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E-waste: A major health and environmental problem in India

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Abstract

Electronic waste (e-waste) refers to the disposal of broken or obsolete electrical and electronic components and materials. E-waste is a popular, informal name for electronic products nearing the end of their "useful life." Computers, televisions, VCRs, stereos, CD, copiers, mobiles, fax machines, microwave and other similar appliances are common electronic products. Many of these products can be reused, reduced and recycled. E-waste is now the fastest-growing waste stream in the world. The UN has called it a tsunami of e-waste. Currently, only a few countries have a uniform way of measuring this waste. There are concerns about the availability and supply of new materials for electronics and electrical devices in the future. Yet e-waste contains many high value and scarce materials, such as gold, platinum, cobalt, rare earths, and high quantities of Aluminium and tin. E-waste presents a potential security threat to individuals & exporting countries and poses a critical issue in terms of solid waste management. Certain components of some electrical and electronic products contain materials that render them hazardous, depending on their condition and density. The processes of dismantling and disposing of electronic waste in developing countries like India led to a number of environmental impacts. Liquid and atmospheric releases end up in bodies of water, groundwater, soil, and in air; therefore affected both domesticated and wild animal in land and sea, in crops and drinking water eaten by both animals & human and harming ecosystem. Rapid innovation and lowering costs have dramatically increased access to electronic products and digital technology with many benefits. This has led to an increase in the use of electronic devices and equipment and creating e-waste. E-waste comes from many sources including households, businesses and governments. E-waste is the toxic legacy of our digital age. It's high time to fix the problem.

Key words: Solid waste management, Rapid Innovation, Toxic legacy.

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E-waste: A major health and environmental problem in India

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Introduction: Electronic waste (e-waste) refers to the disposal of broken or obsolete electrical and electronic components and materials. E-waste is a popular, informal name for electronic products nearing the end of their "useful life." Computers, televisions, VCRs, stereos, CD, copiers, mobiles, fax machines, microwave and other similar appliances are common electronic products. Electronic waste is emerging as a serious public health and environmental problem all over world. This problem has been creating a serious environmental and health issue in India also. India is the 5th largest electronic waste producer in the world and has emerged as the world's second largest mobile market. India imports an undisclosed amount of e-waste from other advanced countries around the world. India discarding roughly 1.5 lakh tones of electronic waste each year, a study says. Telecom equipment alone accounts for 12 per cent of the e-waste, a joint study by ASSOCHAM-KPMG, an industrial body in India. The rising levels of e-waste generation in India have been a matter of concern in recent years. With more than 100 crore mobile phones in circulation, nearly 25 per cent end up in e-waste annually. The Ministry of Environment, Forest and Climate Change has notified e-waste management rules 2016, in which producers are for the first time covered under Extended Producers' Responsibility (EPR). According to ASSOCHAM, the Compound Annual Growth Rate (CAGR) of electronic waste is 30%. With changing consumer behavior and rapid economic growth, ASSOCHAM estimates that India will generate 5.2 million tons of e-waste by 2020. While e-waste recycling is a source of income for many people in India, it also poses numerous health and environmental risks. More than 95% of India's e-waste is illegally recycled by informal waste pickers. These workers operate independently, outside of any formal organization which makes enforcing e-waste regulations difficult to impossible. Recyclers often rely on rudimentary recycling techniques that can release toxic pollutants into the surrounding area. The release of toxic pollutants associated with crude e-waste recycling can have far reaching, irreversible consequences. In India the amount of e-waste generated differs from state to state. The three states that produce the most e-waste, they are mainly Maharashtra, Tamilnadu and Andhra Pradesh. Other states that produce significant e-waste are Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab. We have seen that e-waste is disproportionately generated in urban areas. Indian cities generate more than 60% of India's total e-waste. Mumbai is the top e-waste producer followed by Delhi, Bangaluru, Chennai and Kolkata. (Hindu: 15th May 2016)

Health and environmental impact: Electronic equipments contain many hazardous metallic contaminants such as lead, cadmium, and beryllium and brominates flame retardants. The fraction including iron, copper, aluminum, gold and other metals in e-waste is over 60%, while plastics account for about 30% and the hazardous pollutants comprise only about 2.70%. Growing e-waste problem is a great concern and most of the people in India are not aware of how they can contribute to reduce this problem. Most of the people in India don't know the concept of reduce, reuse and recycle concept of e-waste. It has become an important problem to rationalize electronic waste management systems for the environment. These have been creating a health hazards with the usage of electrical and electronic equipment (EEE) on the rise. The amount of electrical and electronic waste produced each day is equally growing enormously around the globe. Of many toxic heavy metals, lead is the most widely used in electronic devices for various purposes, resulting in a variety of health hazards due to environmental contamination through food, water, air, and soil. Children are particularly most vulnerable to lead poisoning than adults because they absorb more lead from their environment and

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their nervous system and blood get affected. The processes and techniques used during the recycling activities are very primitive. Recycling of valuable elements contained in e-waste such as copper and gold has become a source of income mostly in the informal sector of developing or emerging industrialized countries. Furthermore, recycling activities such as dismantling of electrical equipment may potentially bear an increased risk of injury. Workers in e-waste disposal sector are poorly protected against the risk of it. They dismantle e-waste often by hand, in dreadful conditions. About 25,000 workers are employed at scrap-yards in Delhi alone, where 10,000 to 20,000 tons of e-waste is handled every year, with computers accounting for 25 percent of it. Other e-waste scrap yards exist in Meerut, Firozabad, Chennai, Bangalore and Mumbai.

The e-waste problem has been alarming in India because India generates about 1.5 lakh tones of e-waste annually and almost all of it finds its way into the informal sector as there is no organized sector available at present. Especially, metropolitan cities like Delhi, Mumbai and Bangaluru are at higher risk of environmental pollution due to e-waste. A study reveals that the Mumbai city faces grave health and environmental risks posed by a dump of 19,000 tones of electronic waste produced every month, above these same being imported from other developed countries. The rate of e-waste generation and the current methods of disposal in Mumbai pose a grave environmental and health risks to the city at large due to high density of population. A study on e-waste by the Chittaranjan National Cancer Institute, Kolkata reveals that people in Delhi are about twice as likely to suffer from lung ailments as those in the countryside due to the huge amount of generated e-waste. Bangaluru has been generating about 10,000 tons to 15,000 tons of e-waste every month, as received from different industrial sources. Karnataka State Pollution Control Board has reveals that Karnataka generates about 10,000 tons monthly. The amount of e-waste generated poses a grave threat to the environment as well as to public health in Karnataka and surrounding area.

The hazardous substances found in the e-waste include substantial quantities of lead, cadmium, chromium and flame-retardant plastics. There are no sanitization and masks cover facilities amongst the e-waste pickers & gatherers. So, it becomes a health risk. Cathode ray tubes and components with high lead content are considered dangerous to health. Inhaling or handling such substances and being in contact with them on a regular basis can damage the brain, nervous system, lungs, kidneys and the reproductive system. Those are working in poor-ventilated enclosed areas without masks and technical expertise results in slow poisoning to their health. Due to lack of awareness, workers are risking their health and environment as well. Various studies have shows the soaring levels of toxic heavy metals and organic contaminants in samples of dust, soil, river sediment, surface water, and groundwater in India. In the same areas, the residents had a high incidence of skin damage, headaches, vertigo, nausea, chronic gastritis, and gastric and duodenal ulcers, etc. There is an urgent need for improvement in e-waste management covering technological improvement, institutional arrangement, operational plan, protective protocol for workers working in e-waste disposal and last but not the least education of general population about this emerging issue posing a threat to the environment as well as public health.

E-waste scenario in India: India ranks 177 amongst 180 countries relating to e-waste generation and is amongst the bottom 5 countries on the EPI (Environmental performance Index), 2018, a report from World Economic Forum (WEF). 2018.India shows poor performance in environment health policy and for that reason death rate is alarming due to air pollution .Also, India is ranked fifth in the world amongst top e-waste producing countries after the USA, China, Japan, and Germany and recycles less than 2 per cent of the total e-waste it produces annually. Since 2018, India generates more than two million tons of e-waste annually, and also imports huge amounts of e-waste from other advance countries around the world. Dumping in open dumpsites is a common sight which gives rise to issues such as groundwater contamination, poor health, and more. The Associated Chambers of Commerce and Industry of India (ASSOCHEM), KPMG and Electronic Waste Management in India identified that computer equipment account for almost 70 per cent of e-waste, followed by telecommunication equipment phones (12 per cent), electrical equipment (8 per cent), and medical equipment (7 per cent) with remaining from household e-waste. E-waste collection, transportation, processing, and recycling are dominated by the informal sector. The sector is well networked and unregulated. In addition, there are serious issues regarding leakages of toxins into the environment and workers' safety and health.

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Seelampur in Delhi is the largest e-waste dismantling centre in India. Adults as well as children spend 8–10 hours daily extracting reusable components and precious metals like copper, gold and various functional parts from the devices. E-waste recyclers use processes such as open incineration and acid-leeching. This situation could be improved by creating awareness and improving the infrastructure of recycling units along with the prevalent policies. The majority of the e-waste collected in India is managed by an unorganized sector. Also, informal channels of recycling or reuse of electronics such as repair shops, used product dealers, e-commerce portal vendors collect a significant proportion of the discarded electronics for reuse and cannibalization of parts and components.

There are concerns about the availability and supply of new materials for electronics and electrical devices in the future. Yet e-waste contains many high-value and scarce materials, such as gold, platinum, cobalt, rare earths, and high quantities of Aluminums and tin. E-waste presents a potential security threat to individuals & exporting countries and poses a critical issue in terms of solid waste management. Certain components of some electrical and electronic products contain materials that render them hazardous, depending on their condition and density. The processes of dismantling and disposing of electronic waste in developing countries like India led to a number of environmental impacts. Liquid and atmospheric releases end up in bodies of water, groundwater, soil, and in air which affects both domesticated and wild flora & fauna in land and sea surfaces, in crops and drinking water eaten by both animals & human and harming ecosystem. Rapid innovation and lowering costs have dramatically increased access to electronic products and digital technology with many benefits. This has led to an increase in the use of electronic devices & equipment and creating e-waste. E-waste comes from many sources including households, businesses and government offices, companies, etc. E-waste is the toxic legacy of our digital age. It's high time to fix the problem.

Now a day's e-waste is one of the fastest growing pollution problems which are increasing almost three times than that of municipal waste globally. With the rapid development of electronics items in IT sector, increase in consumption of electronic goods also increases. As there is no separate collection policy of e-waste in organized sector in India. It has been observed that in most of the cases electronic items are stored unguarded, unsupervised because of lack of law, knowledge and proper management system. Generally, such electronic junks used to seen in houses, offices, warehouses, etc. and these wastes are mixed with household wastes which are finally disposed of at landfills. Currently, only a few countries have a uniform way of measuring this waste. There is paucity of data on burdens of heavy metal exposure on environment and human body in India. A large number of workers including small children are exposed to different e-waste picking and dismantling activities. There are no data available about the health implications of these workers. They might be ruining their lives in the lack of appropriate knowledge. This necessitates implementation of appropriate management measures including stringent regulations. The management practices currently in operation in India have severe health and environmental implications. The Ministry of Environment, Forest and Climate Change rolled out the e-waste management Rules in 2016 to reduce e-waste production and increase recycling. Under these rules, the government introduced EPR which makes producers liable to collect 30 per cent to 70 per cent (over seven years) of the e-waste they produce, said the study. The integration of the informal sector into a transparent recycling system is crucial for a better control on environmental and human health impacts. There have been some attempts towards integrating the existing informal sector in the emerging scenario. Organizations such as GIZ India have developed alternative business models in guiding the informal sector association towards authorization. These business models promote a city-wide collection system feeding the manual dismantling facility and a strategy towards best available technology facilities to yield higher revenue from printed circuit boards. By replacing the traditional wet chemical leaching process for the recovery of gold with the export to integrated smelters and refineries, safer practices and higher revenue per unit of e-waste collected are generated. It is one of the components of Reduce, Reuse and Recycle of e-waste. Reduce generation of e-waste through smart procurement and good maintenance. Reuse still functioning in electronic equipment by selling it to someone who can still use it. E-waste is also a rich source of metals such as gold, silver, copper, etc. as mentioned above which can be recover and brought back into the production cycle. There are also some significant socio-economic potential in the efficient recovery of valuable e-waste materials which can provide income generating

opportunities for both individuals and enterprises. Following table shows various e-waste sources, their constituents and its impact on health.

Table: Various e-waste sources, their constituents, and health impacts.

E-waste sources	Constituents	Health effects
Solder in printed circuit boards, glass panels and gaskets in computer monitors.	lead	a) Damage to central and peripheral nervous system, blood system and kidney damage. b) Adverse effects on brain development of children: causes damage to the circulatory system and kidney.
Chip resistors and semi conductors	cadmium	a)Toxic irreversible effects on human health b) Accumulates in kidney and liver. c) Causes neural damage.
Relay and switches , printed circuit boards	mercury	a) Chronic damage to the brain. b)Respiratory and skin disorder due to bioaccumulation in fishes
Galvanized steel plates and decorator and hardener for steel housing	chromium	Causes bronchitis
Cabling and computer housing	plastics and PVC	Burning produces dioxin that causes reproductive and developmental problems
Electronic equipment and circuit board	brominates flame retardants	Disrupt endocrine system functions
Front panels of CRTs	barium and phosphorous , heavy metals	Causes muscle weakness and damage to the heart, liver and spleen
Copper wires, printed circuit boards tracks	copper	Stomach cramps, nausea, liver damage, Wilson's disease
Nickel cadmium rechargeable batteries	nickel	Allergy of the skin to nickel results in dermatitis while allergy of the lung to nickel results in asthma
Lithium ion battery	lithium	a) Lithium can pass into breast milk and may harm a nursing body. b) Inhalation of the substance may cause lung edema

Motherboard	beryllium	a) Carcinogenic (lung cancer). b) Inhalation of fumes and dust causes chronic beryllium diseases or beryllium disease or berylliosis.

Courtesy: www.ban.org

Research on e-waste management in India: In India individual research on e-waste is not going on in a proper way. Most of the researches are done in reference to pollution and environment. Now many more environmental epidemiological studies are required to assess the present status of e-waste management system in India, to assess the e-waste quantities and exact amplitude of the problem in Indian cities and towns, and to establish relationships with the informal recycling sectors. The valuable data will be generated by these studies that would help in drafting an action plan for e-waste management. India should start a surveillance system for diseases and health consequences of e-waste. The sustainability of e-waste management systems has to be ensured by improving the collection and recycling systems. It would be desirable to establish public-private partnerships in setting up buy-back or drop-off centers. Levying advance recycling fees is another approach to ensure waste management sustainability. To identify best e-waste management technologies across the globe and adopt them successfully may be a tool for a sustainable futuristic growth. The reduction of the hazardous substances in the electronic and electrical equipments and the promotion of use of their safer substitutes many countries have adopted the Restriction of Hazardous substances (RoHS) regulations in the manufacture of these items. More and more such less hazardous substitutes should be identified which can be used in electronic equipments (Monika, Kishore, Jugal :2010).

Conclusion: The challenges of managing e-waste in India are very different from those in other countries, both the developed and developing. No doubt, there are several complexity of the e-waste issue in India in the case of vast geographical and cultural diversity and economic disparities. No accurate estimates of the quantity of e-waste in India. The challenges of managing e-waste in India are very different from those in other countries, but we have to take challenges to tackle the problems. It seems less awareness amongst e-waste pickers, gatherers, manufacturers and consumers, which may create hazards due to incorrect e-waste disposal system. There is an urgent need of e-waste management covering technological improvement, operation plans, implementing a protective protocol for the workers in e-waste disposal and educating public about this emerging issue which is posing a threat to the environment as well as public health. The hazardous nature of e-waste is one of the rapidly growing environmental problems of the world. The ever increasing amount of e-waste associated with the lack of awareness and appropriate skill is deepening the problem. A large number of poor workers are involved in dismantling of these electronic items for their livelihood but their health is at risk. Therefore central and state govt. should arrange some plans and programmes to prevent the health hazards for e-waste handling workers in India. Ministry of environment, Health and Industry of govt. of India may prepare some strategy and action plan to tackle such problems. State govt. also may prepare some action plan through panchayat & NGO. Required information should be provided to these workers regarding safe handling of e-waste and personal protection. For e-waste management many technical solutions are available, but to be adopted in the management system, prerequisite conditions such as legislation, collection system, logistics, and manpower should be prepared. This may require operational research and evaluation studies.

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IMPORTANCE OF VOCATIONAL EDUCATION AND TRAINING IN SECONDARY SCHOOLS AND HIGHER EDUCATIONAL INSTITUTIONS IN ASSAM TO CREATE EMPLOYMENT OPPORTUNITIES*

BY

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Abstract
Vocational education has witnessed a painfully slow and stagnant growth in Assam. Those government institutions have been practicing vocational training & education, their infrastructure are also in deplorable condition. As for example, the conditions of District Industrial Training Institute (ITI) of Assam are running in pathetic condition. In Assam unemployment problem becomes a major problem or issue amongst the educated youth which have been creating social, political &economic and insurgency problems. Every year higher education institutions are producing huge amount of graduates in different programmes but failed to get a job according to their expectations and academic level. Some of them are serving as disguised employment in different capacities. We have not seen any govt. policy to overcome the problems. In Assam huge amount of natural resources are available to and fro but due to lack of adequate skill, knowledge and management, many resources have been wasting day by day. But those resources could have been utilized by vocational training and management. In present day situation, higher education institutions can play a pivotal role to develop human resources by giving vocational training and guidance, etc. We can now expect a ray of hope to control the prevailing unemployment problems by opening vocational courses in higher educational institutions of Assam and transform the lives of millions of youth of Assam. University grant commission, NAAC and new education policy, 2020 have recognized that quality of higher education with a focus on vocational subjects is necessary to build capable and competent individuals for 21st century.
Key words: Vocational education, unemployment problem, human resource.

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Introduction:

Vocational education is a one type of stream in education that prepares student for work in a specific trade, a craft, as a technician or in professional vocations such as engineering, accountancy, architecture, law, medicine, nursing, etc. Vocational education creates skills through different types of training. This type of education and training allows students to gain practical experience in their selected career path before they even highly qualified. Student who finish this type of programme, have the credentials and training they need to get started right away in their chosen career path.

Vocational education or Vocational Education & Training (VET), also called Career and Technical Education (CTE), prepares learners for jobs that are based in manual or practical activities, traditionally non-academic and totally related to a specific trade, occupation or vocation, hence the term, in which the learner participates. It is sometimes referred to as technical education, as the learner directly develops expertise in a particular group of techniques or technology. Vocational education in schools is a relatively modern development. Until the 19th century such education, except for the professions, was provided only by apprenticeship. This situation was partly due to the low social status associated with such instruction as opposed to a classical curriculum, which was considered "necessary for a gentleman." With the growth of industrialization during the 19th century, however, several European countries, notably Germany, began introducing vocational education in elementary and secondary schools. In Great Britain, however, opposition to vocational education persisted into the 20th century, although a few trade and junior technical schools were established by local authorities before World War II. By the late 19th century public (common) school vocational education in the United States consisted of manual training and practical arts. These programs were gradually expanded until 1917 when federal aid was provided to public schools for trade and industrial, agricultural, and homemaking courses. After World War II the demand for trained paraprofessionals in the relatively new fields of computer science, electronics, and medical services led to an increased interest in short-term postsecondary specialized training programs in these areas as an alternative to a traditional college education. Vocational education has witnessed a painfully slow and stagnant growth in Assam. Those government institutions have been practicing vocational training & education, their infrastructure are also in deplorable condition. As for example, the conditions of District Industrial Training Institute (ITI) of Assam are running in pathetic condition. In Assam unemployment problem becomes a major problem or issue amongst the educated youth which have been creating social, political &economic and insurgency problems. Every year higher education institutions are producing huge amount of graduates in different programmes but failed to get a job according to their expectations and academic level. Some of them are serving as disguised employment in different capacities. We have not seen any govt. policy to overcome the problems. In Assam huge amount of natural resources are available to and fro but due to lack of adequate skill, knowledge and management, many resources have been wasting day by day. But those resources could have been utilized by vocational training and management. In present day situation, higher education institutions can play a pivotal role to develop human resources by giving vocational training and guidance, etc. We can now expect a ray of hope to control the prevailing unemployment problems by opening vocational courses in higher educational institutions of Assam and transform the lives of millions of youth of Assam. University grant commission, NAAC and new education policy, 2020 have recognized that quality of higher education with a focus on vocational subjects is necessary to build capable and competent individuals for 21st century.

Objectives:

Name of Trade/Sector	No. of Schools
Agriculture	97
Retail	173
Private security	77
IT	177
Tourism & Hospitality	39
Healthcare	98
Beauty & Wellness	21
Grand Total	682

Source: NSDC.

In sync with the policy of self-reliance, the AHSEC (Assam Higher Secondary Education Council) has already introduced 27 new vocational and skill development courses from this academic session. The 27 new subjects are – Agriculture, DTP-Computer Application, Front Office Operation Counter, Office Procedure and Practices, Fabrication Technology, Automotive, Electrical and Electronic Technology, Plumber, Financial Market Management, Banking, Marketing, Salesmanship, Insurance, Taxation, Cost Accounting, Horticulture, Silk, Animal Rearing, Tourism, Beauty and Wellness, Healthcare, Textile Designing, Food and Nutrition, Mass Communication, Yoga, Fishery and Hotel Management.

Assam government has introduced a popular mission as Assam Skill Development Mission (ASDM) since 2017. Since then the society has been working on skill, employment and entrepreneurship development and targeted to give appropriate skill to 1.50 lakhs unemployed youth in a year. The mission of the ASDM is as follows-

(a) Employability based Skill training will be undertaken from state budget.

(b) Skilling for self employment will be from state budget.

© Entrepreneurship development scheme with special focus on construction, fisheries, dairy, food Processing, sericulture, bamboo etc. with micro finance guarantee to adopt.

(d) Training will be 50% residential and 50% will be of non residential.

Suggestions and recommendations:

Vocational education is gaining tremendous importance in our country in recent years. The lack of employability as an outcome of the education system has given rise

to the need for skill based education. The Researcher has made the following suggestions and recommendations:

(i) The Researcher feels that in order to plan, promote, effectively regulate, develop and popularize the Vocational Education, Training and Skill Development sector, it is essential to create an administrative structure and framework through State legislation

(ii) The Researcher believes that a separate Umbrella or enabling Act for establishment of a Vocational University is required to be enacted at State level. The Act should enable the State to establish one or more Vocational Universities in a PPP Model.

(iii) The Researcher feels that a comprehensive Vocational Education and Training Act must be formulated for the State of Assam.

(iv)The Researcher recommends the creation of a separate quality council for Assam that that the creation of such regulatory bodies including the Commission, Accreditation Board and Quality Council will help in integrating the Vocational Education and Training sector. It will also enable the standardization of courses, curricula and certificates in this sector thus bringing about a qualitative change. In the long run, this model legislative and regulatory framework will help in creating large number of skilled resources in line with industry needs thus establishing a successful Vocational Education and Training system in the State of Assam.

(v) Students should be given choice of many more vocational subjects to opt for. It would be desirable to offer non-technical vocational subjects in the high growth sectors also. Options of various vocational subjects as electives must be given to students without any restrictions. A multi-disciplinary approach is recommended to be adopted.

(vi)It is recommended that each college/school providing HSC Vocational should have tie-up with the local industry, NGOs and other community stakeholders through the Industry Management. Committee thus facilitating inputs in project work, teacher training, guest lectures, student grooming, summer placements, in service training of industry employees etc.

(vii) It is recommended that each college/school providing HSC Vocational should have a Placement Cell, Entrepreneurship Development Cell and Finishing School/Department.

(viii) Teacher training is required to orient the vocational teachers to the new teaching learning methodology, scheme and curriculum.

(ix) Higher enrollment into the vocational sector will reduce the burden on conventional colleges and universities and will open new opportunities of learning for students.

(x) The curriculum revision should be undertaken on annual basis in line with the industry needs. The curriculum should be modular, competency based with multi entry exit option.

(xi) Vocational University should be to provide vertical mobility to students in vocational stream by offering Bachelor's, Master's and Doctoral programs in vocational studies and offer various specializations as required by local community & industry.

Conclusion:

Vocational education and training strengthens any country's employment and the same way its economy. The Vocational Education, Training & Skill Development sector is rapidly gaining significance in the present scenario. India being a developing world has come a long way to enhance and implement vocational education and training. The Central Govt. has realized the direct correlation of skill based education and gainful employment for the youth of our country. The rising unemployment amongst youth educated in conventional streams has further accentuated the importance of Vocational Education and Skill Development. The present scenario around this sector is quite dismal and there is scope for significant reforms. During the course of over 2-3 years of in-depth research, the Researcher has been able to identify problems with the governance, regulation, administration, planning, policy, standards and other aspects related to the Vocational Education, Training and Skill Development sector. The Researcher has given recommendations for each problem area with clear direction for implementation. Vocational Education and Training (VET) is an important element of nation's education initiative. For Vocational Education to play its part effectively in the changing global environment, it is imperative to redefine the objectives of vocational education and training and to make it flexible, contemporary, relevant, inclusive and creative. India is expected to become the global powerhouse of human resource by 2025. In the emerging era of knowledge-driven society, declining workforce and aging population in developed countries, India with its large young population has the opportunity to position itself as a quality source of skilled manpower for the world. The large population can reap rich dividend for the country through a focus on providing quality vocational education and training. At present, there is no specific Government rule related to vocational faculty qualifications. The World Bank Report (2006) suggests that one of the major concerns of industry is poor quality of curriculum.

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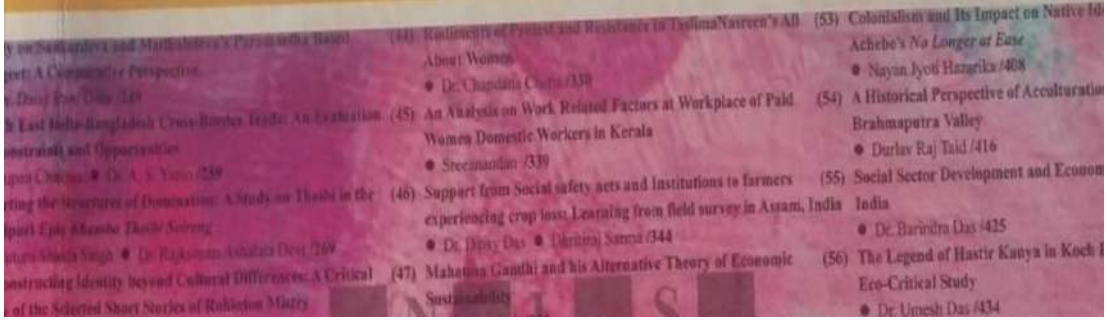
দগো ৰাংছাং

গৱেষণা পত্রিকা, নৱম বছৰ, ষষ্ঠদশ সংখ্যা, জুলাই, ২০২২



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হৰিমোহন সৰকাৰৰ 'বহুৰঙী গীতৰ আঁচলত' পুথিখনৰ বিশ্লেষণাত্মক আলোচনা

● দীপিকা ৰাভা
অধ্যাপিকা, অসমীয়া বিভাগ, বিকালী মহাবিদ্যালয়, ধূপধৰা।
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সংক্ষিপ্তসাৰ ঃ *ৰাভা জনগোষ্ঠীৰ এগৰাকী বিশিষ্ট সাহিত্যিক তথা সমাজ সংগঠক ৰাজেন ৰাভা সৌৰৱণী সাহিত্যিক বঁটা প্ৰাপ্ত স্মৰণীয় ব্যক্তি হ'ল হৰিমোহন সৰকাৰ। লোক সংস্কৃতিৰ গৱেষক এইগৰাকী ব্যক্তিয়ে ছাত্ৰ অৱস্থাৰে পৰা জাতিগত কলা-সংস্কৃতিৰ বিকাশত অহৰহ চিন্তা-চৰ্চাত নিজকে নিমজ্জিত কৰিছিল। অসম সাহিত্য সভাৰ সভাপতি বেণুধৰ শৰ্মাৰ অনুপ্ৰেৰণাত কামৰূপ আৰু গোৱালপাৰা জিলাত সিঁচৰতি হৈ থকা বহুৰঙী গীতসমূহ সংগ্ৰহত ইখন গাঁৱৰ পৰা সিখন গাঁও, দুৰ্গম বাস্তা খোজ কাঢ়ি, কান্ধত মোনা এখন ওলোমাই যাযাবৰ হৈ ঘুৰি ফুৰিছিল। ৰাভাসকলৰ হিয়াৰ আমঠু বহুৰঙী গীতবোৰ বুটলি আনি ১৯৬৫ চনত পুথি আকাৰে ছপা কৰি উলিয়ায়। পুথিখনৰ নাম ৰাখিছিল 'বহুৰঙী গীতৰ আঁচলত'। পুথিখনৰ গীতসমূহৰ মাজত প্ৰতিফলিত হোৱা ৰাভাসকলৰ সামাজিক-সাংস্কৃতিক, অৰ্থনৈতিক দিশ সুন্দৰকৈ দাঙি ধৰিছে। বৰ্তমান এই পুথিখন ছপা আকাৰত পাবলৈ নাই। গৱেষণা পত্ৰখনত পুথিখনৰ বিস্তৃত আলোচনা এটি দাঙি ধৰাৰ প্ৰয়াস কৰা হ'ব। পত্ৰখনত বিশ্লেষণাত্মক পদ্ধতি অৱলম্বন কৰা হ'ব।*

বীজ শব্দ ঃ *ৰাভা, বহুৰঙী গীত, হৰিমোহন সৰকাৰ, লোকগীত।*

অৱতৰণিকা ঃ

বিষয়ৰ পৰিচয় ঃ

ৰাভা সাহিত্য সংস্কৃতিৰ এগৰাকী সু-সাহিত্যিক, চিন্তাবিদ, সমাজ সচেতন ব্যক্তি হ'ল হৰিমোহন সৰকাৰ। গোৱালপাৰা জিলাৰ বৃহত্তৰ টিপলাই অঞ্চলৰ এক অখ্যাত গাঁও চিতলমাৰী বনগাঁৱত তেওঁৰ জন্ম। এই গাঁওখনত কেইঘৰমান ৰাভা সম্প্ৰদায়ৰ হোৱা বাবে তেওঁলোকে বিভিন্ন সম্প্ৰদায়ৰ লগত একেলগে মিলামিচা কৰিবলৈ যাওঁতে বিভিন্ন সমস্যাৰ সন্মুখীন হ'ব লগা হৈছিল। ৰাভা সম্প্ৰদায়ৰ জনজাতীয় ল'ৰা হোৱাৰ বাবে বিভিন্ন সমস্যাৰ সন্মুখীন হোৱা সত্বেও নিজৰ জাতি সত্তাক কেতিয়াও বিসৰ্জন দিয়া নাছিল। এইসকল লোকৰ আগত ৰাভা লোক বুলি পৰিচয় দি আত্মগৌৰৱ অনুভৱ কৰিছিল। এফালে দৰিদ্ৰতা আনফালে সমাজ তাতে জাতিটোৰ নামত কিবা এটা কৰাৰ দুৰ্বাৰ হেঁপাহ বা আকাংক্ষাই তেওঁক ছাত্ৰ অৱস্থাৰ পৰা বিভিন্ন সংগঠনৰ লগত জড়িত হৈ থকাৰ উপৰিও নিৰবিচ্ছিন্নভাৰে সাহিত্য চৰ্চা কৰিছিল। তেখেতৰ কলমৰ পৰা সৃষ্টি হৈছিল বহুতো নাটক, কবিতা, গীত আৰু বিভিন্ন বিষয়ৰ গৱেষণাধৰ্মী আৰু চিন্তাশীল প্ৰবন্ধবাজি।

বুৰঞ্জীবিদ বেণুধৰ শৰ্মাৰ প্ৰেৰণাত হৰিমোহন সৰকাৰে গোৱালপাৰা আৰু কামৰূপ জিলাত প্ৰচলিত পাতি ৰাভাসকলৰ মাজত পৰম্পৰাগতভাৱে চলি অহা বহুৰঙী গীতসমূহক সংগ্ৰহ কৰি ১৯৬৫ চনত 'বহুৰঙী গীতৰ আঁচল'ত নামৰ পুথিখন প্ৰকাশ কৰে। কিতাপখন সৰু হ'লেও গীতি সাহিত্য জগতত আপুৰুগীয়া সম্পদ। গীতৰ সংকলনটিৰ সম্পৰ্কত অসম সাহিত্য সভাৰ প্ৰাক্তন সভাপতি বেণুধৰ শৰ্মাই লিখিছে— এই সংকলন শ্ৰীমান হৰিমোহন সৰকাৰৰ

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WETLAND ANALYSIS AND MAPPING USING RS & GIS BASED SPECTRAL INDICES A STUDY ON TAMRANGA BEEL, BONGAIGOAN, ASSAM, INDIA

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Assistant Professor, Bhattadev University

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ABSTRACT

Wetland has its importance for its role in restoring, functioning, balancing, and its ecological productivity for various ecosystems. However, due to highly exploitation and threats on wetlands, Degradation and shrinking of wetland has become the major environmental issues at regional and global level. The present paper has made an analysis of the Tamranga beel (wetland) of Bangaigoan district through mapping using different spectral indices of Remote sensing and GIS. The main objective of this paper is to highlight the effective measurement of spatio- temporal wetland change for 18 years duration using LANDSAT7/8 OLI satellite images and GIS tools and techniques.

Keywords: Restoring, shrinking, spectral, spatiotemporal and satellite.

INTRODUCTION

Wetland is considered as the home for a large number of ecologically and economically important species. The Ramsar Convention defines wetland as "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres"(Sarkar Jaimini, 2011, Ramsar Convention Secretariat.) Wetlands are vital source for the environment to function in a balanced way that provides a biological diversity with enormous human benefits too. The Tamranga Beel is an important natural wetland, harbouring several fish species and providing livelihood opportunities for the local people. Human activities have been increasing on the wetland due to rising settlement in the surrounding area. Tamranga Beel is been polluted by dumping of garbage, drainage of sewage and waste products, surface run off carrying pesticides and fertilizers from nearest crop fields and many more such alarming activities. The wetland provides primary occupation to the local people like- agriculture, fishing, collection of fire woods, etc. The ever increasing human activities like land use, wetland use, etc. are the major driving forces which lead to the degradation of the wetland.

LITERATURE REVIEW

A number of research works has been done on the study of different aspects of wetland at different levels.**H. Jesse Walker et, al. (1987),**in the journal "Wetland Loss in Louisiana" write about the Coastal wetland loss in Louisiana, now considered to amount to more than100km2 / year. This loss is the result of a variety of complex interactions among numbers of physical, chemical, biological, and cultural processes.**Mahmud Mallik Sezan et, al. (2011),** in their journal "Remote Sensing & GIS Based Spatio-Temporal Change Analysis of Wetland in Dhaka City, Bangladesh" evaluates wetland changes in Dhaka Metropolitan Area (DMA), Bangladesh, between 1989 and 2009.**J .Garg, (2013)** in the article "Wetland assessment, monitoring and management in India using geospatial techniques", discusses that geospatial techniques have proven extremely useful for managers concerned with conservation and management of important wetlands.**M. Kalita et, al. (2018),** in the study topic "Vegetation coverage change and risk assessment-A case study of Chandubi Lake, Assam" examined on two major issues- one, the study of vegetation loss and secondly to map the wetland loss over 16 years from 2000 to 2016 using Remote sensing, GIS (Geographic Information System) analysis.

OBJECTIVES

The main objectives of the study are :

- To identify change detection of the wetland (in 18 years from 2002 to2020),
- To identify the physio-chemical elements of the wetland using various indices and
- To show the wetland loss identification and its impact on wetland ecosystem.

DATA BASE AND METHODOLOGY

The data base for this paper is mainly the satellite imageries i.e. Landsat 7 (Feb 17, 2002), having 7 bands and Landsat 8 (Jan 26, 2020), having 11 bands, collected from United States Geological Survey (USGS). The digital image processing has been done using ArcGIS 10.3 software.

The methodology consists of supervised classification of satellite imagery and then the extraction of the wetland using various indices such as NDVI, NDWI, MNDWI, NDTI and NDPI.

Table 1: Data specification of Landsat 7 and Landsat 8

Satellite	Sensor	Path-row	Spatial Resolution			Total bands
			Visible-MIR	TIR	Panchromatic	
LANDSAT 7	ETM+ L1	137 , 042	30	30	15	7
LANDSAT 8	OLI-TRIRS- LI TP	137 , 042	30	30	15	11

LOCATION OF THE STUDY AREA

The study area is situated in the Boitamari block area of Bongaigaon district, lies close to Bishnupur village. The wetland geographically located at 26°18'45" N latitude and 90°34'58"E longitude. The study area is surrounded in Northern side by Khagarpur and Bongaigaon town and Nimagaon & Hill block N.C. in the Western part, Abhayapuri town, Salamara in the North-East side and Sakumura, Chalantapara located in the West. The wetland situated 27 km away from Bongaigaon town and 11 km from Abhayapuri town (fig. 1).

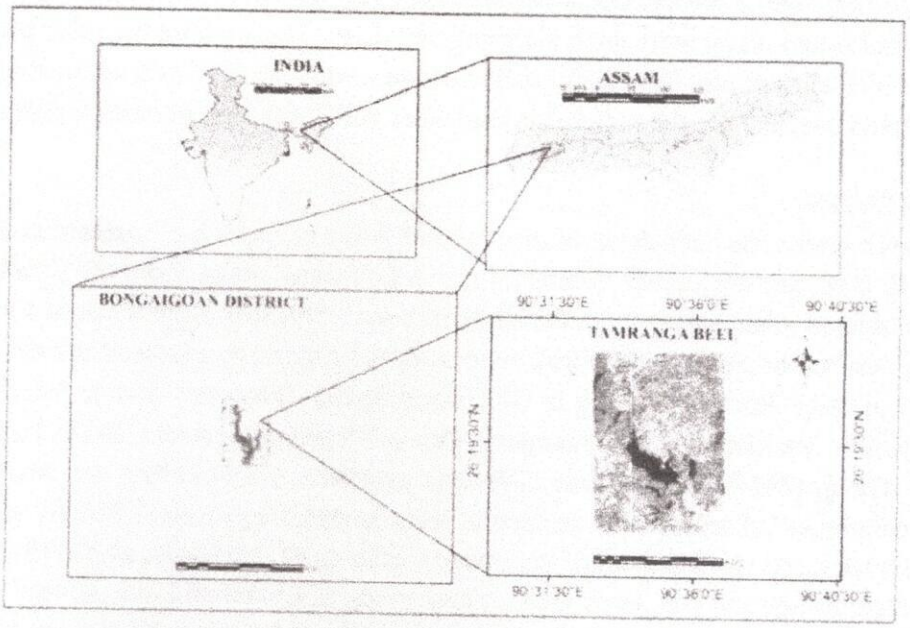

Figure :1 Location map of the study area

The formula for NDVI is - NDVI= NIR - RED/NIR + RED

Value of NDVI, between 0.2 to 0.4 is represented as sparse vegetation; value between 0.4 to 0.6 means moderate vegetation and above 0.6 is represented as dense

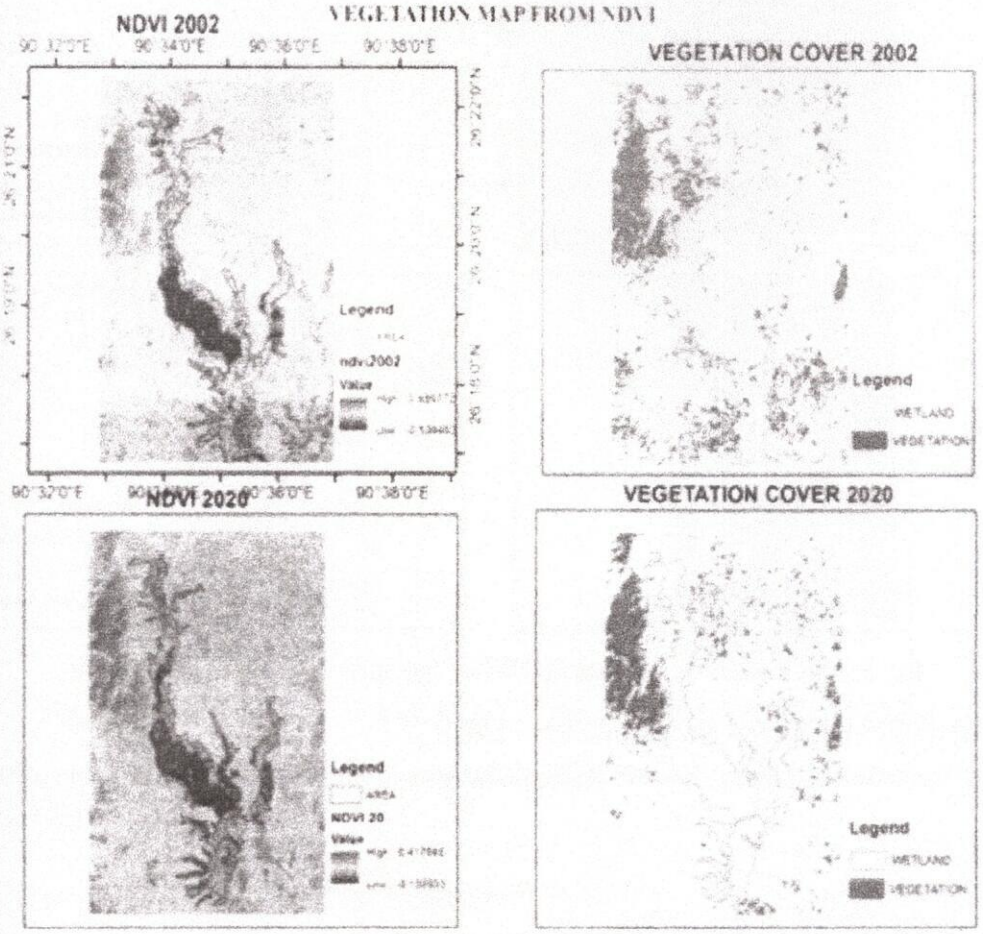

Fig.2: Vegetation map from NDVI of the study area (2002 and 2020)

vegetation cover. From the NDVI map (fig. 2) , it is seen that the vegetation cover has decreased from the region. From 2002 to 2020, a period of 18 years, the vegetation cover has lost 8.32 sq. km.

NDWI : It stands for Normalized Difference Water Index. It is used for monitoring the changes of water content in water bodies.

The formula for NDWI is- NDWI= NIR - SWIR/NIR + SWIR

The value of NDWI between -1 to 0 indicates no water content in this area and the value +1 indicates availability of water content. From the NDWI map, it can be seen that the water body has extended from 2002 to 2020. A good amount of water content and sufficient moisture can be seen available in the wetland (fig. 3).

MNDWI - The full from of MNDWI is Modified Normalized Difference Water Index. This index uses Green and SWIR bands for the enhancement of open water features.

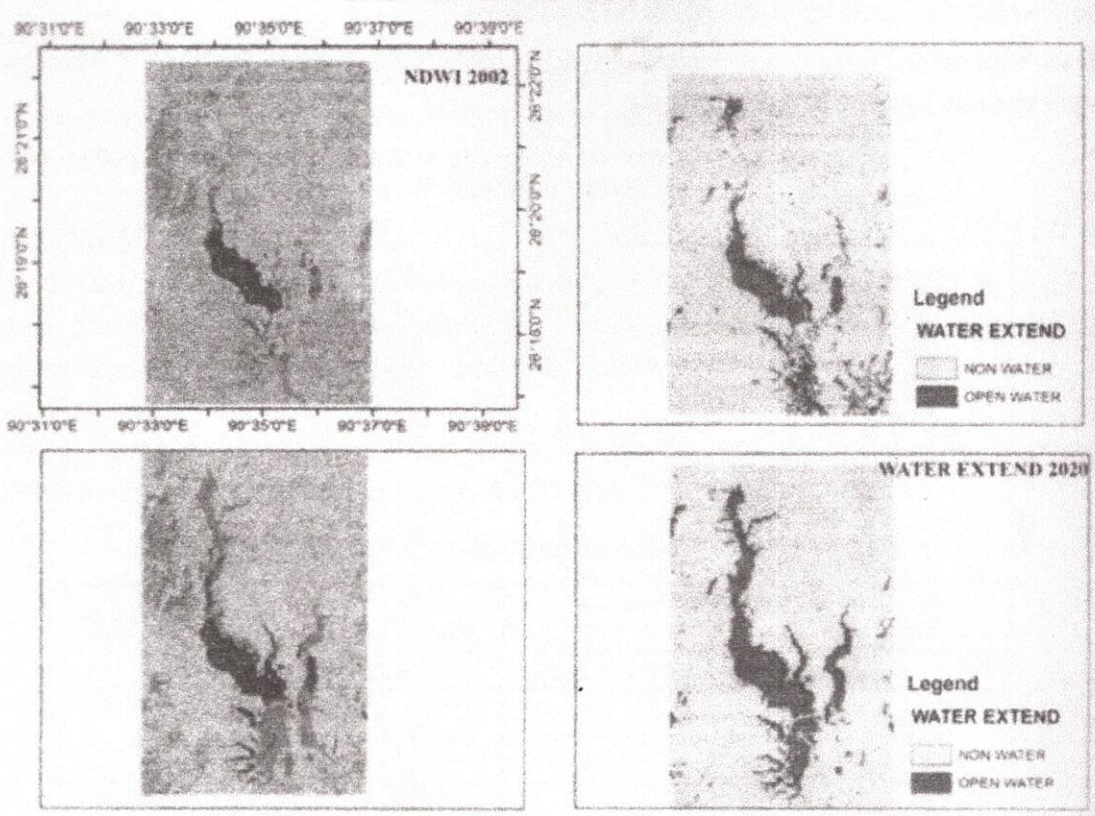

Fig.3: Open water map from NDWI of the study area (2002 and 2020)

Its formula is MNDWI= GREEN – SWIR/GREEN +SWIR .

The water body has extended from 2002 to 2020 in the area. This is a good water reservoir wetland of the region (fig.4).

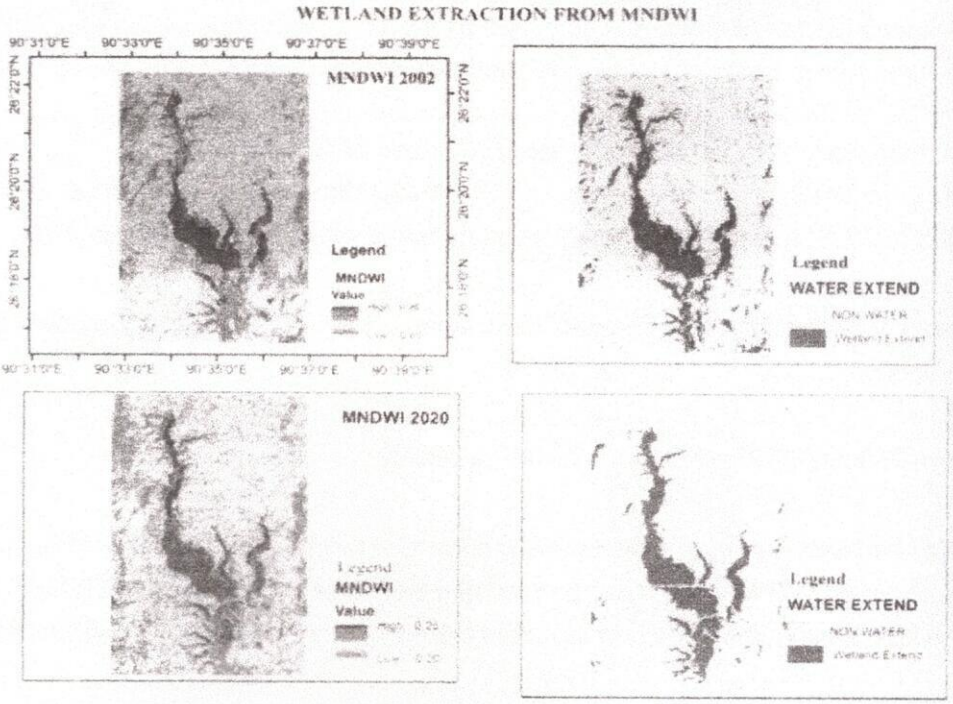

Fig.4 : Wetland extraction from MNDWI of the study area (2002 and 2020)

iv) NDTI - NDTI means Normalized Difference Turbidity Index.
It measures the amount of vegetation and their condition. Its formula is-NDTI= RED – GREEN/RED + GREEN. With NDTI map analysis, it is seen that the vegetation cover has lost in the area. In 2002, a good amount of vegetation cover was seen in the area. But from 2002 to 2020, the vegetation degraded (fig.5).

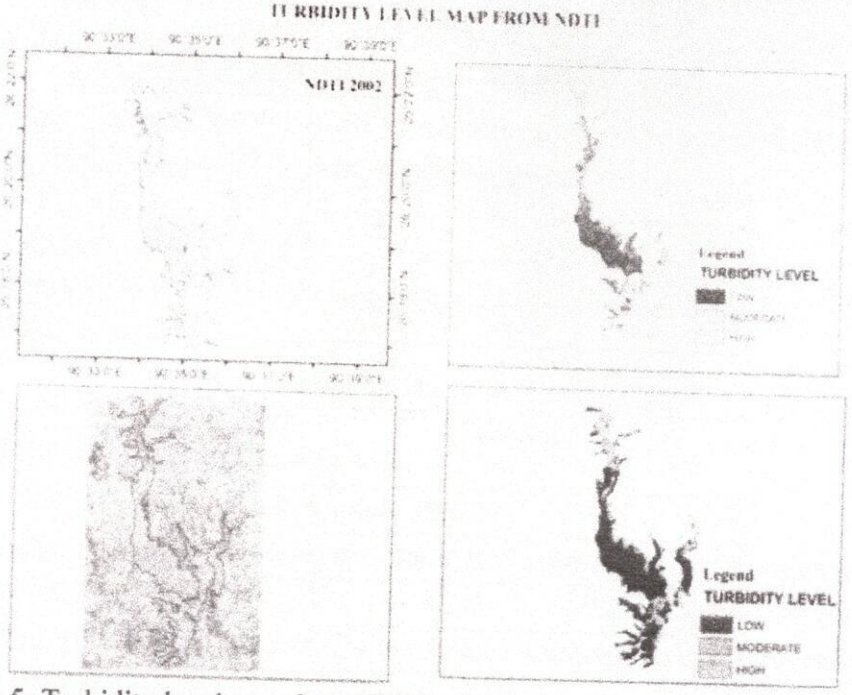

Fig.5: Turbidity level map from NDTI of the study area (2002 and 2020)

(v) NDPI - NDPI or Normalized Difference Pond Index exploits the low reflectance of water in SWIR and its contrast with the GREEN band.

Formula is – NDPI= SWIR – GREEN/SWIR + GREEN
Using this index, sole water body is extracted. It is used to see the turbidity level of the study area. It has been categorized as low, medium and high values (fig. 6).

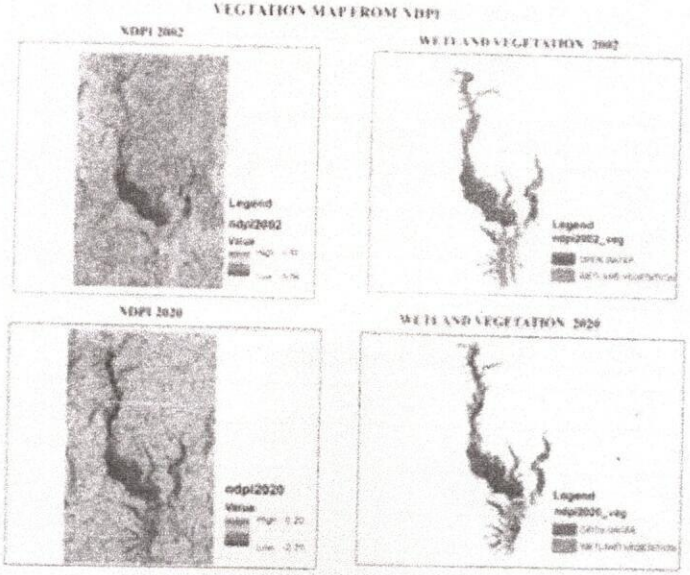

Fig.6: Vegetation map from NDPI of the study area (2002 and 2020)

THRESHOLD VALUES OF VARIOUS INDICES

Threshold defines a variable that is continuous, made into a binary (0 to 1) variable. In Geostatistical Analysis, if values are above the threshold, they become a 1, and if they are below the threshold, they become a 0. From the maps using the indices, with the help of threshold values, different characteristics can be determined. Like, a 0.25 threshold value can determine the vegetation cover. The threshold values are highlighted against different indices in the following tables (table .2,3,4,5 & 6).

Table 2: Area and threshold value of NDPI

	NDPI		Threshold values
Year	2002	2020	Wetland Vegetation : 0.25
Area	5.2	3.7	
Maximum	2.1	0.2	
Minimum	-0.92	-0.25	

Table 3: Area and threshold value of MNDWI

	MNDWI		Threshold values
Year	2002	2020	Wetland Extend: 0.15
Area	11.09	9.5488	
Max	0.96	0.25	
Min	-0.6	-0.6	

Table 4: Area and threshold value of MNDWI

	NDVI		Threshold values
Year	2002	2020	Forest Cover: 0.25
Area	16.17	7.6462	
Maximum	0.48	0.41	
Minimum	-0.53	-0.1	

Table 5: Area and threshold value of MNDWI

	NDWI		Threshold values
Year	2002	2020	Open Water: 0.10
Area	7.68	9.81	
Max	0.6	0.12	
Min	-0.38	-0.36	

Table 6: Area and threshold value of MNDWI

	NDTI		Threshold values
Year	2002	2020	Low
Area	3.31	5.05	
Maximum	0.11	2.51	Medium
Minimum	-0.22	1.93	
			High

ONCLUSION

amranga Beel area is naturally fertile providing the best foothold for agricultural practices. The wetland also ovides a permanent need for water to the crops. Rice, the staple food of the region, is grown in fair good mount. Vegetables are also grown, as food and also commercially. Most of the people of the neighbouring ea of the wetland are basically engaged in primary occupations like pottery, fire wood collection, etc. The per assessment of the resource availability of the study area using geospatial spectral indices has become ry much essential as this area has environmental as well as economical significant. The tables and figures of s paper thoroughly highlights the basic aspects of the study area with geospatial data base. It needs more d more research works on this area for further precise investigation.

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The occurence of the least pipistrelle Bat, *Pipistrellus tenuis* (Temminck, 1840) (Chiroptera: Vespertilionidae) in Goalpara District, Assam, India

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Key words: Chiroptera, Morphometrics, Least pipistrelle, Vespertilionidae, Assam

Abstract

A recent survey identified a colony of *Pipistrellus tenuis* (n = 5) in Kanyakuchi Pahar village (26°00'32.8"N 90°53'29.0"E), a rural remote site situated at Goalpara district of Assam. This species, commonly known as the Least Pipistrelle, was previously reported by Hinton and Lindsay (1926), Sinha (1999), Ghosh (2008), Saikia *et al.* (2011) and Boro *et al.* (2018) from different parts of Assam. The Goalpara district of western Assam is encircled by the foothills of Meghalaya to the South and the Brahmaputra River to the North possesses a variety of flora and fauna due to the dense foliage of the high forest canopy. The climatic condition of the region along with its topography favours roosting of bat population. The distribution of the bat species *P. tenuis* in the surveyed area has not been previously recorded. For the purpose of taxonomic identification, morphometric parameters (external and cranio-dental measurements) were compared to standard literature by Bates and Harrison (1997). Captured bat specimens (n=3) were examined at the ZSI (Zoological Survey of India), NERC-Shillong, Meghalaya. The recorded mean body weight of captured specimens was 2.61g ± 0.160 (S.D) and the mean forearm length (FA) was 27.39mm ± 0.165 (S.D). This manuscript validates sightings of this bat species at the study location, compares its morphometric and cranio-dental traits to standard literature (Bates and Harrison, 1997) for identification, discusses its distribution as well as its ecological importance.

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Introduction

Bats are the only mammals that can fly for long periods of time, making them the second-largest order of mammals with over 1,400 different species. The two suborders of bats, Microchiroptera (echolocating bats) and Megachiroptera (Old World bats) make up the taxonomic group Chiroptera. 127 species of bats from India were listed by Talmale and Saikia (2018) and were categorised into 41 genera and 9 families. About 39 different bat species, divided into 16 genera, are found in Assam, including 34 Microchiropteran species and 5 Megachiropteran species (fruit bats) (Ali, 2022). The Himalaya and Indo-Burma Biodiversity Hotspot, which includes Northeast India, contains 74 species of the 127 species of bats that are known to exist in India (Saikia, 2019). There are nine families in the order Chiroptera that are represented in India: Pteropodidae, Megadermatidae, Hipposideridae, Rhinolophidae, Emballonuridae, Rhinopomatidae, Molossidae, Vespertilionidae, and Miniopteridae.

With 62 species, the family Vespertilionidae (commonly known as evening bats) is the most diverse and numerous family of bats found in India (Saikia 2019; Ali, 2022). The tiniest pipistrelle found in the Indian subcontinent belongs to the Vespertilionidae family and is known as the least pipistrelle (Figs. 2 and 3). The genus Pipistrellus has 51 species worldwide, including 12 species being found on the Indian subcontinent (Koopman, 1993). It's prevalent over the majority of Southeast Asia, Southeast China, and South Asia (Simmons, 2005). This species is found in Pakistan, Bangladesh, Afghanistan, India, Nepal, and Sri Lanka (Molur *et al.*, 2002; Das, 2003; Vanitharanie, 2006; Korad, 2007). This bat occasionally shares a roost with Indian Pipistrelles, but they don't interact with one another. They frequently form colonies of 1 to 25 individuals and are present in both woodlands and populated places and often prefer living in close proximity to human population. They build their nests in trees, leaf canopies, the ceilings or walls of buildings, and abandoned homes (Francis *et al.*, 2010). Seasonal variations in the species' diet are evident. It consumes a variety of insects and beetles during the monsoon and summer, and termites, cockroaches, wingless ants, and moths during the winter (Hamidullah *et al.*, 2019).

P. tenuis are categorised as insectivorous bats in terms of preferred diet and feeding habits. A typical pipistrelle bat can often consume one-third of its body weight in insects per night, significantly lowering the number of insects. They devour a lot of insects at night, which costs the US $3.7 billion in pest control every year. It has been shown, according to the Smithsonian Tropical Research Institute and the University of Michigan that places with insectivorous bat populations greatly reduce the amount of insects and plant damage (Kalka *et al.*, 2008). Recent study on the reproductive activity of the *P. tenuis* species indicate that there are two peaks between the months of July and August, and one between February and March. The greatest abundance of prey occurred during each of these times. In China and India, pregnant and nursing females have been spotted at all times of the year, proving that reproduction is possible all year long (Wilson and Mittermeier, 2019). Due to their nocturnal lifestyle and ecological diversity, bats are a fascinating group of animals as well as a difficult species to research.

A number of researchers from the Zoological Survey of India and other institutions have made significant contributions to the study of Indian bat taxonomy and geographic distribution in the post-independence era. Some of the most important revisions of the geographical range and taxonomy of Indian bats include Brosset (1962abc, 1963); Hill and Corbett (1992); Bhat and Kock (1994); Sinha (1970, 1973, 1999); Bates & Harrison (1997); Pradhan (2008); Das (2003); Csorba *et al.* (2003); Ramarkishna *et al.* (2003); Ghosh (2005, 2008); Srinivasulu (2001, 2006); Alfred, (2006). A monograph by Bates & Harrison (1997) listed 28 species of bats from Assam. Recently, there are only a few significant works on the study of different species of bats in the state of Assam by Sinha (1999), Ghosh (2008) and Boro *et al.* (2013; 2015; 2018), Ali (2010; 2022), Rahman and Choudhury (2017), Saikia *et al.* (2011; 2018; 2019; 2021).

Furthermore, little is known about the distribution and taxonomic status of bats, notably microchiroptera, in the Assam region. This article aims to investigate the distribution and current status of the Pipistrellus genus in Assam's Goalpara district. This paper on *Pipistrellus tenuis* occurence is the first at the study site (Fig. 1) and is based on measurements of morphometric features in comparison to current standard literature (Bates and Harrison, 1997).

Materials & methods

Study area

The present study was carried out at the village of Kanyakuchi Pahar in the Goalpara district of Assam, India (26°00'32.8"N 90°53'29.0"E). It is 52 kilometres from Goalpara, the district headquarters, and 12 kilometres from Dudhnai, the subdistrict headquarters. Only 86 families reside in the 936.11 hectares of the studied area (Fig. 1; Census 2011). Most of the study site is covered in Banana, Saal, Bamboo, and Teak trees.

The habitat of the study area were found ecologically suitable for the expansion of the bat population because of it's high dense forest and has few caves, and streams on the sides of hills. The area's climate is ideal for a humid subtropical region with dry winters (Classification: Cwa). The district receives yearly temperatures of 27.55 °C and precipitation totals of 82.07mm. The yearly rainfall ranges from 3805mm to 149.8 inches (Climate-data.org, 2022). Google Maps provided the locational map (Fig. 1) of the survey region.

Survey method

There has been plenty of evidences which reported that there were bats at the investigation site (26°00'32.8"N 90°53'29.0"E). The survey was conducted with the help of the villagers from 18:30 to 20:30 in the evening. In a small area of the ceiling of an abandoned house in the village, five bats were discovered to be nesting. With the aid of a modified butterfly net (59-inch extendable handle, a 14-inch net ring, and 0.8mm net holes), the bats were driven out of the narrow space. Only a small number (n=3) of bats were collected, immediately released, and while under anaesthesia in 70% ethanol for subsequent investigation, stored as taxonomic voucher specimens.

Morphometric measurements and identification

Multiple measurements of the characteristics required for precise identification had to be made during capture (n=3). Records of external body measures were made. Following that, morphometric characteristics were measured with a millimetre calliper (Zhart-150mm/6") with accuracy as close to 1mm as possible.

Every single specimen was measured, and measurements were recorded for comparison with available literature (Table 2). Cranio-dental measurements were recorded by dissecting and preparing the skulls of the same bats (n=2) for further taxonomic identification and confirmation of the species.

The acronyms of the different body and skull measurements (Table1; Table 2) are FA: Forearm length; TIB: length of tibia; T: Tail length; HB: Head and body length; Tr: Tragus length; E: Ear; 3mt: 3rd metacarpal, 1ph3mt: length of 1st phalanx to third metacarpal; 2ph3mt: length of 2nd phalanx to 3rd metacarpal; 3ph3mt: length of 3rd phalanx to third metacarpal; 4mt: length of the 4th metacarpal; 1ph4mt: length of 1st phalanx to fourth metacarpal; 2ph4mt: length of 2nd phalanx to 4th metacarpal; 5mt: 5th metacarpal; 1ph5mt: length of 1st phalanx to fifth metacarpal; 2ph5mt: length of 2nd phalanx to 5th metacarpal; HF: hind leg length; WSP: Total wingspan length. GTLi: Greatest length of skull including incisor; CCL: Condylo-canine length; GTL: Greatest length of skull; BB: Breadth of braincase; CBL: Condylo-basal length; ZW: Zygomatic width; MAB: Under the brain; M3 -M3: width across third molars; CM^3: maxillary tooth; CM_3: row of mandibular teeth; ML: Mandible length.

Body mass (g), identification of the reproductive stage and sex

A digital weighing scale (Range 0.1g-10kg) was used to measure the weight (g) of each specimen. Ossification of the phalanges acted as a marker for adult or juvenile reproductive stage, whereas the presence of external genitalia served as a sex distinguishing trait (Kunz, 1988). For further detailed identification and confirmation, the captured bat specimens were analyzed at the laboratory down to the species level at Zoological Survey of India (ZSI), NERC-Shillong, Meghalaya.

Statistical Calculation

Standard deviations were calculated to measure the deviation of raw data. A low standard deviation indicates that data points are generally close to the mean or the average value.

A high standard deviation indicates greater variability in data points, or higher dispersion from the mean. For n number of specimens (Table 1), the mean or the average value for the range of measurements is calculated first and later standard deviation is calculated using online software tool (calculator.net).

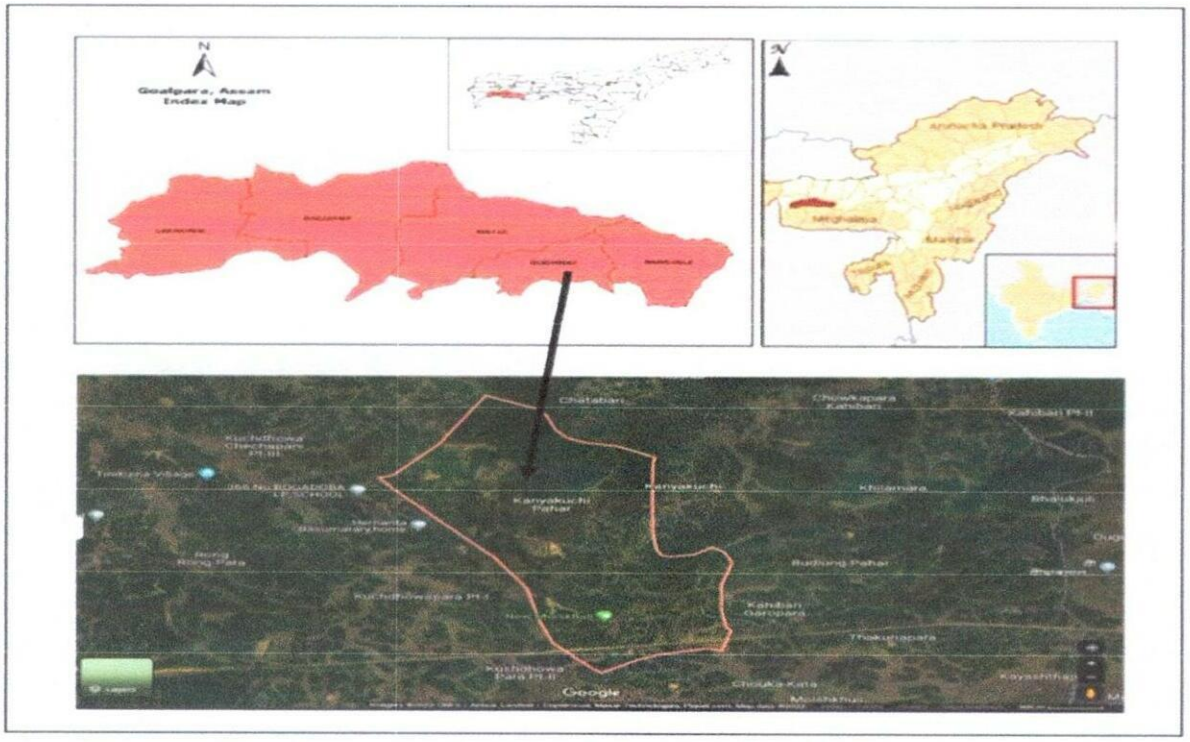

Fig. 1. Map indicating the location of the *P. tenuis* bat roost found in the Goalpara district of Assam (26°00'32.8"N 90°53'29.0"E).

Results and discussion

Morphologically, the upper portion of *P. tenuis* coat was medium brown in appearance. This specimen had a paler ventral surface. The ears were short and oval-shaped, with weekly folds along the back border. The end of the tragus is short and blunt. Similar traits have already been identified (Javid *et al.*, 2011; Saha *et al.*, 2015). The specimens(n=3) collected for this investigation had an average body mass of 2.61mm ± 0.160 g, head and body length of 42.53mm ± 2.336mm, and forearm length of 27.39mm ± 0.165mm. The average lengths of the 3rd, 4th, and 5th metacarpals were (25.85mm ± 0.623mm, 25.45 ± 0.82mm, and 24.66mm ± 1.312mm, respectively). The tail length was measured at 18.94mm 1.625mm, while the average wingspan was 147.133 33.987mm (Table 1).

Based solely on external characteristics, *Pipistrellus tenuis* is difficult to differentiate from its congeners (Bates and Harrison, 1997). This species' detailed skull measurements (n=2) revealed that the mean

GTL was 9.75mm with a standard deviation of 0.176, the braincase width was 5.68mm with a standard deviation of 0.042, and the jugular width was 6.39mm with a standard deviation of 0.332. Average CCL, CBL, and mandibular length (ML) were, respectively, 9.37mm 0.14 (SD), 9.38mm 0.254, and 7.51mm 0.011mm. It was noted that the dental pattern was 2123/3123=34.

The dissected skull's lateral aspect is shown in (Fig. 4).It varies from *Pipistrellus coromandra* in the following ways: its body is delicately formed; the CBL and M^3-M^3 are smaller in size (Korad *et al.*, 2004). According to morphometric data (Table 1) from the specimen used in this investigation and measurements of additional cranio-dental features, this species is primarily identified as *P. tenuis* (Fig. 2).

The systematic classification of the identified species is :

Phylum-Chordata
Class-Mammalia
Order-Chiroptera
Family-Vespertilionidae
Genus- *Pipistrellus*
Species-*Pipistrellus tenuis* (Temminck, 1840)

In comparison to members of the genus Myotis, members of the genus Pipistrellus have smaller muzzles and fewer teeth. They are plain-faced bats with typically tiny eyes, a simple, well-developed tragus, and a tail that is not completely free of uropatagium. The majority of them are brown, grey, or dark brown in colour (Elangovan, 2018).

P. tenuis, a member of the family Vespertilionidae, is the smallest bat that has been discovered in India. The average forearm length (FA) of this pipistrelle in India is 27.7mm (Bates and Harrison, 1997; Saikia *et al.*, 2011). They have been seen breeding near to human habitations in bamboo openings of huts and shelters, building roofs and crevices, and tree cavities where they reside in tiny groups (Molur *et al.*, 2002; Acharya, 2010).

Occasionally, this bat and the Indian pipistrelle cohabitate the same roost, but they don't interact. In its habitat, *P. tenuis* bats play a critical role in controlling insect populations.

This species typically hunts in close proximity to the ground and favours to consume tiny insects from many orders, such as the Coleoptera, Hymenoptera, Diptera, and Lepidoptera (Saikia *et al.*, 2021). It uses echolocation to find prey, and in a few rare instances, it has been seen catching prey with its wings before catching it with its jaws.

In Table 2, measurements from the current study were compared with the earlier records of Bates and Harrison (1997) and Saikia *et al.* (2011).

The mean values and its ranges of the collected specimens for morphometric parameters such as head and body length, ear length, forearm length, length of the third metacarpal, length of the fourth metacarpal, length of the fifth metacarpal, and tail length are in accordance with the findings of Bates and Harrison (1997). The similar outcome has been demonstrated for cranio-dental parameters such as mandibular length and braincase breadth. However, in certain instances, the measurements with Saikia *et al.* (2011) are fairly similar.

A low standard deviation of FA, TIB, Tr, GTL, CM_3, CM^3 and BB of the morphometric parameters (Table 1; Table 2) indicates that data points are generally close to the mean or the average value. This species does not appear to be under any significant long-term threats given the local abundance it possesses throughout its geographic range (Francis *et al.*, 2010).

This widely distributed and somewhat adaptable species of pipistrelle is not at high risk, although in some areas, it is threatened by localised hunting for both food and medicine (Molur *et al.*, 2002).

The behavioural, roosting, and feeding habits of *P. tenuis* are highly diverse.

Table 1. External, cranial and dental measurement (mm) of *Pipistrellus tenuis*.

External body measurements (n=3)	(Mean / ± S.D)	Cranial & Dental Measurements (n=2)	(Mean / ± S.D)
HB	42.53mm ± 2.336	GTL	9.75mm ± 0.176
T	18.94mm ± 1.625	GTLi	9.67mm ± 0.106
TIB	9.4mm ± 0.173	CBL	9.38mm ± 0.254
FA	27.39mm ± 0.165	CCL	9.37mm ± 0.014
E	6.72mm ± 0.530	BB/BW	5.68mm ± 0.042
Tr	3.56.mm ± 0.015	MAB	5.86mm ± 0.098
Thumb	3.61mm ± 0.127	ZB	6.39mm ± 0.332
3mt	25.85mm ± 0.623	M^3 -M^3	4.66mm ± 0.098
1ph3mt	9.76mm ± 0.661	CM^3	3.67mm ± 0.035
2ph3mt	7.72mm ± 0.079	CM_3	4.02mm ± 0.042
3ph3mt	6.05mm ± 0.205	ML	7.51mm ± 0.001
4mt	25.35mm ± 0.607		
1ph4mt	9.42mm ± 0.747		
2ph4mt	7.03mm ± 0.721		
5mt	23.66mm ± 1.312		
1ph5mt	5.73mm ± 1.001		
2ph5mt	4.11mm ± 1.028		
HF	4.17mm ± 0.049		
Weight	2.61 g ± 0.160		
WSP	147.133± 33.987		

*Mean and S.D (Standard deviation) is calculated for a range of "n" number of specimens.

Table 2. Body mass (g), external, and cranio-dental measures (mm) of several *P. tenuis* specimens were compared to previously published literature.

External body Parameters	Bates & Harrison, 1997	Saikia *et al.*, 2011	Present Study (n=3)
Body mass	---	-----	2.61 ± 0.160
Head and Body length	39.1(33.0-45.0)	37-37.5	42.53 ± 2.336
Ear Length	9.7(5.0-11.0)	8.0-8.2	6.72 ± 0.530
Tragus Length	---	3.4-4.0	3.56 ± 0.015
Forearm	27.7(25.0-30.2)	27.5-28.5	27.39 ± 0.165
3rd metacarpal	26.7(23.9-29.7)	----	25.85± 0.623
4th metacarpal	26.4(23.7-29.2)	----	25.35± 0.607
5th metacarpal	25.9(23.5-28.5)	----	23.66± 1.312
Tibia	----	11.9-12.0	9.4 ± 0.173
Tail	28.9(20.0-35.0)	29.0	20.35 ± 1.625
Cranio-dental Parameters			Cranio-dental (n=2)
Breadth of braincase	6.0(5.6-6.3)	5.8-6.2	5.68 ± 0.042
Zygomatic breadth	7.4(7.3-7.6)	7.4	6.39 ± 0.332
Condylo-canine length	10.2(9.3-10.7)	10.3-10.5	9.37 ± 0.014
Condylo-basal length	------	10.8-11.0	9.38± 0.254
Greatest length of skull	11.5(10.7-12.1)	11.2-11.4	9.75± 0.176
Maxillary toothrow	------	3.8-3.9	3.67± 0.035
Mandibular toothrow	------	4.0-4.3	4.02± 0.042
Mandible length	7.9(7.2-8.3)	8.0-8.1	7.51± 0.001

*Mean and S.D (Standard deviation) is calculated for a range of "n" number of specimens. Bates & Harrison, 1997= (n=2), Saikia *et al.*, 2011= (range) and Present study=(n=3; n=2)

Fig. 2. *P. tenuis* (Female).

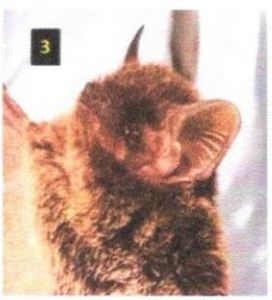

Fig. 3. Distinct ear with week folds.

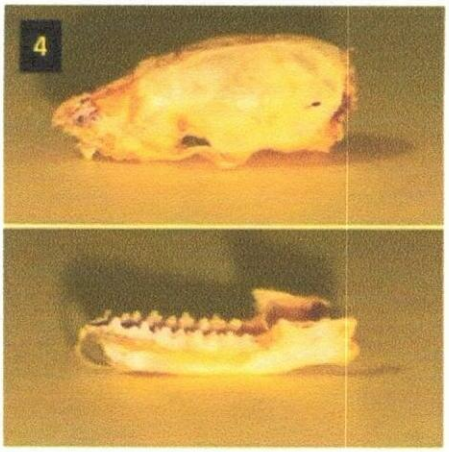

Fig. 4. Lateral view of Skull *(P. tenuis).*

Conclusion

P. tenuis has probably expanded in its niche range throughout the Goalpara district, as evidenced by the colony of the species that can be found in the study area. The existence of this species has allowed the co-existence of other chiropterans that usually breed in Assam and other ecosystems of the region. If further in-depth investigation is conducted in the Assam, it may reveal more details about bat diversity. Ecologically, if this insect-eating bat (*P. tenuis*) vanishes due to varied anthropogenic pressure, the insect population will rise, resulting in crop failures and other economic harm across its habitat (ADW 2022; BCI 2022). Gathering information about *Pipistrellus tenuis* and analyzing its morphometric parameters and its distribution will provide a baseline data for future taxonomic studies.

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Conflict of interest

Both the authors declare that we have no conlict of interest.

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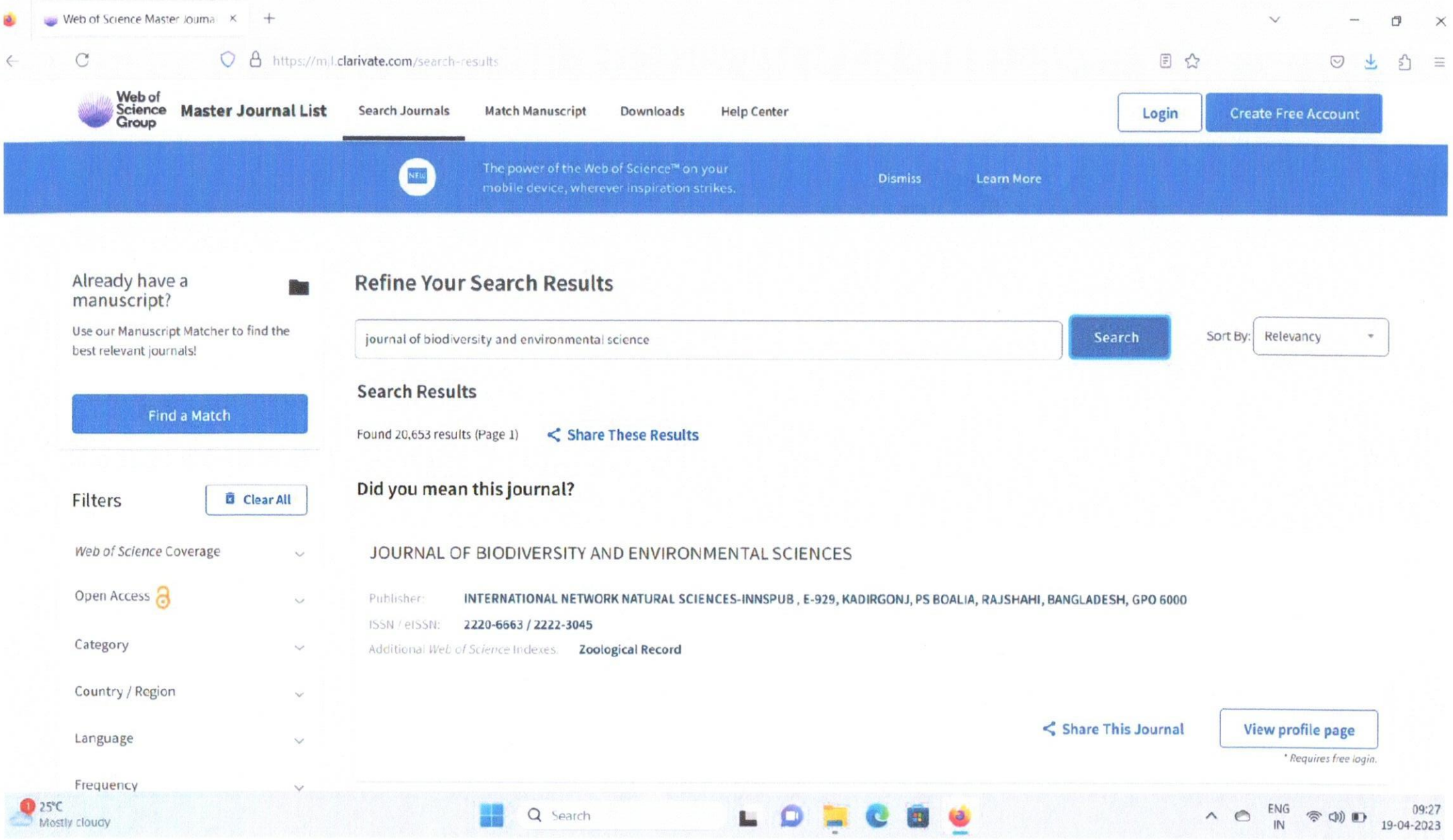
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