and their families through various endeavours. The development of self-reliance is the aim of any livelihood plan. According to Ellis (2000), A livelihood is characterised as the set of resources, activities, and availability of these components that impact the food a person or family obtains together. Natural, physical, human, financial, public, and social assets are all considered household assets. These assets can increase or decrease in value over time.

The tribal livelihood is closely associated with nature and the natural environment, and 15% is abysmal **(Manna & Ghosh, 2020).** They solely depend on natural resources for their survival. Based on nature and physiographic conditions, tribal communities practice various livelihood activities. In India, such activities are hunting and food gathering, pastoralists, primitive subsistence agriculture, shifting cultivation, agricultural and industrial labour, etc. Many changes have occurred regarding land use, Access, control, and resource utilization. These changes have primarily affected people's sustainable livelihoods without emphasizing sustainable replacement **(Shivaprasad and Eswarappa, 2007).** Livelihood is how tribal people fulfil their basic requirements or get all essential commodities and better living opportunities. The tribal people are entirely dependent on nature and the surrounding environment. Lack of education and awareness minimises their livelihood pattern in the study area. Most livelihoods consist of various multifaceted economic activities that alter throughout time due to changes in people's lives. Livelihood constitutes the various types of working opportunities for each household member. People can get chances and financial support to

sustain their way of life inside this framework. Human well-being, which might include access to many other services and basic comforts, health, employment, and discrimination in the workplace, social and economic spheres, is intimately linked to livelihood. Tribal people typically use livelihood to support their way of life without negatively affecting the sustainability of the environment. Tribal households rely on various sources for their income, and it is expected that alternation measures will affect them in several ways, linked to vibrant and vulnerable over time and environmental sustainability. Various development projects undertaken by the government in and around natural surroundings destroy the environmental balance and cause the loss of the unique culture, primary livelihood, and religious practice of the tribal people of Jhargram.

The five capitals of sustainable living were examined by Scoones (1998). These are the following areas: a) Human capital is made up of skills, knowledge, labour (which includes physical fitness and health), and savings; b) Natural capital is made up of stocks of natural resources (soil, water, air, and genetic resources) and environmental services (like the hydrological cycle); c) Economic or financial capital is made up of a capital base (cash, credit/debt, economic assets); d) Physical capital is made up of buildings, roads, production equipment, and technologies; and e) Social capital is made up of networks, social claims, ties, and affiliations.

1.1 Statement of the Problem

Tribes are primitive and prefer to live in isolation in dense forests, hills or mountains, deserts, or remote areas, generally cut off from civilized areas. They have limited contact with our so-called modern society. They always try to preserve their social customs, norms, traditions, and religious beliefs to a large extent. The tribes have a long historical relationship with nature and natural resources like land, water, and forests. They have developed indigenous knowledge over many generations, which is holistic, traditional, and scientific. They consider elements of nature to be Gods. Natural resources like forests, land, and water dominate the economy of the tribal people. Their lives, livelihoods, and living standards depend on nature and natural resources. Due to the developmental process, these natural resources are degraded rapidly, affecting the livelihood and living standards of the tribal people. Thus, a sustainable environment leads to sustainable development. The primary concern is balancing responsible environmental practices with economic development and means of subsistence for the

Jhargram districts and the tribes' overall populations. The ability of livestock production, forestry, and agriculture to provide the impoverished tribes with a sustainable means of subsistence in the Jhargram district continues to decline. Consequently, the tribal people of the Jhargram district were constrained to earn a decrease in their livelihood from agriculture, forestry, and livestock production. Besides this, commercial exploitation of natural resources in the Jhargram district is increasing daily.

One of West Bengal's most populous districts with a high concentration of tribal people is Jhargram. Measuring the perceived level of the tribal people regarding the natural environment is essential because only this helps us achieve sustainability. So, the perception of tribal people regarding the natural environment and environmental sustainability is one of the key factors in protecting against environmental degradation and maintaining the sustainable livelihood and living standards of tribal people of Jhargram district in particular.

1.2 Review of Literature

The present research work attempts to determine the environmental sustainability and livelihood patterns of the tribal population in West Bengal's Jhargram district. The research aims to discuss the environmental condition of Jhargram district with concern about the changing nature of the practice of livelihood and living standards of the tribal people. How do tribal people try in order to preserve and safeguard the surrounding environment to maintain a sustainable livelihood and living standards? The review of related literature is done from that perspective.

1. Aggarwal, Paul, and Das (2009), in their book chapter, stated that about 23% of India's land is covered by forests. The Indian forest's productivity is low in relation to international norms. The study reveals that India's forests face enormous pressure due to the growing demand for fuel, fodder, and competing forest land uses. According to the report, India's forests have been home to various tribal and other forest-dwelling cultures. About 275 million rural Indians, or 27% of the country's population, rely on forests for a minimum of some of their food. Most of the country's forests are owned (97%) and solely managed (69%) by the state. The study also focuses on forest acts that are not accompanied by the settlement of rights of tribal and indigenous communities. This has led to the degrading of community rights, institutions, and livelihood systems and has diluted conservation efforts. The study suggests a need to

rethink forestry management in India to reduce the pressure on forests and improve their productivity. As this would involve substantial financial resources, it is necessary to facilitate public-private partnerships by instituting enabling legislation. It is essential to realize the true potential of forests in providing livelihoods; issues of rights and tenure and skills and capacity building of forest-dependent communities must be addressed systematically. Climate change mitigation interventions offer livelihood and revenue options for forest-dependent communities. However, tenure rights and governance issues must be addressed simultaneously.

2. Ajaz-ul-Islam et al. (2013), in their study, propose to discuss the tribal communities of Bundu block in the Ranchi district of Jharkhand state that rely on forest resources for their existence. The area's mean income earned from these activities was 2199.70/household/annum. The livelihood generation from forest-based Since no businesses based on wood or Non-Timber Forest Products (NTFPs) were formed, there was no secondary employment in the research area. Agriculture contributed a significant share (36.23%) of total household annual income, followed by forest resources (25.05%), labour (9.74%), livestock (8.86%), business/shop (8.72%), service (6.77%), and others (4.63%). Thus, A paradigm change centered on forest resources is required to promote livelihood among tribal people in light of present and upcoming problems.
3. Baghel, Acharya, and Rao (2017), in their article, tried to explore the current status of Mahua's negatively skewed contribution to the livelihood income of the tribal population. The study also explores the role of SHGs in promoting collaborative urban marketing strategies, an address in the study. The study emphasizes the variable model for collective harvesting storage and innovative post-harvest value addition for Mahua. The study also reveals that forests are a significant renewable natural resource that impacts rural societies' socio-economic development.
4. Bandyopadhyay, Rahaman and Karan (2023), in their article, tried to explore the fact that due to the water crisis, 30% of people in the Jhargram district were forced to depend on mono-crop culture due to water shortage. The prime causes responsible for this are pedogenic unevenness and lack of scientific techniques for the advancement of agriculture. The study focuses on Agriculture Potential Zone Mapping and builds proper tools for developing this map. The study also finds that The area that has good potential is 166032.5 hectares in the Jhargram district, which is nearly 50% of this district. The medium potential zone covered 20857.2 hectares, and the less potential

zone covered 8628.021 hectares. The study also suggests that the APZM method may be used for agriculture practice and assessment purposes for regional development.

5. Biswas, Chatterjee, and Roy (2020), in their article, have tried to evaluate the extent of farmers' participation in climate change and their strategy to cope with climate change. The study also reveals that farmer' attitudes towards climate change are largely influenced by their readiness to adapt to climate change by considering some adjustments to their cultivation and production practices. The study also found that 50% of respondents were optimistic that it would be possible to cope with climate change if the government could help them. The study also reveals that only 13% of farmers perceived government plans on climate change as an adaptation strategy, and 40% of respondents followed more or fewer strategies.
6. Chambers (1988), in his study, reveals that standard professionalism and critical thinking are part of the problem. The study emphasises how sustainable resource management promotes the sustainable livelihood of poor rural people. The study also emphasises developing a new approach for professionals to the environment and development that poor people's livelihoods can combine with 'Sustainable Livelihood Thinking (SLT).' The study also gives importance to practical applications, including certain rights for the poor to use and sell assets and new professionalism, which starts not with things but with people, putting first those who are poorest.
7. Das and Das (2020), in their study, deal together with the spending on consumption of tribes and non-tribes in three backward districts of Wes Bengal, namely Purulia, Bankura, and West Medinipur, and examine the trend and pattern of consumption of tribes and non-tribes. The study reveals that the monthly per capita consumption (MPCE) of tribes has been increasing over time, and the consumption expenditure on the constant price shows the same trend for both categories. The study also reveals that over time, food consumption decreases. Still, items like eggs, fish, milk, meat, spices, fuel, light, clothing, and durable and miscellaneous goods have increased in both communities. Finally, the researcher concludes that over time, tribes are converging towards non-tribes. As a result, their dependency on market consumption has been increased. Once more, the consumption patterns of the many tribes in the district are similar despite the fact that they have largely relied on social security and shared property resources.
8. Debata (2018) described Tribal women's status in the Kandhamal district of Orisha in his paper. The author tries to compare pre and post-globalization and its effects on the

livelihoods of tribal women. The study reveals that the livelihood of poor tribal women solely depends on forest-based resources. The study reveals that the green business model adopted by tribal women has positively impacted their income. The study also recommends proper marketing of minor forest products. The government should adopt different policies to protect the interests of primary producers who play a crucial role in conserving the environment based on sustainable development business practices and ensure tribal women's livelihoods are sustainable.

9. Everard et al. (2020), in their paper, have tried to explore the linkages between a community with protected tribal forest rights and river ecosystems. Authors try to establish a synergistic relationship between local people and the ecosystems they have protected. The paper tries to establish that authoritative local governance arrangements prioritize community subsistence, limiting external actors in state government and private influence on natural resource exploitation. The paper further emphasizes sustainable development, which has been possible by recognizing the importance of ecosystem services that healthy, functioning habitats provide. There will also be potential for the development of payment for ecosystem services (PES) markets. The authors also advocate ecotourism and cultural tourism. The paper also suggested that better ecosystems and In the midst of anticipated climate change stressors, community connections in places with protected tribal rights might highlight sustainable strategies that could be applied to more expansive geopolitical areas.

10. Farrington et al. (1999), in their article, focus on sustainable livelihood practices to improve poverty. This study emphasizes different perspectives on poverty and how this poverty is eliminated through different skills and programs, making clear choices in planning and executing different development activities. The authors try to identify the underlying barriers to improving livelihoods. The work also focuses on the micro-level understanding of poverty in the policy and institutional change process. The study also focuses on the difficulties related to sustainable livelihood practices, such as a) conflict over Access to resources impinges on livelihood choice; b) cost-effective model of livelihood analysis; c) priorities of the needs of the poorest; d) formation of an appropriate common livelihood frame; and e) handling the trade-offs, for instance, between local pressure and broad concern for making policy on resource sustainability at the local and national level.

11. Ghosh et al. (2019) conducted a study that aimed to employ conservation agriculture tools to enhance ecosystem services. The research particularly focused on minimising

energy consumption and greenhouse gas emissions. The management practices based on conservation agriculture prioritize sustainability in agricultural crop production. The conservation agriculture system is associated with various ecosystem services, encompassing provisioning, regulating, and supporting services. The emphasis on regulating services includes enhancing carbon status and improving the soil's physical, chemical, and biological properties, which contributes to providing services by ensuring sustained crop and water productivity. Additionally, the study highlighted the importance of improving soil biodiversity both above and below ground. As discussed in the study, conservation agriculture is pivotal in promoting sustainable crop intensification and establishing a climate-resilient crop management system.

12. Giri and Murugesan (2019), in their article, tried to focus on rural livelihoods and forest resources, which should be taken into consideration while making policy choices and other initiatives. The study shows that the cultural, traditional, and environmental significance of the forest resources in the Darjeeling hills has received relatively little attention. The study reveals that forest resources are common, resulting in a lack of active participation of rural households in forest conservation practices. The study also reveals that rural households use other sources of diversified livelihood strategies in addition to income from agriculture and forestry. The study suggests that the local community's active involvement helps achieve sustainable development goals.

13. Gope, Behera and Roy (2017), in their paper, have tried to explore how nature has played an essential role in generating community-centric indigenous knowledge. They also explored how community practices deeply connect with the land, local environment, and community. They also commented that indigenous knowledge is usually disseminated across generations through content and by observing various community practices. Indigenous knowledge is highly personalized and community-centric. Therefore, it appears that indigenous knowledge is community-specific and traditional.

14. Guha and Ismail (2014), in their study, pointed out environmental changes and their impacts on physical as well as socio-economic activities. The study reveals that the environmental process changes the acidity of soils, natural soil composition, the nutritional status of soils, surface water properties, and the world's food chain systems. The study explores that humans need a man to convert forests to industrial land, settlements, marketing places, multiplexes, pastureland, and grassland to cropland or

parking. However, significant habitat change and biodiversity loss are still undesired. Environmental change brings a change in the social structure of civil societies. Physical, biological, and social changes are all correlated with environmental changes. It is brought on by pollution of the air, water, and society, as well as other everyday issues brought on by environmental change. The study aims to determine how rural life in the Birbhum district's Sonajhuri hamlet changes.

15. Jana et al. (2019) examined the growth of female entrepreneurship in the economically disadvantaged area of West Bengal's Jhargram District, as evidenced by their study published in the Asian Journal of Multidimensional Research. Focusing on rural areas, the research acknowledged the crucial role of women entrepreneurs in contributing to economic independence and the overall Indian economy. The study recognized government initiatives encouraging rural women to partake in entrepreneurship, particularly in districts with lower literacy rates and limited employment opportunities. By analyzing the influence of self-help groups, the research underscored how women's entrepreneurship evolves, such as forming groups, mobilizing savings, and launching small enterprises. The study provided insights into the unique aspects of women entrepreneurship in Jhargram, including the types of trades, profitability, and income contribution to household finances, offering a comprehensive understanding of the economic dynamics in this backward district.

16. Jha et al. (2017), in their study, focus on those tribal peoples who are more affected by climate change and vulnerability. The study also states that tribal people depend on the natural support system and agricultural practices. The study also focuses on the integrated rural support system and human systems badly affected by climate change. The study also reveals that decreased vulnerability helps to increase employment opportunities and daily wage levels. Thus, it affects the economic status of the tribal people. This study also emphasizes how well-thought-out government initiatives can support sustainable development by strengthening adaptive ability and assisting in the fight against climate change and its aftereffects.

17. John, Mc Andrew and Oeur (2009) showed diverging patterns in their study. The study emphasizes the changing lives of northeast Cambodia's indigenous peoples due to increased market activity and diminishing natural resources. Further, the study also assesses indigenous groups' livelihood strategies and market participation. The study also found that indigenous people who retain control over their communal land and

natural resources are better positioned to adapt to the market economy's rapid and inevitable change than those who do not.

18. Karlberg, Rockstorm and Falkenmark (2009), in their article, aimed to address the challenges faced by various stakeholders and smallholder farmers in addressing the persistent issue of land degradation and achieving sustainable management of agroecosystems. The findings highlight that involving farmers in innovation is justified by recognising that soil and water management issues are often specific to particular sites or individual farms. Investments in these resources prove to be beneficial. When supported by conducive policies and institutional structures that empower individual farmers and communities, smallholder farmers are more likely to protect their land and water resources against degradation. The study also underscores that such investments generate positive returns, and with supportive policies and institutional frameworks, individual resource users and communities are motivated to safeguard their land and water resources.

19. Khan, Chatterjee and Bisai (2013), in their article, tried to develop a Human Vulnerability Index (HVI) in the Paschim Medinipur district considering block-level secondary data based on the Paschim Medinipur Human Report,2011. They developed their report based on (UNDP, 2006) to normalize the selected parameters. First, they try to establish a functional relationship between the indicators and the identified human vulnerability. They use Kendall's coefficient of concordance to find out the HVI of Paschim Medinipur district. They also try to rank all blocks according to the HVI value.

20. Khatua, Ray and Patra (2020), in their article, help maintain the environmental health of Jhargram district. The article also reveals different bird species in Jhargram district. The study also finds 128 species in 108 genera of Jhargram district. The study also reveals that some bird species are distant migrants or occasional dwellers, but most are residents.

21. Leatherman and Marcouiller (1996), in their article, tried to focus on patterns of regional household income distribution linked to productive activities that are significant to a large number of rural communities. The study also focuses on a comprehensive investigation employing a social accounting matrix analysis, which was undertaken to scrutinize the dynamics of agricultural production, agricultural processing, forestry production, forest products processing, and tourism within a small rural region in Wisconsin. The aim was to showcase the diverse distributional

characteristics inherent in private market structures and to shed light on their implications for local economic development policy. The study also reveals a significant difference between high-income, moderate-income, and low-income home households to sectoral factors.

22. Lin and Lin (2020) in their study, emphasize the tangible aspects of construction but point out a noticeable lack of attention to the social dimension in the recovery process. The focus of the study is to comprehend the function of culture in rehabilitating indigenous communities that have been relocated, particularly through the avenue of tourism livelihood. The findings highlight that grounding the foundation of a relocated tribe's community on their culture, rather than mere infrastructure, has the potential to mitigate disputes inside the community and enhance social resilience. Additionally, the study brings to light that embracing indigenous culture-based tourism can function as a significant source of livelihood, fostering the sustainable development of tribal communities.

23. Majhi and Puhan (2017), in their article, endeavoured to investigate the current influence of education and modern technology on the evolving patterns of occupation and livelihood among the Santhal community residing in the Jamda block of Mayurbhanj district in Odisha. The study also explores the current change in the educational scenario in tribal areas of the particular sample area. They need to improve their agriculture production and productivity –both permanent and shifting agriculture. This can be done by improving seeds and other agricultural inputs, fertilizers, agricultural implements, and agricultural technology and practice improvement. Their income can also be increased by reclaiming land taken from them, boosting forest productivity by replanting degraded forests, making it easier for tribes to collect such items, and ensuring a fair return by managing their sales.

24. Nair, Agrawal and Verma (2022), in their article, tried to focus on Lignocellulosic biomass (LCB) as an energy source for the production of biofuels and value-added compounds. They prescribe some physical, chemical, biological, physicochemical, etc. strategies to overcome some barriers. The study also suggests metagenomics, which helps overcome limitations. It has been both cost-effective and environmentally friendly. The study also suggests additional measures in biorefineries, tactics for developing zero-waste refineries, and bottlenecks.

25. Narasimham and Subbarao (2017) investigated in their article how tribal societies typically perceive gender dynamics as complementary and egalitarian, wherein each

gender role is defined but seen as complementary to the other. In such societies, men often concentrate on cultivation, while women are engaged in planting and gathering food. Thus, both roles are necessary and complementary in the holistic relationship of the family/community. Tribal women, in particular, have fewer possibilities to use their natural resources and territories because of the integration and assimilation attempts of the dominant culture, capitalistic systems, and the notion of private ownership. Gender relations have been altering in tribal societies as a result.

26. Nayak (2016), in his article, tries to explore the ways tribal people adopt to protect biodiversity in different cultural zones. The paper explains how tribal groups use their endogenous knowledge systems to protect biodiversity and conserve natural resources. Traditional environmental knowledge of the tribal people is instrumental in migration plans for cropping with climate change to sustain their livelihoods. The paper also reveals that culture-specific prescriptions and taboos utilize natural and sustainable products. They are always protesting against all types of destroyers, those who destroy natural resources. The author also explains how their indigenous knowledge system ensures sustainable lifeways and biodiversity protection.

27. Oraon (2012), in his paper, tried to explore the traditional pattern of livelihoods and their changing livelihood scenarios. The study revealed that the livelihood patterns of tribal people had changed enormously over time. The tribal people in this region collect forest-based products and fuel the wood from nearby forests properly. They also practice mono-cropping, which is subsistence in nature. The study also reveals that due to industrialization, the intervention of outsiders, and the rise in the population, forest cover has degraded, forcing the tribal people of this region to adopt alternative livelihood patterns. Most of the tribal people in this region are engaged in various industrial works.

28. Panda (1999), in her study, tried to explore the exceptional rate of environmental degradation occurring in several Asian hill forest regions home to indigenous and tribal cultures. This also applies to the state of Orissa in eastern India. The study also shows that because the residents in the area rely on indiscriminate forest collection and swidden cultivation for their livelihoods, they are accountable for the destruction of the forest. Efforts to halt the cultivation of swidden land have not been effective. This study suggests an integrated framework for creating a sustainable natural resource management strategy for tribal groups. However, swidden cultivation may eventually

give way to wetland cultivation with a suitable transition period due to the problem of long-term sustainability inside natural borders.

29. Patel (2017) study revealed that any form of economic growth is intricately connected to environmental degradation, even though sustainable development, as a popular concept, incorporates a minimal environmental impact. The author puts forth tribal agricultural technology to foster development and alleviate poverty, aligning with the true essence of sustainability. The study particularly underscores the utilization of organic fertilizers and pesticides by tribal communities, which are both eco-friendly and supportive of sustainable practices. In addition, the author promotes indigenous agricultural technologies in conjunction with effective marketing infrastructure, fostering the all-encompassing growth of indigenous communities while avoiding environmental damage. This strategy is recommended since it is recognized that tribal people have a stronger affinity for the outdoors and forests than do other groups within our society.

30. Patidar et al. (2018), in their study, focused on the Sustainable Livelihood Approach to improve the design and implementation of poverty reduction efforts. The status of the tribal population is emphasized in the study, as it is strongly correlated with several factors, including socio-personal, economic, psychological, communicational, and situational characteristics. The study also reveals that in Jharkhand State, tribal people's livelihood mostly depends on NTFPs. The study also states that the effect is important in making people with low incomes less vulnerable, more well-being and more sustainably strong.

31. Prajapati, Solanki and Thakkar (2014), in their study, gave importance to a sustainable livelihood, which is closely related to food security, sustainable agricultural practice, and poverty—the author's indicators to measure sustainable livelihood: social, economic, and environmental. Further, the 12 sub-indicators are considered. Ultimately, all indicator values are summed up to get the Sustainable Livelihood Index (SLI). The study also reveals that the average mean score of all the selected sub-indicators of non-tribal respondents was higher than that of the tribal respondents. Additionally, it shows that a low to medium percentage of the tribal respondents (90.91) had sustainable livelihoods. Conversely, 87.27% of non-tribal respondents reported a medium to high level of sustainability in their way of life.

32. Priyadarshini and Abhilash (2019), in their article, sought to investigate anthropogenic alterations in planetary bio-physical systems and their correlation with environmental

deterioration and climate change. A major focus of the conclusion is the traditional wisdom of people living in harmony with the natural world. This is essential for supporting national conservation plans and demonstrating the impact of climate change. The study also emphasizes how ancient activities are mainly connected and how Sustainable Development Goals (SDGs) 2, 6, and 15 are relevant to India's climate action policy. Furthermore, the research suggests that effective policy interventions aimed at tribal welfare may contribute to long-term efforts to reduce the negative consequences of climate change.

33. Raju and Jonathan (2006), in their investigation, centres on the mutualistic association between the forest and the economics and culture of the surrounding tribal peoples. The Eastern Ghats Forest is one of India's rich biodiversity regions and has enormous natural resources to sustain the different tribal communities of this region. The study also reveals that tribal people use traditional knowledge to protect and conserve this region's rich biodiversity. The tribal people follow customs related to gathering and handling wood, non-timber forest products, water, and other natural resources. They also follow customs for reforesting forest preservation and regeneration. They also use a conventional technique for gathering water for the cultivation of different types of crops.

34. Rauniyar & Kanbur (2010), in their article, aimed to concentrate on inclusive growth, inclusive development, or inclusive social development. Findings highlighted that despite the absence of a universally accepted definition for inclusive growth or development, the concept generally signifies 'growth accompanied by equitable opportunities' and encompasses economic, social, and institutional aspects. The study further proposes that achieving inclusive growth and development necessitates implementing a combination of mutually reinforcing measures. These recommended measures include (1) fostering efficient and sustainable economic growth, (2) establishing a fair political environment, and (3) enhancing capacities while establishing social safety nets.

35. Roy and Mukherjee (2018) focus on the district's existing forest resources in their paper. In addition, the study looks for patterns in the temporal variation of forest cover as well as the causes and effects of tribal livelihood in the context of tribal interdependency in the forest. The study also shows that different anthropogenic activities have reduced Purulia's forest resources, which has a detrimental impact on the region's ecology, environment, and natural sustainability, as well as the

sociocultural and economic well-being of the tribal people and forest fringe residents. According to the study, sustainable forest management and environmental preservation are related to a sustainable livelihood. Sustainable rural livelihoods result from a harmonic balance between the protection of forests and the growth of communities that depend on them for their livelihoods.

36. Sen and Bhakat (2021), in their article, focused on Sacred groves as pristine areas harbouring a diverse array of species safeguarded for generations; thanks to taboos, cultural, and religious beliefs, local communities have thought that these groves have a heavenly presence that shields the residents from numerous disasters. The primary focus of the investigation was on characteristics, which were particularly determined for adult trees with a diameter at breast height (GBH) higher than 31 cm. These factors included species density, frequency, basal area, abundance, evenness, and other diversity indices. According to the research, 146 tree species in 116 genera are arranged into 44 families and 21 orders. The study notably emphasizes that sacred groves have a strong potential for regeneration in the tree species population structure as a whole. Additionally, it implies that cooperation between the forest department, legislators, and conservationists is necessary to create management plans to protect priority species in the forest.

37. Shawoo and Thornton (2019), in their article, aimed to explore the capability of the suggested platform for Indigenous peoples and local communities to actively apply traditional ecological knowledge (TEK) to climate policy. It underscores the significance of environmental management literature and establishes criteria for evaluating the platform. Additionally, the research brings to light the insufficient consideration given to institutional barriers within the UNFCCC and the limitations of pursuing knowledge "integration" as a standalone objective. The study also found that using rights-based framing gives tribal people more decision-making power over IPs. It helps them mitigate climate-related problems.

38. Shivalinga and Chandrashekar (2017), in their paper, have tried to analyze the success of the programs that led to sustainable development in the district of Mysore's rural villages. The research additionally discloses that throughout the wet season, the tribes embraced intercrop farming. Crop yield and soil fertility were also enhanced by it. The study also reveals conserving soil and water through tranche cum bund, bolder bund, waste wires, applying silt, clearing the land, deep ploughing, pits, and Agro-Horti-Forestry development is the best sustainable development method.

39. Subramanyam and Veerabhadrudu (2003), in their study, tried to establish the connection between the surroundings and sustainable development. The study emphasizes tribal ecology, the livelihood of the tribe, shifting agriculture, and deforestation. The study also emphasizes how the traditional knowledge of the tribal people helps protect them. Preserve and replenish the resources to protect the ecosystem and encourage the Eastern Ghats tribes' sustainable development.

40. Tripathi, R.R. (2018), in their study, focus on the tribal population of Hyderabad, India, who has diversified their means of subsistence through migration and other means. The study also focuses on the shifting work habits and migration of the tribal people, which is one of the emerging trends among the Juang and has an impact on their sociocultural and economic lives.

1.3 Gaps in the Existing Literature

Table 1.2 Gaps in the Existing Literature

Main Them	**Level**	**Literature Gap**
Environmental Sustainability	International	Most studies focused on environmental sustainability, shifting agriculture, agro, and village ecosystems.
	National	Most of the study focused on resource management, mainly forest resources. Other natural resources like land, water, and animals are neglected. No such study was found on environmental sustainability and its role on tribal people and how natural resources disproportionately impact the poor tribal people.
	Regional	Very few numbers of studies were done on environmental sustainability at the regional level. No study focuses on the environmental sustainability of the Jhargram district in particular.
	International	Most studies focus on sustainable livelihood approaches that are linked to poor tribal people.

		Few studies focus on how market activity changes the livelihood of the tribal people.
Tribal livelihood Pattern	National	Maximum studies focus on the livelihood of tribal people and sustainable livelihood practices. No such research was found on the extent to which environmental sustainability affects tribal livelihood in general and the role of the cultural environment in changing the livelihood pattern of the tribal people.
	Regional	No such particular study was found on The degree to which the tribal livelihood of the Jhargram district is affected by environmental sustainability. How does environmental sustainability disproportionately affect the livelihood patterns of the different tribal groups in the Jhargram district?

Source: Prepared by the Researcher

So, it may be concluded that there is an enormous gap in the existing literature and ample scope for research on environmental sustainability and the livelihood patterns of the tribal people of Jhargram district.

1.4 Scope of the Study

I. The study will help comprehend the current pattern of the spatial distribution of the tribal people of different CD blocks of the Jhargram district.
II. The study will help recognise the Jhargram district's level of environmental sustainability.
III. The study will help to understand the livelihood patterns of different CD blocks in the Jhargram district.
IV. The study will help grasp the changing environmental pattern due to recent developmental activities in the Jhargram district.
V. The study will help highlight the changing livelihood patterns due to the area's changing environment and socio-economic factors.

VI. The study will help to realize the relationship between environmental sustainability and the tribal livelihoods of the field of study.
VII. The study will help construct a sustainable livelihood map for the study area.
VIII. The research will also help policymakers frame effective policies, strategies, and planning for the balanced and harmonious developmental process in the most tribally concentrated district of Jhargram.
IX. The study will also help to minimize environmental fragility and human vulnerability in the tribal-prone district of Jhargram by introducing a sustainable livelihood pattern.

1.5 The Objectives of this Study

The current study's objective is to evaluate the tribal population's livelihood patterns in West Bengal's Jhargram area and the sustainability of the environment. The specific objectives of the study are as follows.

I) To show the spatio-temporal distribution of the major tribes in Jhargram district.
II) To study the livelihood patterns of the major tribal people in the district of Jhargram.
III) To highlight the indigenous knowledge of major tribes for maintaining environmental sustainability in Jhargram district.
IV) To explore the role of environmental sustainability on the livelihood patterns of the major tribal people in the district of Jhargram
V) To find out the challenges and opportunities of environmental sustainability and livelihood patterns of major tribal people in the Jhargram district.

1.6 Research Questions

In this study, the researcher will explore the environmental sustainability and livelihood patterns of the tribal people in Jhargram district. The specific research questions of this study are:

I) How the major tribal people are spatially distributed and changed through time in the Jhargram district?
II) What type of livelihood patterns are found among major tribal people in Jhargram district?
III) Does the indigenous knowledge of the tribal people help in maintaining environmental sustainability in Jhargram district?

IV) What is the role of environmental sustainability in the livelihood pattern of major tribal people in Jhargram district?

V) What are the challenges and opportunities for environmental sustainability and livelihood patterns of the major tribal people in the Jhargram district?

1.7 Database and Methodology

With an ex-post-facto research design, the current study used a descriptive cross-sectional survey approach. The study area's physical characteristics have been described using a variety of maps and imagery, including satellite images, district planning series maps, and topographical maps. Programmes like ArcGIS (Version: 10.3.1) and QGIS have been utilised to create the necessary maps. The temporal change in land cover and usage has been assessed using data from remote sensing. Several indices, including the NDVI, NDBI, and multi-criteria decision-making (MCDM) techniques, will be used in this study.

The secondary data has been collected from various sources, such as the District Census Handbook, District Gazetteer, District Statistical Handbook, District Industrial Profile, District Agricultural Annual Plan, and data from & L.RO and & L.RO offices to describe the socio-economic characteristics of the people of the study area. Environmental data from the concerned department has been collected and analyzed to describe the study area's environmental status.

To describe the socioeconomic characteristics of the people living in the study area, secondary data has been collected from a variety of sources, including the District Agricultural Annual Plan, District Industrial Profile, District Census Handbook, District Gazetteer, District Statistical Handbook, and data from B.L. & L. R.O. and D.L. & L. R.O. offices. The environmental status of the research region has been described through the collection and analysis of environmental data from the relevant department.

Stratified random and purposive sampling techniques have been adopted to collect primary data. Primary data was collected using two types of tools: 1) an interview schedule for important respondents and 2) a semi-structured interview schedule for conducting focus groups with important respondents and in-depth interviews with important respondents such as community leaders and officials at the district and block levels.

1.8 Choice and Selection of Sample Size and Sample Design

To carry out the present study, stratified random and purposive sampling techniques have been adopted. The research work was conducted in the Jhargram district as the study area, which

was selected purposively because it is the highest concentrated tribal population district in West Bengal **(The Census of India, 2011).** Out of eight blocks, all the blocks of Jhargram district tribal people concentration are high (22.71% - 40.01%). For this reason, all the blocks of Jhargram district have been purposefully selected to collect the samples. Next, the researcher will take six major tribes, such as Santhal, Bhumij, Munda, Lodha, Kora, and Mahali, adopting stratified random sampling and proportional allocation methods **(Kothari & Garg, 2019).** The percentage share of the tribal population will determine the sample size in each block.\

Further, from each block, the tribal household was selected based on the concentration of major tribes, the nature of dwellings (forest and agro-based villages), and the distance from the block headquarters. The researcher will take a 1% sample of the total tribal households. The sampled tribal household has been 84 in Jhargram block,112 in Binpur-I block, 150 in Binpur-II block, 74 in Jamboni block, 132 in Nayagram block, 60 in Sankrail block, 68 in Gopiballavpur-I block, and 68 in Gopiballavpur-II block.

Table 1.3 Block-wise Population Distribution and Sample Size of Households in Jhargram District

CD Block	Area in square km.	No. of Household	Total population in '000	ST (%)	ST Population	No. of ST Household	No. of Sample households (1%)
Jhargram	515.11	36875	170097	22.71	38629	8374	84
Binpur-I	357.62	39855	156153	28.15	43957	11219	112
Binpur-II	583.5	37682	164522	39.95	65727	15054	150
Jamboni	318.83	25526	113197	28.60	32374	7300	74
Nayagram	501.44	32998	142199	40.01	56894	13202	132
Sankrail	276.8	24434	115418	24.97	28820	6101	60
Gopiballavpur-I	275.83	19978	108254	34.01	36817	6795	68
Gopiballavpur-II	192.17	21364	104996	31.78	33368	6789	68
Total	3021.3	238712	10,74,836		3,36,586	74,836	748

Source: Census Report of India, 2011

1.9 Methods

1.9.1 Descriptive statistics

Descriptive statistics enable us to list and summarise a set of data's properties. The significant descriptive statistics are the mean, median, mode, standard deviation, kurtosis, and skewness. Descriptive statistics, including mean, percentage, and standard deviation, were utilised to summarise and comprehend the data in this study.

1.9.1.1 Mean

The average value within a set of data is called the mean. The computation involves summating all values inside the dataset, and Extreme values or outliers can significantly impact the average, so the mean is sensitive to them.

1.9.1.2 Standard deviation

The standard deviation measures the variability or spread of a set of data. The variance's square root is used to compute it. A low standard deviation denotes a close-knit cluster of data points around the mean, whereas a large standard deviation suggests that the data points are dispersed from the mean.

1.9.2 Inferential statistics and Different indices

A plethora of inferential statistics and indices were applied in the study. The inferential tests and indices used in this study are discussed in the following section.

1.9.2.1 Cropping Intensity

Cropping intensity (CI) typically denotes how frequently an agricultural field is used for cultivating crops within a specific period in the farming calendar. It is expressed using the following formula:

$$C.I = \frac{GCA}{NCA} * 100 \quad \text{.....(2)}$$

In the Eq. (2) C. I indicate the cropping intensity; GCA refers to the Gross Cropped Area, and NCA is the Net Crop Area.

1.9.2.2 Shapiro-Wilk Test

Step 1: State the hypothesis

A normality test called the Shapiro-Wilk test can be used to ascertain whether a given sample is representative of a normally distributed population (Buja et al., 2020). According to the Shapiro-Wilk test's null hypothesis, the sample is from a normally distributed population. According to the alternative theory, the sample was taken from a population that was not normally distributed.

Step 2: State the significance level

Select a significance level, commonly represented by α, which represents the likelihood of dismissing the null hypothesis if it is true. A common value for α is 0.05.

Step 3: Gather the data

Gather the data sample you wish to check for normalcy. The sample size should be between 3 and 5,000 observations.

Step 4: Determine the statistic for the Shapiro-Wilk test.

The Shapiro-Wilk test statistic is calculated using the following equation:

$$W = (\sum(yi - \hat{y})^2) / (\sum(yi - \bar{y})^2) \quad \text{.....(3)}$$

Where, yi = the ith ordered value in the sample, $\hat{y}$ = the ith expected value under normality, $\bar{y}$ = the mean of the sample

Step 5: Calculate the expected values under normality

The anticipated values under normality are calculated using the following equation:

$$\hat{y}i = \Phi^{-1}((i - 0.375) / (n + 0.25)) \quad \text{..... (4)}$$

where, Φ^{-1} = the inverse normal cumulative distribution function, i = the ith ordered value in the sample, n = the sample size

Step 6: Calculate the critical value

Statistical tables or software can be used to determine the critical value for the Shapiro-Wilk test. The sample size and the selected significance level determine the critical value.

Step 7: Examine the critical value and the test statistic

It is necessary to compare the obtained test statistic with the critical value. The sample is taken from a normally distributed population, and in case the test statistic is less than the critical value, the null hypothesis remains valid. If the test statistic is greater than the critical value, the null hypothesis is rejected, and the sample is not drawn from a population that is regularly distributed.

1.9.2.3 Levene's Test

Step 1: State the hypothesis

In general, Levene's test is a hypothesis test that is meant to ascertain whether the variances of two or more groups are equivalent (Auwarter and Aruguete, 2008). According to the null hypothesis, the variances within each group are equal. The group variances are not equal, according to the alternative hypothesis.

Step 2: State the significance level

The chance of rejecting the null hypothesis in the event that it is true, represented by the symbol α, is the significance level that we must choose. The standard value is 0.05.

Step 3: Gather the data

Collect data from two or more groups that you want to test for variance equality. Each group should have a sample size of at least 3.

Step 4: Calculate the Levene's test statistic

The Levene's test statistic is calculated using the following equation:

$$W = (N-k) / (k-1) * [(\sum ni\ (\hat{y}i - \bar{y})^2) / (\sum ni - 1)] \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where, N = the total number of observations in all groups combined, k = the number of groups, ni = the sample size of the i^{th} group, ŷi = the mean of the i^{th} group, ȳ = the overall mean

Step 5: Calculate the critical value

The Levene's test critical value can be found in statistical tables or software in this section. The sample size and significance level chosen establish the critical value.

Step 6: Examine critical value with the test statistic

It is necessary to compare the acquired test statistic with the critical value. If the test statistic is higher than the crucial value, the null hypothesis is rejected, and the group variances are not equal. If the test statistic is less than or equal to the crucial value, the null hypothesis is not rejected, and the group variances are the same.

1.9.2.4 Kruskal-Wallis Test

The nonparametric Kruskal-Walli's test is applicable when the data is neither homoscedastic nor regularly distributed. This is an example of a study article's methods section for the Kruskal-Walli's test, complete with a step-by-step equation:

Step 1: Rank the data.

Combine the data from all groups and rank the observations from smallest to largest. Assign a rank to each observation based on its position in the ordered list. Assign each observation the average of the ranks if there are ties.

Step 2: Calculate the test statistic.

The Kruskal-Walli's test statistic is calculated as follows:

$$H = [(12 / (N(N+1))) * \Sigma(Ri - (N+1)/2)^2] - 3(N+1) \ldots\ldots\ldots(6)$$

where H is the test statistic, N is the total sample size, Ri is the sum of the ranks in group i, and Σ is the sum of the squared deviations from the group mean.

Step 3: Determine the critical value or p-value.

The chance of rejecting the null hypothesis in the event that it is true, represented by the symbol α, is the significance level that we must choose. The standard α value is 0.05.

Step 4: Correct for multiple comparisons.

The critical value or p-value is adjusted using a method such as the Bonferroni correction or false discovery rate (FDR) correction to correct for multiple comparisons.

Step 5: Interpret the results.

It can be determined that there is a significant difference between the groups under comparison if the adjusted p-value is less than the significance level (e.g., 0.05) (Robinson et al., 2001).

The Kruskal-Wallis test was used in this investigation to compare three or more groups. R software 4.0.3 was used to do the statistical analyses.

1.9.2.5 ANOVA

Step 1: State the hypothesis

The ANOVA test is utilised to determine whether there are any statistically significant differences between the means of two or more groups (Andriastuti et al., 2020). The alternative hypothesis asserts that at least one group's mean differs from the others, contrary to the null hypothesis, which argues that all group means are the same. (Tezer et al., 2017).

Step 2: State the significance level

The significance level we must choose is the chance of rejecting the null hypothesis if it is true, represented by the symbol α. A frequent value is 0.05.

Step 3: Gather the data

Collect data from two or more groups to test for mean differences. Each group should have a sample size of at least 5.

Step 4: Calculate the ANOVA test statistic

The ANOVA test statistic is calculated using the following equation:

$$F = (Between - group\ variance\ estimate) / (Within\ group\ variance\ estimate \ldots\ldots (7)$$

Where, Between-group variance estimate = SSbetween / dfbetween, Within-group variance estimate = SSw / dfw, SSbetween = $\sum(ni * (\bar{y}i - \bar{y})^2) / (k - 1)$, SSw = $\sum \sum (yi - \bar{y}i)^2 / (n - k)$, dfbetween = k - 1, dfw = N – k.

Again, ni = the sample size of the ith group, $\bar{y}i$ = the mean of the ith group, $\bar{y}$ = the overall mean, yi = individual observation in the ith group, k = the number of groups, n = the total number of observations in all groups combined, N = the total number of observations

Step 5: Calculate the critical value

Software or statistical tables can be used to find the critical value of the ANOVA test. The selected significance level and sample size determine the critical value.

Step 6: Examine critical value with the test statistic

We have to compare the calculated test statistic to the critical value in this step. If the test statistic is greater than the critical value, the null hypothesis is rejected, and there is at least one group mean that differs from the rest. If the test statistic is less than or equal to the crucial value, the null hypothesis is not rejected, and the group means are all equal.

1.9.2.6 Welch's ANOVA

The Welch's ANOVA test is employed when comparing the means of three or more independent groups when the assumption of equal variances is violated. When the data being analyzed is not normally distributed or homogeneous, researchers can use Welch's ANOVA as an alternative to the classic ANOVA to determine the explanatory power of variables. This method allows the analysis to be carried out even if the data violates the assumption of variance homogeneity (Zhang et al., 2021). Put differently, when the data fails to meet the assumptions necessary for conducting a conventional ANOVA, Welch's ANOVA can be a viable alternative for assessing the significance of differences between groups. (Hunter et al., 2022). Using this method, researchers can obtain accurate and reliable results even when the data does not conform to the standard assumptions of classical statistical methods (Giacomin et al., 2011).

Here is an example of how to write the methods section of a research article for the Welch ANOVA test, including a step-by-step equation:

Step 1: Calculate the sum of squares between groups (SSB).

The SSB measures the variability among the means of the groups and is calculated as follows:

$$SSB = \Sigma ni(Xi - X))^2 / (k-1) \quad \text{.....(8)}$$

where ni is the sample size of group i, Xi is the mean of group i, X is the grand mean, and k is the number of groups.

Step 2: Calculate the sum of squares within groups (SSW).

The SSW measures the variability within each group and is calculated as follows:

$$SSW = \Sigma\Sigma (Xij - Xi)^2 / (N-k) \quad \text{.....(9)}$$

where Xij is the jth observation in group i, Xi is the mean of group i, and N is the total sample size.

Step 3: Calculate the Welch F-ratio.

The Welch F-ratio is calculated as follows:

$$F = SSB / dfB / (SSW / dfW) \quad \text{.....(10)}$$

where dfB is the degrees of freedom for SSB and dfW is the degrees of freedom for SSW.

Step 4: Determine the critical value or p-value.

With the aid of statistical software or an F-distribution table, the critical value, also known as the p-value, is ascertained by utilising the Welch F-ratio and the degrees of freedom.

Step 5: Interpretation of the results- If the p-value is less than the significance level (e.g., 0.05), it is feasible to conclude that there is a significant difference between at least two of the groups being compared.

When the assumption of equal variances was broken in this investigation, the Welch ANOVA test was used to compare the means of three or more independent groups.

1.9.2.7 Tukey's Honestly Significant Difference (HSD):

This test is used in statistics to determine if the means of multiple groups are significantly different pair-wise after conducting an ANOVA (Analysis of Variance) test. The Tukey HSD test compares all possible pairs of means and calculates a critical value. If the difference between the means of two groups is greater than this critical value, then those means are considered significantly different.

The following equation calculates the Tukey HSD test:

$$HSD = r\,x\,\sqrt{\frac{Msw}{n}} \quad \text{.....(11)}$$

In the above Equation, HSD is the Tukey Honesty Significant Difference, r denotes the Critical Value, which was computed using Studentized range distribution, Msw indicates the mean square within the specific groups obtained from the prior performing ANOVA of F test, n refers the frequency of each group.

1.9.2.8 Chi-Square test

A statistical technique, the chi-square test, is performed to ascertain whether two categorical variables correlate significantly. The chi-square test was used to evaluate the relationship between two category variables. (Al-Dlaigan et al., 2001). In contrast to the null hypothesis, which claims that there is no link, the alternative hypothesis is that there is a substantial correlation between the two variables.

This is an illustration of how to write the chi-square test procedures portion of a research article, complete with a step-by-step equation:

Step 1: Calculate the expected frequencies for each cell.

The expected frequency for each cell is calculated as follows:

$$E_{ij} = (R_i * C_j) / N \quad \text{.....(12)}$$

where E_{ij} is the expected frequency for cells i,j, R_i is the total number of observations in row i, C_j is the total number of observations in column j, and N is the total number of observations.

Step 2: Calculate the chi-square test statistic.

The chi-square test statistic is calculated as follows:

$$\chi^2 = \sum ((O_{ij} - E_{ij})^2 / E_{ij}) \quad \text{.....(13)}$$

where χ^2 is the test statistic, O_{ij} is the observed frequency for cells i and j, and E_{ij} is the expected frequency for cells i and j.

Step 3: Determine the degrees of freedom.

The degrees of freedom for the chi-square test are calculated as follows:

$$df = (r - 1) * (c - 1) \quad \text{.....(14)}$$

where r is the number of rows and c is the number of columns in the contingency table.

Step 4: Calculate the p-value.

The p-value is calculated based on the chi-square test statistic and the degrees of freedom using a chi-square distribution table or statistical software.

Step 5: Interpretation of the results-

The null hypothesis is rejected, and it is determined that there is a significant correlation between the two categorical variables if the p-value is smaller than the significance level (e.g., 0.05) (Dos Santos Junior et al., 2014).

1.9.2.9 Computation of Index Values

To verify the consistency and absolute comparability of the chosen indicators, indicator normalisation is essential (Chowdhury, 2023; Das et al., 2023; Ghosh & Mistri, 2021).

Step 1: Calculate the Weighted Sum (WS) for each tribe:

$(Degree\ value * Percentage\ value)$ ……..……..…(15)

Example: WS (Santhal) = (0.50 * 2.60) + (0.75 * 62.34) + (1.00 * 9.09) = 1.30 + 46.755 + 9.09 = 57.175

Step 2: Calculate the Total Weighted Sum (TWS):

$TWS = \sum Wij$ ……(16)

Where, $\sum Wij$ = Summation of weightage sum of all tribes.

Example: TWS = WS (Santhal) + WS (Lodha) + WS (Mahali) = 57.175 + 6.8175 + 12.3425 = 76.335

Step 3: Calculate the Normalized Score (NS) for each tribe and each response category:

$NS = TWS/WS$ ……(17)

Example: NS(Santhal) = WS (Santhal) / TWS = 57.175 / 76.335 ≈ 0.749

Step 4: Calculate the Sustainability Index (SI) for each tribe:

SI= NS*W ……(18)

Where, NS= Normalization Score, W=Weight

1.9.2.10 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP), which was introduced to Saaty in 1980, stands out as a dependable and straightforward Multi-Criteria Decision-Making (MCDM) method. Its primary function involves ranking attributes within a hierarchical structure. This structure typically

encompasses a goal at the highest level, criteria at the subsequent tier, and alternatives at the lowest tier. In our study, we applied the AHP model to quantify the 18 criteria for assessing the performance of various alternatives.

1.9.2.11 Standardization of factors

Standardizing the factors utilized in this study before their integration into the AHP methodology holds significant importance. Additionally, assessing the favourable correlation of these factors with land suitability remains a crucial step. Employing reclassifying spatial analysis tools, we comprehensively reclassified each criterion within the raster layer, assigning distinct weights accordingly. Subsequently, all factors were categorized into subgroups, and a commonly used formula was applied to compute the weightage of these factors:

$$\text{Eigen Vector= Aj}=\frac{\text{A+B}}{\sum \text{A+B}} \times 100 \quad \text{.....(19)}$$

1.9.2.12 Pair-wise comparison matrix

In this study, the AHP methodology was employed to assess a total of 18 choice criteria along with their respective sub-factors. Utilizing Saaty's 9-point intensity scale, a matrix table for pair-wise comparisons was constructed to establish the relative significance of these parameters. The comparison matrix table, illustrated in Table 1, displays the outcomes of these pair-wise assessments, elucidating the relative importance assigned to each parameter relative to the others.

1.9.2.13 Computation of Consistency Index and Consistency Ratio

The equation below was employed to compute the CI (Consistency Index):

$$CI = \frac{(\gamma \max - n)}{(\text{n}-1)} \quad \text{.....(20)}$$

Where, CI= Consistency Index, $(\gamma \max - n)$ is the highest or principal Eigen vector in the comparison matrices, and n is the number of criteria. The consistency ratio (CR) is generally calculated to evaluate whether the decision-maker's judgment is reasonable.

In equation 2, CI represents the Consistency Index, where $(\gamma \max - n)$ denotes the highest or principal Eigenvector derived from the comparison matrix, and 'n' represents the number of criteria. The Consistency Ratio (CR) is typically computed to assess the rationality of judgments made by the decision-maker.

The following equation expresses the CR (Consistency Ratio):

$$CR = \frac{CI}{RI} \qquad (21)$$

Where, CR is the Consistency Ratio, CI is the Consistency Index, and RI is the Random Index.

In this study, the maximum Eigen Value (γ-max) was determined as 19.2640, resulting in a Consistency Index (CI) of 0.07435 and a Consistency Ratio (CR) of 0.0460. At the same time, the Random Index (RI) was established at 1.615. Typically, a CR value less than 0.10 is considered acceptable. Hence, based on this criterion, we can assert that the weights assigned to the factors were accurately allocated in this analysis.

Table 1.4: Pair-wise comparison matrix for performing the AHP method

Factors	Changes in NDBI	Changes in NDVI	SQI	WQI	WMI	Sanitation	MSI	SPI	NDVI	PC	LST	Rainfall	Slope	RR	PD	Pop. Growth	CMI	SMI
Changes in NDBI	1.00	2.00	2.00	3.00	3.00	4.00	4.00	5.00	5.00	6.00	6.00	7.00	7.00	8.00	8.00	8.00	9.00	9.00
Changes in NDVI	0.50	1.00	2.00	2.00	3.00	3.00	4.00	4.00	5.00	5.00	6.00	6.00	7.00	7.00	8.00	8.00	9.00	9.00
Soil Quality Index	0.50	0.50	1.00	2.00	2.00	3.00	3.00	4.00	4.00	5.00	5.00	6.00	6.00	7.00	7.00	8.00	8.00	9.00
WQI	0.33	0.50	0.50	1.00	2.00	2.00	3.00	3.00	4.00	4.00	5.00	5.00	6.00	6.00	7.00	7.00	8.00	9.00
WMI	0.33	0.33	0.50	0.50	1.00	2.00	2.00	3.00	3.00	4.00	4.00	5.00	5.00	6.00	6.00	7.00	8.00	9.00
Lack of sanitation	0.25	0.33	0.33	0.50	0.50	1.00	2.00	3.00	3.00	4.00	4.00	5.00	5.00	6.00	6.00	6.00	7.00	8.00
Moisture Stress Index	0.25	0.25	0.33	0.33	0.50	0.50	1.00	2.00	2.00	2.00	3.00	3.00	4.00	4.00	5.00	6.00	7.00	8.00
SPI_3	0.20	0.25	0.25	0.33	0.33	0.33	0.50	1.00	2.00	2.00	2.00	3.00	3.00	4.00	4.00	5.00	6.00	7.00
NDVI	0.20	0.20	0.25	0.25	0.33	0.33	0.50	0.50	1.00	2.00	2.00	3.00	3.00	4.00	4.00	5.00	5.00	6.00
Average Power consumption	0.17	0.20	0.20	0.25	0.25	0.25	0.50	0.50	0.50	1.00	2.00	2.00	2.00	3.00	3.00	4.00	4.00	5.00
LST	0.17	0.17	0.20	0.20	0.25	0.25	0.33	0.50	0.50	0.50	1.00	2.00	2.00	3.00	3.00	4.00	4.00	5.00
Rainfall	0.14	0.17	0.17	0.20	0.20	0.20	0.33	0.33	0.33	0.50	0.50	1.00	2.00	2.00	3.00	3.00	4.00	4.00
Slope	0.14	0.14	0.17	0.17	0.20	0.20	0.25	0.33	0.33	0.50	0.50	0.50	1.00	2.00	2.00	3.00	3.00	4.00
Relative Relief	0.13	0.14	0.14	0.17	0.17	0.17	0.25	0.25	0.25	0.33	0.33	0.50	0.50	1.00	2.00	2.00	3.00	3.00
Population density	0.13	0.13	0.14	0.14	0.17	0.17	0.20	0.25	0.25	0.33	0.33	0.33	0.50	0.50	1.00	2.00	2.00	3.00
Decadal Growth of Population	0.13	0.13	0.13	0.14	0.14	0.17	0.17	0.20	0.20	0.25	0.25	0.33	0.33	0.50	0.50	1.00	2.00	3.00
CMI	0.11	0.11	0.13	0.13	0.13	0.14	0.14	0.17	0.20	0.25	0.25	0.25	0.33	0.33	0.50	0.50	1.00	2.00
Soil Moisture Index	0.11	0.11	0.11	0.11	0.11	0.13	0.13	0.14	0.17	0.20	0.20	0.25	0.25	0.33	0.33	0.33	0.50	1.00

1.9.2.14 Entropy Weighting Method

Entropy is a renowned and robust technique in objective Multi-Criteria Decision Making (MCDM) for weight determination. Initially incorporated into information theory by Shannon in 1948 (Bhattacharya et al., 2021), the entropy approach stands out as a swift and efficient tool for assessing the significance or weightage of individual factors (Bhowmik et al., 2018). Leveraging probability theory, this method calculates entropy or uncertainty information, offering a systematic means to determine weights, especially when researchers face challenges or hesitancy in assigning specific weights to different elements (Chodha et al., 2021; Goswami and Behera, 2021).

Step 1: The initial values of decision factors were normalized in this step. The following equation normalizes the decision matrix:

$$N_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad \text{.....(22)}$$

Where, N_{ij} refers to the normalized value of decision factors, x_{ij} indicates the original (initial) values of i^{th} alternative of j^{th} factor, and m is the total number of alternatives used in the study.

Step 2: In this step, the entropy values (E_i) were calculated by the following formula:

$$E_i = -\frac{1}{\ln m}\sum_{j=1}^{m} N_{ij} \ln\left(N_{ij}\right) \quad \text{.....(23)}$$

Were, $\mathrm{j} = 1,2,3,4 \ldots, \mathrm{n}$, $\mathrm{i} = 1,2,3,4 \ldots, \mathrm{m}$

Step 3: The degree of discrepancy or divergence (D_j) was computed as follows:

$$D_j = 1 - E_i \quad \text{.....(24)}$$

Step 4: The precise indicator of the intensity (or degree of disparity) of the choice factors is D_j. The following formula was used to determine the weight of the relative importance of choice factors in the fourth step of the entropy method:

$$Wj = \frac{D_j}{\sum_{j=1}^{n} D_j} \quad \text{.....(25)}$$

Where, Wj is the weight of j^{th}decision factors and $j = 1,2,3,4 \ldots \ldots n$.

1.9.2.15 TOPSIS (Technique for Preference Ordering Based on Similarity to Ideal Solution)

Hwang and Yoon introduced TOPSIS, a reliable technique for Multi-Criteria Decision Making (MCDM), in 1981 (Behzadian et al., 2012). This approach works by identifying ideal solutions that are positive and negative. According to Bagherzadeh and Gholizadeh (2017), the negative ideal solution decreases benefit criteria and increases cost criteria, while the positive ideal solution emphasises benefit criteria and minimises cost criteria. Notably, the most advantageous option is situated closest to the ideal positive solution and furthest from the ideal negative solution (Konstantinos et al., 2019). We carefully followed a number of stages in our effort to assess environmental sustainability using the TOPSIS technique.

Step 1: First, a normalized decision matrix has been generated due to the unequal dimensions of all the factors. Consequently, the following formula is used to convert all of the values into dimensionless values:

$$N_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^{m} x_{ij}{}_{kj}^{2}}} \quad \ldots\ldots(26)$$

Where, N_{ij} is the normalized decision matrix (vector normalization), m is the total number of alternatives, x_{ij} represents the actual value of i^{th} alternative of j^{th} factor.

Step 2: Secondly, the weighted normalized decision matrix has been computed. To do this, we should multiply the normalized value of each cell with the weightage of each factor using the following formula:

$$W_{ij} = N_{ij} * W_j \quad \ldots\ldots(27)$$

Where, W_{ij} is the weighted normalized decision matrix, W_j represents the weight of the j factor.

Step 3: Thirdly, the ideal and negative ideal solutions have been computed. The ideal solution is the best performance value of W_{ij} and negative ideal solution represents the worst value of W_{ij}. The ideal positive solution is computed with the following formula:

$$B^{+} = \left\{\left(\max_{i} v_{ij} \lfloor j \in J\right), \left(\min v_{ij} \mid j \in J'\right)\right\} \quad \ldots\ldots(28)$$

Where, B^{+} is the ideal solution, J is the benefit criteria (factor), J' represents cost criteria, max indicates maximum value, and min is the minimum value. The ideal negative solution, on the other hand, is calculated by the following formula:

$$B^{-} = \left\{ \left(\min v_{ij} \mid j \in J \right), \left(\max_{i} v_{ij} \lfloor j \in J' \right) \right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (29)$$

Where, B^{-} is the negative ideal solution.

The values which are computed in equation 14 can be represented as $B^{+} = \{v_1^{+}, v_2^{+}, \ldots, v_n^{+}\}$. Contrarily, values calculated in equation 15 is depicted as $B^{-} = \{v_1^{-}, v_2^{-}, \ldots, v_n^{-}\}$.

Step 4: Positive and negative ideal separation has been calculated in this step. Positive ideal separation is computed as follows:

$$S_i^{+} = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^{+} \right)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (30)$$

On the other hand, negative ideal separation is computed with the following formula:

$$S_i^{-} = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^{-} \right)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (31)$$

Where, S_i^{+} and S_i^{-} are the positive and negative ideal separation, respectively.

Step 5: The relative proximity to the ideal solution (P) has been computed in this step. This is done with the following formula:

$$P = \frac{S_i^{-}}{S_i^{-} + S_i^{+}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (32)$$

In this study, to develop the E-TOPSIS method, we gave weightage to factors in the TOPSIS method computed by the entropy method.

1.9.2.16 Human Vulnerability Index

A methodical process assesses human vulnerability within various blocks of Jhargram District. Initially, for indicators like NIM, BPL, ILL, LandL, and LAB, displaying a direct functional relationship with vulnerability, the normalized scores (Xij) for each block (ith) and indicator (jth) are computed. These normalized values are obtained using the formula:

$$Xij = (Xij - Min\, Xj) \,/\, (Max\, Xj - Min\, Xj) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (33)$$

Ensuring a consistent scale across indicators and blocks. Conversely, for the indicator BPL (Yij), which has an inverse functional relationship, its normalized values are computed differently:

$$Yij = (Max\, Sj - Xij) \,/\, (Max\, Xj - Min\, Xj) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (34)$$

It results in values complementary to the direct relationship scores. Notably, for the same indicator within a block, the sum of Xij and Yij equals 1, simplifying the computation of Yij as $(1 - Xij)$.

With all indicators equally weighted, the HVI is constructed by averaging each block and indicator's Xij and Yij values. The formula used for this calculation is

$$HVI = (Xij + Yij) / n \quad \text{.....(35)}$$

where 'n' denotes the number of indicators.

The resulting Human Vulnerability Index (HVI) values represent the relative vulnerability of each block. The blocks are then ranked based on their HVI values, with the highest index assigned rank 1, followed by subsequent ranks in descending order according to their vulnerability. This method allows for a clear ranking of blocks regarding their susceptibility, assisting in identifying the most vulnerable regions within Jhargram District.

1.9.2.17 Kendall's coefficient of concordance

Kendall's coefficient of concordance gauges how closely rankings from different indicators match. It tests the agreement among these rankings, revealing how consistent the blocks' positions are across various factors.

The formula for Kendall's tau is as follows:

$$\tau = \frac{Number\ of\ concordant\ pairs - Number\ of\ discordant\ pairs}{T} otal\ number\ of\ pairs \quad (36)$$

Here, Number of concordant pairs refers to pairs of observations that follow the same order in both variables ($i.e.,\ Xi > Xj\ and\ Yi > Yj\ or\ Xi < Xj\ and\ < Yi < Yj$).

A number of discordant pairs represent pairs of observations that have opposite orders in the two variables ($i.e.\ Xi > Xj\ and\ Yi < Yj\ or\ Xi < Xj\ and\ Yi > Yj$).

The number of pairs is calculated as $[n \cdot (n-1)]/2$, where n is the total observations.

The value of W in Kendall's coefficient of concordance falls within the range of 0 to 1.

$W = 1$ implies a scenario where there is complete agreement or perfect unanimity among the various components in the ranking of the blocks. It suggests a consistent and unanimous trend in the rankings across all components. Conversely, $W = 0$ indicates no overall trend or agreement among the components when ranking the blocks. It signifies a lack of consensus or consistency across the different components in determining the block rankings. W has been calculated using the formula.

$$W = \frac{12S}{m^3(M^3 - M)} \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .. (37)$$

Where, $S = \Sigma(Ri - \bar{R})^2$; $R = \frac{m(M+1)}{2}$ $and\ Ri = 1,2,3, \ldots, n$

W is the test statistic in this case and has been checked with the critical value with $(M - 1)$ df and 0.05 significance level.

$$\chi 2 = m(M - 1)W \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (38)$$

Where, m = No of components and M = No of Blocks

Here, W= 0.451.

1.9.2.18 Population Density:

Collected data is processed to measure the tribal population density and sex composition of the different blocks in a district. MS Excel was applied to process and analyze the data. Various cartographic techniques are also used to represent the process data. We can calculate the tribal population density by applying the subsequent formula:

$$\text{Tribal Population Density} = \frac{\text{Total Tribal Population}}{\text{Total Geographical Area}}$$

1.9.2.19 Location Quotient:

The index of concentration of the tribal population is also measured through the Location Quotient Method (Mahmood,1977).

$$\text{LQ} = \frac{\text{No.of Tribal Population to the total population of a Block}}{\text{Total Tribal population of District to total Population of District}}$$

i. If the LQ value is above 1, the concentration of the tribal population is high.
ii. If the LQ value is below 1, the concentration of the tribal population is low or disperses.
iii. If the LQ value is equal to 1, the concentration of the tribal population is balanced.

In this study, we have considered over 50 years, from 1971 to 2011, to analyze the tribal people's concentration in the different blocks of the Jhargram district.

1.9.2.20 Age-Sex Composition:

Tribal sex composition or ratio is measured by the number of females per thousand males. The following formula is used for calculation:

$$\text{Tribal Sex Composition/Ratio} = \frac{\text{Total No.of Tribal Female}}{\text{Total No.of Tribal Male}} \text{ x } 1000$$

1.10 Tentative Chapters of the Study

Chapter I: Introduction

Chapter II: General Background of the study area

Chapter III: Spatio-temporal distribution of the major tribal people in Jhargram district.

Chapter IV: Livelihood patterns of the major tribal people in Jhargram district

Chapter V: Indigenous knowledge and environmental sustainability of the major tribal people

Chapter VI: Role of environmental sustainability on the livelihood patterns of the major tribal people

Chapter VII: Challenges and Opportunities of environmental sustainability and livelihood patterns of the major tribal people

Chapter VIII: Suggestions and Conclusions

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