News and Notes

Agrogeology and its Awareness in the Indian Context: Bridging Geosciences and Sustainable Agriculture

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India, a country with a deeply rooted agrarian economy supports over 50% of its population through agriculture, has a rich agricultural legacy stretching back over 10,000 years. Today, it ranks second globally in agricultural production (India economic survey, 2018). While agronomic advancements have improved food security, declining soil health, water scarcity, and unsustainable farming practices pose long-term threats. Agrogeology, which integrates geology with agriculture, offers a scientifically grounded method for addressing these issues by utilizing naturally occurring rocks and minerals to replenish soil nutrients and manage land sustainably.

Despite India's geological richness, agrogeological practices are underutilized. This paper seeks to examine agrogeology's relevance and current awareness levels in India and proposes actionable pathways for its integration into mainstream agricultural practices. Despite a gradual decline in its share of GDP, agriculture remains India's largest industry and a pillar of its socioeconomic development. The key 9 states which play a major role in the agrarian development of India (see the Agricultural map of India at https://www.mapsofindia.com/indiaagriculture/) are Punjab, Uttar Pradesh, Madhya Pradesh, Haryana, Bihar, Andhra Pradesh, Maharashtra, West Bengal and Gujarat (Table 1). The total arable territory in India (15,73,50,000 km^2, which represents about 52.92% of the overall land zone of the country) is diminishing due to continuous strain from increasing number of inhabitants and growing urbanisation. Salient features of Indian agriculture and challenges (Table 2-3) reveal need for geological inputs e.g., agromineral resource assessments, the mapping and classification of soils and soil amendments, the evaluation of landscapes for their vulnerability to physical and chemical degradation, regional geochemical studies of plants, trace element deficiencies and toxicities, broad-scale water quality investigations, agricultural chemicals and the hydrogeologic interface, and minimally processed and ion-exchange agrominerals. In this context, the Government of India has been trying to put into operation different plans to increase investment or outlay in merchandising and commercialising (Table 4) and using the institutional supports [e.g. Indian Council of Agricultural Research (ICAR): Apex body for research and education; Indian Agricultural Research Institute (IARI): Pioneered Green Revolution; develops testing and research models].

An additional objective is to enhance agricultural productivity through geological resources that improve soil chemical and physical properties, including agrominerals such as phosphate rock, potassium minerals, and zeolites. This paper reviews preliminary agrogeological strategies, including mineral amendments and soil pH correction, highlighting India's strong potential for agrogeological innovation despite technical, institutional, economic, and social challenges, and proposes recommendations to address these constraints.

Table 2: Salient Features of Indian Agriculture

Feature	Description
Subsistence Farming	Predominantly small-scale farming for family consumption.
Population Pressure	Growing population strains food supply and land availability.
Limited Mechanisation	Partial adoption since Green Revolution; full mechanisation yet to occur.
Monsoon Dependency	66% of agriculture still depends on monsoon rains.
Role of Animals	Draft animals are essential for tilling, transport, and irrigation.
Crop Diversity	Supports both tropical and temperate crops due to varied climate and soils.
Food Crop Focus	Priority on food crop production (rice, wheat, pulses)
Seasonal Cropping	Three main seasons: Kharif, Rabi, and Zaid

Table 3: Challenges in Indian Agriculture

Problem	Details
Production Stagnation	Yield of key crops like wheat has plateaued
Soil Exhaustion	Overuse of land and monocropping has depleted soil nutrients
Declining Groundwater	Over-irrigation and dependency on underground water have led to sharp declines
Rising Input Costs	Increased prices of fertilizers, seeds, pesticides, and labor hinder small farmers

Table 1: Major Agricultural States in India

State	Contribution Highlights
Punjab	Major producer of wheat and rice
Uttar Pradesh	Largest food grain producer
Madhya Pradesh	Leading in pulses and oilseeds
Haryana	High productivity in wheat and dairy
Bihar	Strong in maize, pulses, and vegetables
Andhra Pradesh	Leading in rice and tobacco
Maharashtra	Major producer of cotton and sugarcane
West Bengal	Top in rice, vegetables, and fish production
Gujarat	Strong in groundnut, cotton, and livestock

Table 4: Government Initiatives

Initiative	Objective
Market Research & Information Network	Data for better decision-making and pricing
Construction of Rural Godowns	Reduce post-harvest losses, improve storage
Grading and Standardisation	Ensure quality of produce
Agricultural Marketing Infrastructure	Boost infrastructure for farm-to-market linkage

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Background and Problem Identification

Geological substrates control soil mineralogy, acidity, and moisture. Agrogeology examines parent rock influence on soil formation, applies rock-based amendments to enhance fertility, and integrates mineralogical and hydrogeological mapping for sustainable land use and long-term soil health. The use of raw materials as fertilizers dates back to the 1800s and at present also major 5 raw materials from geological knowledge are noteworthy (Table 5). In 1927–28, Norwegian chemist Erling Bjarne Johnson developed the nitrophosphate process (also known as the Odda process), which acidifies phosphate rock with nitric acid to produce nitrogen fertilizers without generating gypsum waste. However, the first agrogeology project to receive major funding was the Tanzania-Canada project in 1989. This initiative aimed to assist farmers in southern Tanzania by identifying and testing local raw materials to enhance soil productivity (Chesworth, 1989).

Industrial fertilizers becoming more of an issue for farmers (as costs continue to increase) and also for environmentalists with ecological concerns. Thus, many people have been searching for alternatives like the use of multi-nutrient rock fertilizers (contain micro-nutrients, such as K, Ca, and Mg, and P) which mimic natural weathering of geological rocks to form soil over long periods of time (Yadav, 2017; Singh, 2011; Powell and Jeannette, 1978; Peter Van, 2007; Singh and Eric, 2021). By utilizing locally available geological materials—such as phosphate rocks, carbonates, and zeolites—agrogeology provides an alternative to conventional chemical fertilizers, reducing dependency on imported inputs and lowering costs for farmers. By harnessing the potential of geological resources, this emerging field offers promising solutions for enhancing agricultural resilience and productivity.

Approximately 30% of the India's land is degraded due to factors such as erosion, salinization, and nutrient depletion, leading to an annual economic loss of Rs. 2.54 trillion, or about 2% of the GDP (Government of India, 2023). As per India water portal, over ~70% of Indian soils suffer from acidity or alkalinity, and widespread deficiencies in essential nutrients like nitrogen, phosphorus, potassium, and micronutrients such as zinc and boron further exacerbate the decline in soil fertility (Patra *et al.*, 2015). According to ICAR there are eight major soil types in India (Fig. 1), which in turn are related to geological setting of different provinces (Table 6). Therefore, Sustainable agricultural development must integrate geological mapping, erosion control, and aquifer management.

Agrogeological Diversity in India

India exhibits immense agrogeological diversity (Table 7) due to its complex geological history, varied climate zones, and physiographic features. This diversity results in a wide range of soil types (Fig.2), mineral availability, landforms, and water resources that influence agricultural practices and productivity across regions. Understanding this diversity is essential for applying agrogeological principles to promote soil health, improve nutrient management, and ensure sustainable land use. The correlation between soil types and underlying geology across India forms the basis of agrogeological practices. Each terrain-specific soil presents unique challenges and opportunities for crop production.

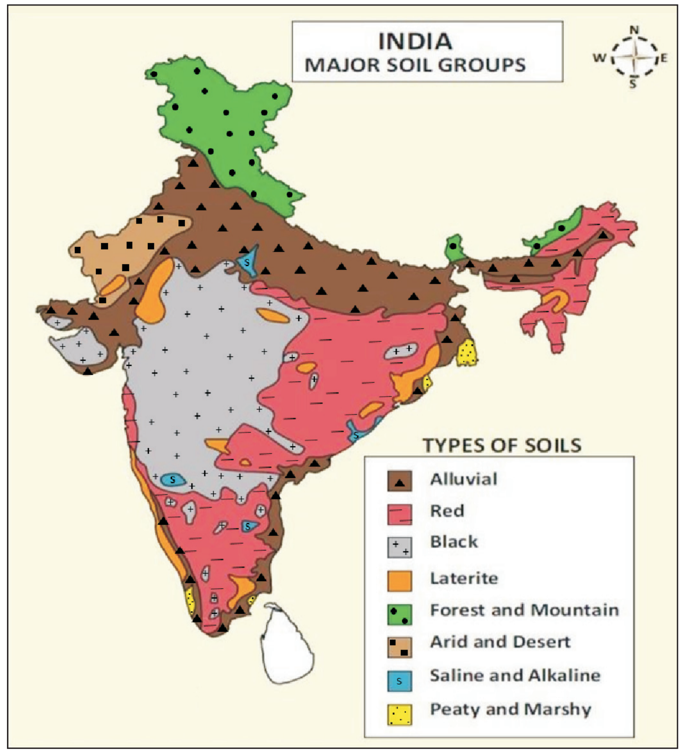

Fig. 1. Map showing different soil types in India as per ICAR classification

Deccan Traps (Western and Central India)

The Deccan Traps region, covering Maharashtra, Madhya Pradesh, Gujarat, and parts of Karnataka and Telangana, is underlain by Cretaceous basaltic lava flows and is characterized by regur (black cotton) soils rich in iron, magnesium, and calcium but deficient in nitrogen and phosphorus. These soils are well suited for crops such as cotton, soybean, and sorghum, and their productivity

Table 5: Major minerals play significant roles in sustainable agriculture by enhancing soil fertility, correcting nutrient deficiencies, and improving soil structure and pH balance

Mineral	Agricultural Use	Supporting Details
Apatite	Slow-release phosphate source in acidic soils	Apatite, a primary component of phosphate rock, gradually dissolves in acidic conditions, providing a sustained release of phosphorus essential for plant growth
Carbonate	Liming material to neutralize soil acidity	Calcium carbonate (CaCO?), commonly found in limestone, is used to raise soil pH, thereby reducing acidity and alleviating related toxicities such as aluminum toxicity
Malachite	Correction of copper deficiencies	Malachite, a copper carbonate hydroxide mineral, can be utilized to address copper deficiencies in plants, especially in soils with low available copper levels
Scoria	Mulching material for water conservation and nutrient release	Scoria, a porous volcanic rock, serves as an effective mulch, aiding in soil moisture retention and gradually releasing nutrients as it weathers
Zeolite	Enhances nutrient retention and raises soil pH	Zeolites, particularly clinoptilolite, improve soil health by conserving nitrogen, facilitating phosphorus release from apatite through coupled reactions, and increasing soil pH, thus mitigating acidit

Table 6: Different types of soil in India as per ICAR

Soil Type	Percentage	Characteristics	Region
Alluvial Soil	29.55%	Found in the Upper and Middle Ganga plains. Two types: Khadar (new) and Bhangar (old). Fertile and good for agriculture.	Northern plains (Punjab, UP, Bihar, WB)
Black Soil	19.62%	Also called 'Regur' or 'Black Cotton Soil'. Rich in clay and retains moisture; ideal for cotton cultivation.	Deccan Plateau (Maharashtra, MP, Gujarat)
Red Soil	19.62%	Reddish due to iron content; develops from crystalline/metamorphic rocks. Turns yellow when hydrated.	Southern and eastern peninsular India
Desert Soil	14.02%	Sandy and saline in nature; low organic matter.	Rajasthan, parts of Gujarat
Laterite Soil	4.77%	Rich in iron and aluminum; poor in fertility but used for bricks and construction.	Western Ghats, Odisha, West Bengal
Mountain Soil	Not specified	Also called 'Forest Soil'; loamy/silty on valley sides, coarse-grained on upper slopes.	Himalayan region (Himachal, Uttarakhand, NE India)
Snowfields	Not specified	Found under snow/glaciers; not used for cultivation.	Karakoram, Ladakh, Zaskar
Grey and Brown Soil	Not specified	Submontane soils, typically found in areas with moderate elevation and slope.	Lower Himalayas and adjacent regions
Red and Black Soil	Not specified	Mixed soil regions where both red and black soil types occur together	Transitional zones (e.g., parts of Karnataka, AP)

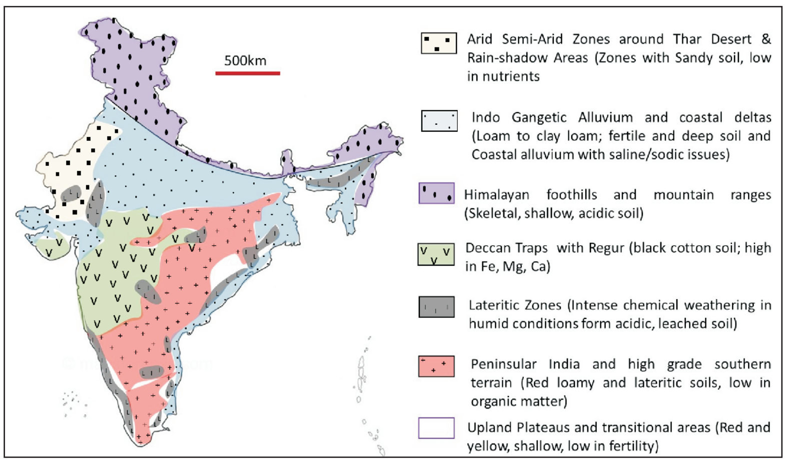

Fig. 2. Proposed Agrogeological map of India

can be enhanced through the application of ground basalt as a slow-release silicate fertilizer and by adopting soil nutrient mapping for site-specific management.

Indo-Gangetic Alluvial Plains

The Indo-Gangetic Alluvial Plains, encompassing Punjab, Haryana, Uttar Pradesh, Bihar, and West Bengal, are formed by Quaternary alluvium deposited by the Indus–Ganga river systems and are characterized by deep, fertile loam to clay loam soils. While the region supports highly productive agriculture, excessive irrigation and nitrate leaching pose significant challenges. The area is ideally suited for crops such as wheat, rice, sugarcane, and pulses, but sustainable productivity requires improved groundwater recharge planning and judicious aquifer management guided by detailed hydrogeological mapping.

Peninsular Gneissic Complex (Southern India)

The Peninsular Gneissic Complex of southern India, covering Tamil Nadu, Karnataka, and Andhra Pradesh, is dominated by Archaean gneiss, schist, and granite and is

Table 7: Agrogeological Zones of India

Region	Dominant Geology	Soil Type	Agrogeological Features	Major Crops
Deccan Plateau	Basaltic	Black cotton (regur)	High Fe, Mg; poor in N, P	Cotton, soy, millets
Indo-Gangetic Plains	Alluvium	Alluvial loam	Fertile, high-water table	Wheat, rice, sugarcane
Peninsular India	Gneiss, granite	Red, lateritic	Acidic, low P, K	Groundnut, pulses
Himalayan Foothills	Schist, gneiss	Shallow, acidic	Erosion-prone, low fertility	Horticulture, barley
Coastal Deltas	Marine sediments	Saline, sodic soils	Salinity, waterlogging	Rice, coconut, aquaculture
Arid Zones	Sandstone, aeolian	Desert soils	Low OM, water retention	Bajra, legumes
Lateritic Belt	Laterite	Leached, acidic	Rich in Fe, Al; low P	Cashew, rubber
Upland Plateaus	Granite, limestone	Red/yellow soils	K-deficiency, shallow soils	Rice, maize, minor millets

characterized by red loamy and lateritic soils with low organic matter. These soils commonly suffer from acidity and phosphorus deficiency, but agricultural productivity can be improved through the application of rock phosphate and feldspar dust, along with liming using locally available limestone or dolomite to enhance soil pH and nutrient availability.

Himalayan Foothills and Mountain Ranges

The Himalayan foothills and mountain regions, including Uttarakhand, Himachal Pradesh, parts of Jammu & Kashmir, and Arunachal Pradesh, are underlain by metamorphic and sedimentary rocks and are characterized by shallow, skeletal, and acidic soils. These areas face severe soil erosion and low fertility but can sustain terrace farming of millets, maize, and fruits when supported by geological terracing for erosion control and appropriate micronutrient supplementation.

Coastal and Deltaic Regions

The coastal and deltaic regions of India, encompassing Odisha, Andhra Pradesh, Tamil Nadu, Kerala, and West Bengal, are underlain by marine and deltaic alluvium and are characterized by coastal alluvial soils affected by salinity and sodicity. Poor drainage and salinization limit productivity; however, these regions are well suited for rice cultivation, coconut plantations, and aquaculture when managed with gypsum application for sodic soils and effective subsurface drainage planning.

Arid and Semi-Arid Zones (Thar Desert and Rain-Shadow Areas)

The arid and semi-arid zones of India, including the Thar Desert and rain-shadow areas of Rajasthan, parts of Gujarat, interior Karnataka, and Maharashtra, are dominated by aeolian sand dunes and Precambrian rocks and are characterized by sandy, nutrient-poor soils. High evapotranspiration and low fertility constrain agriculture, but productivity can be improved through the application of zeolites and silicate minerals to enhance water retention, along with soil conditioners such as locally available rock dust.

Lateritic Zones (mostly Western Ghats, Eastern Coastal Belt and other spots)

The lateritic regions of India, including Kerala, Goa, Karnataka, and Odisha, are formed under humid conditions of intense chemical weathering and are characterized by acidic, highly leached lateritic soils rich in iron and aluminum oxides but deficient in available phosphorus. Agricultural productivity in these areas can be improved through lime application for pH correction and the use of locally available rock phosphate, particularly for crops such as cashew and tea.

Plateau and Upland Areas (Cratonic insides and other small transitional areas)

The plateau and upland areas including Jharkhand, Chhattisgarh, Madhya Pradesh, and parts of Uttar Pradesh, are underlain by Precambrian granites, schists, quartzites and limestones. These are characterized by shallow red and yellow soils with low fertility. These soils commonly exhibit potassium and micronutrient deficiencies, which can be addressed through the application of feldspar-rich rock dust, while detailed mineralogical surveys can support site-specific soil amendment strategies.

India's agrogeological diversity is both a challenge and an opportunity. Each region's unique geology provides distinct resources and constraints for agriculture. Leveraging this diversity through targeted agrogeological interventions- such as mineral-based fertilizers, erosion control, and land-use mapping — can enhance sustainable agricultural productivity across the country. Raising awareness, investing in region-specific research, and integrating geoscience with agronomy are critical for harnessing India's full agrogeological potential.

Challenges in Promoting Agrogeology in India

Promoting agrogeology in India faces several interconnected challenges. Farmer awareness of practices like rock dusts, natural mineral fertilizers, and soil-specific geological amendments is low, and extension programs rarely include geology-based solutions. Agrogeology is also underrepresented in academic curricula. Collaboration between geologists, soil scientists, and agronomists is limited, hindered by few interdisciplinary platforms and differences in terminology. Farm-scale geological mapping is inadequate, with scarce data on mineral deficiencies, trace elements, and beneficial rock types, particularly in upland, tribal, and lateritic regions. Although India has abundant mineral resources, processing and distribution are constrained by infrastructure, accessibility, and economic viability for small enterprises. Policy frameworks are lacking, with unclear certification, no specific guidelines, and exclusion from fertilizer subsidies. Environmental concerns include potential mining impacts, soil contamination, and the carbon footprint of processing. Research and field validation remain limited, with few long-term trials and underdeveloped geospatial modeling tools. Socioeconomic factors, including farmer risk aversion and affordability, further limit adoption, as smallholders often favor familiar, subsidized chemical inputs. Addressing these challenges requires improved awareness, interdisciplinary integration, supportive policies, sustainable resource management, and evidence-based strategies to advance agrogeology in India.

Future Pathways and Recommendations

Agrogeology offers significant potential for revitalizing degraded soils, reducing dependence on imported fertilizers, and promoting sustainable agriculture in India. Realizing this potential requires a strategic and collaborative approach that bridges knowledge, policy, and infrastructure gaps. Applied geoscientific observations, such as those highlighted by Mukherjee *et al.* (2017) in their study of lime kankar as surface indicators of concealed dykes in the Southern Cuddapah Basin, demonstrate how surface geogenic features can reveal subsurface controls on groundwater movement, emphasizing the relevance of integrating geological insights into agricultural planning. To mainstream agrogeology, several pathways are recommended. First, capacity building is essential, involving the training of extension agents and local resource persons to bridge grassroots knowledge gaps. Second, interdisciplinary research hubs should be established, fostering collaboration among geologists, soil scientists, and agronomists for region-specific studies. Third, policy reforms are needed to include agrogeological inputs in national fertilizer frameworks, with clear guidelines on quality assurance, labeling, and subsidy support. Fourth, pilot projects and demonstration farms across diverse agro-climatic zones can showcase practical benefits, encouraging farmer adoption. Fifth, detailed micro-level agrogeological and soil mineralogy mapping, leveraging GIS and remote sensing tools, can guide precise soil amendments. Finally, promoting small-scale, environmentally responsible mining of rocks suitable for agricultural use can ensure a sustainable supply of mineral inputs while minimizing ecological impacts. Collectively, these measures provide a comprehensive roadmap to harness the benefits of agrogeology (Table 8), enabling India to advance sustainable, resilient, and scientifically informed agricultural practices.

Table 9 highlights how specific soil nutrients benefit particular crops, emphasizing the role of agrogeology in sustainable agriculture.

Table 8: Recommendations for Promoting Agrogeology in India

SN	Recommendation	Methods and steps
1	Capacity Building	- Train agricultural extension agents and Krishi Vigyan Kendra (KVK) staff on agrogeological practices. - Identify and support local resource persons (LRPs) for knowledge dissemination. - Use multilingual training modules and digital content. - Raise public awareness via mobile advisories, radio, and demonstrations.
2	Interdisciplinary Research Hubs	- Establish agrogeology research centers within agri-universities and Council of Scientific and Industrial Research (CSIR) labs. - Promote joint research projects between geologists, soil scientists, and agronomists. - Create databases for soil-rock-crop studies. - Launch academic programs for agrogeological expertise.
3	Policy Reforms	- Recognize rock dusts and natural minerals in the Fertilizer Control Order (FCO). - Offer subsidies/incentives for mineral fertilizers. - Develop standards as per Bureau of Indian Standards (BIS) for agro-mineral quality and labeling. - Ensure regulatory checks for heavy metals and ecological risks.
4	Pilot Projects	- Set up demonstration farms across varied agro-climatic zones. - Evaluate crop response, yield, and soil health using rock-based inputs. - Involve farmers via participatory methods. - Use results to create case studies and best practice guides.
5	Mapping Initiatives	- Prepare high-resolution (1:10,000 scale) soil-geology correlation maps. - Create state-level mineralogical atlases. - Integrate GIS data for soil fertility, crop suitability, and rock type. - Train officials in using geospatial tools for agro-planning.
6	Sustainable Mining Framework	- Promote small-scale, regulated quarrying for agro-mineral sources. - Implement fast-track clearance norms with environmental safeguards. - Support rural rock grinding units under PPP or MSME schemes. - Encourage safe reuse of mining by-products for soil amendment.

Table 9: Essential Elements and Crop Associations

Element / Nutrient	Type	Role in Plant Growth	Crops That Thrive in Rich Areas	Deficiency Symptoms
Nitrogen (N)	Macronutrient	Leaf & stem growth, chlorophyll production	Corn, Wheat, Rice, Sugarcane, Leafy Vegetables (e.g., spinach, lettuce), Potatoes	Yellowing (chlorosis) of older leaves, stunted growth
Phosphorus (P)	Macronutrient	Root development,flowering, energy transfer (ATP)	Maize, Wheat, Legumes (beans, peas), Cotton, Sunflower	Purplish or dark green leaves, poor root growth
Potassium (K)	Macronutrient	Water regulation, enzyme activation, disease resistance	Banana, Tomato, Potato, Citrus, Grapes, Sugar Beet	Scorching or browning of leaf edges, poor fruit quality
Calcium (Ca)	Secondary Macronutrient	Cell wall strength, root and leaf development	Tomato, Apple, Peanuts, Lettuce, Carrot	Blossom-end rot (e.g., in tomato), poor root tips
Magnesium (Mg)	Secondary Macronutrient	Central atom in chlorophyll, enzyme activator	Tobacco, Spinach, Potato, Soybeans, Banana	Interveinal chlorosis in older leaves
Sulfur (S)	Secondary Macronutrient	Protein and enzyme function, chlorophyll synthesis	Cabbage, Garlic, Onion, Mustard, Cruciferous crops	Yellowing of younger leaves, poor growth
Iron (Fe)	Micronutrient	Chlorophyll synthesis, electron transport	Soybean, Groundnut, Rice, Citrus, Spinach	Interveinal chlorosis in young leaves
Zinc (Zn)	Micronutrient	Enzyme activation, hormone production (auxins)	Rice, Wheat, Maize, Citrus, Grapes	Rosetting, shortened internodes, pale leaves
Copper (Cu)	Micronutrient	Enzyme cofactor, lignin synthesis, respiration	Wheat, Oats, Vegetables, Fruit trees	Leaf tip dieback, pale young leaves
Manganese (Mn)	Micronutrient	Photosynthesis, enzyme systems	Sugarcane, Soybean, Citrus, Beans, Barley	Interveinal chlorosis, brown spots
Boron (B)	Micronutrient	Cell wall formation, flower & fruit development	Apple, Grapes, Cauliflower, Beetroot, Sunflower	Cracked fruit, poor pollination
Molybdenum (Mo)	Micronutrient	Nitrogen fixation (esp. legumes), enzyme activity	Legumes (beans, lentils, peas), Cauliflower	Leaf cupping, yellow mottling
Chlorine (Cl)	Micronutrient	Osmosis & ionic balance, photosynthesis	Coconut, Barley, Wheat, Tomato	Wilting, bronzing of leaves

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Framework for Submarine Geohazard Evaluation and Spatial Screening in Offshore Wind Farm Planning along India's Western and Eastern Margins

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India has taken significant steps toward offshore wind energy deployment as part of its broader energy transition strategy. Government initiatives led by the Ministry of New and Renewable Energy (MNRE), including the Viability Gap Funding (VGF) mechanism and offshore wind leasing programs, have identified the continental shelves off Gujarat and Tamil Nadu as priority zones for early projects (MNRE, 2024). These areas collectively host several tens of gigawatts of estimated offshore wind potential and are expected to support pilot and commercial-scale developments over the coming decade.

Unlike onshore wind projects, offshore wind farms are exposed to complex seabed and sub-seabed processes that may compromise foundations, inter-array and export cables, and operational safety. Indian continental margins exhibit evidence of submarine landslides, active seismic sources capable of generating tsunamis, weak Holocene sediments prone to liquefaction, and dynamic sediment transport systems driven by monsoon-influenced currents (Bijesh *et al.*, 2022; Prizomwala, 2022; INCOIS, 2025). For early-stage projects supported by public funding, inadequate geohazard assessment can result in cost escalation, insurance challenges and long-term operational risk.

This paper proposes a pragmatic, staged framework for submarine geohazard screening and spatial evaluation suitable for offshore wind farm planning along India's western and eastern margins. The framework emphasizes early hazard identification, proportional escalation of investigations, and direct linkage between hazard assessment, design decisions and regulatory compliance.

Submarine Geohazard Setting of the Indian Offshore Region

The Indian continental margins display a diverse range of geological and oceanographic conditions relevant to offshore wind development. Along the western margin, the relatively wide continental shelf off Gujarat transitions into steeper slopes toward the Arabian Sea basin. Geophysical studies have documented large-scale submarine landslides and slide scars, including the Cochin offshore slide system, indicating potential for mass movement and turbidity current activity (Bijesh *et al.*, 2022; Zhang and Wang, 2025). Although such features are often located beyond shallow shelf areas, export cable routes and deeper foundations may intersect zones of instability.

Seismic and tsunami hazards also require consideration. The Makran subduction zone in the Arabian Sea and the Andaman–Sumatra subduction system in the eastern Indian Ocean is both capable of generating tsunamis that may impact Indian coastlines (Prizomwala, 2022; Rashidi *et al.*, 2025). While recurrence intervals for major tsunamigenic events are long, offshore wind infrastructure is designed for multi-decadal lifespans, necessitating inclusion of low-probability, high-impact scenarios in risk assessments.

On the eastern margin, the Bay of Bengal shelf off Tamil Nadu is influenced by large sediment fluxes, seasonal monsoon-driven currents and relict sedimentary structures. Thick accumulations of fine-grained Holocene sediments may exhibit low shear strength and susceptibility to cyclic degradation or liquefaction under seismic or hydrodynamic loading. Seabed scour around foundations and cable exposure due to sediment mobility are additional concerns in both regions (Duguid, 2017).

Principles of Staged Geohazard Screening

Effective geohazard assessment for offshore wind projects should follow a staged, risk-proportionate approach. Early

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