Review Paper:

Bioshields as a viable solution for managing ecosystem-related disasters, offering a long-term solution to the frequent issue of sea erosion

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Abstract

Coastal regions of India possess high population densities. The damage faced by the coastal ecosystem, especially the land–sea border, is increasing due to natural calamities during monsoon and cyclones as well as climate change. Land erosion is a significant concern nowadays because of the loss of human life and properties. Existing practice to prevent such damage is constructing a sea wall, groynes or tetrapods. Such construction requires huge manpower and money.

The study discusses the importance of a bioshield in mitigating such calamities. Bioshields consist of a patch of vegetation at the land-sea border. The composition of such vegetation can be grasses, shrubs, creepers and trees. The current study discusses a few selected species for inclusion in such a bioshield with multipurpose objectives: income generation, enriching the local ecosystem and slowing down the calamities due to waves and wind.

Keywords: Bioshield, Multipurpose vegetation, Natural disaster, Soil erosion,

Introduction

Any vegetation belt is referred to as a bioshield. This can include natural or man-made forests, sacred grooves, grasslands, mangroves, or any other small patches of vegetation. Such bioshields serve dual functions: First, it serves as a genetic diversity bank, sustaining an ecosystem. Second, bioshields help to reduce the impact of cyclones, tsunamis, floods and pollution. As a result, bioshields are regarded as the most logical option for mitigating the effects of natural disasters and climate change[12].

The high population density along India's coastline is critical. This has resulted in an increase in anthropogenic activities. The result of such human intervention is a disturbed and damaged coastal ecosystem.

Natural causes of seashore damage include waves, winds, tsunamis and sea level rise[6,29]. Due to monsoon, natural calamities and climate change, there has been a significant loss of human life and property over the years[16]. As a result, scientific efforts to mitigate such damage are critical particularly along India's coastal lines. The current practise for mitigating coastal disasters is to build a stone wall, groynes and tetrapods. It is a quick fix for the problem, acting as a physical barrier to the incoming high current waves[5]. However, there are few disadvantages (i) Building such a wall necessitates bringing large stone pieces, which are costly. It also involves machinery, which contributes to air pollution. The practice of building stone walls also harms the ecosystem from which the material is extracted. (ii) The retreat of waves with great force, putting greater pressure on the beach in front of the wall and hastening the erosion action there. Natural sand dunes will vanish as a result of it. Thus, the future of this traditional method of physical barrier remains uncertain.

Scientists are looking for a sustainable natural solution to overcome the disadvantages and impact of a stone wall. Vegetation in coastal areas, according to studies and scientific findings, increases slope stability, consolidates silt and reduces wave energy[25]. This fact inspired the creation of the bioshield.

Composition of bioshields

Bioshield consists of trees, shrubs, creepers and grasses. The vegetation can be composed of a single species or multiple species. Naturally, growing plant species with an intensive and well-proliferated root system is highly recommended for bio-belt. The plants suitable for this can be categorised under (A) Grasses (B) Creepers (C) Shrubs and (D) Trees[8,12,30]. Based on the review, the following species are considered beneficial for such bioshields in the coastal regions, especially in South India. The species are selected after considering (i) natural occurrence (ii) ability to earn additional income for the local unemployed women's community (iii) improving the ecosystem by assisting further nourishment of the coastal flora and fauna (iv) less utilization.

(A) Grasses

(1) *Cynodon dactylon* (Bermuda grass): *C. dactylon* is found in sea shore as a part of sand dune vegetation. The damage that happened to sand dunes also affected *C. dactylon* occurrence[23]. Because of its extensive root system, this grass has exceptional sand-binding abilities. *C. dactylon* is also a salt-tolerant species. The plant also has powerful medicinal properties and is utilized in drug preparations[28]. Temples also make use of the plant for garlands and other rituals. As a result, in addition to its ecological function,

plant cultivation can provide a means of income generation for the unemployed women community in the coastal area.

(2) *Cyperus sp.*: The genus contains several species, many growing naturally in sand dunes on beaches. They are an ideal candidate as a member of the carpet flora of a bioshield against natural hazards encountered at beaches because they have a well-proliferated root system. *C. arenarius*, *C. javanicus*, *C. peduncularis* and *C. maritima* are ideal species[6]. *Cyperus* sp. adapts and survives well on beaches due to the presence of a large subterranean tuber system[11,22]. The *Cyperus* genus possesses significant potentials for both economical products such as oils and drug molecules. It is one of the underutilized grass species as well[7].

(3) *Spinifex littoreus*: *Spinifex littoreus* is an effective sand binder, helping to stabilise dunes and preserve dune topography. It is a perennial species and grows well in the wet biome. The species yields a fiber with excellent thermal and mechanical properties for synthetic fiber composits[17]. Therefore, *S. littoreus* is highly recommended for inclusion in the bioshield of India's coastal belts serving as multipurpose vegetation.

(B) Creepers

(1) *Ipomoea pescaprae*: It is one of the most salt-tolerant plants that can grow and survive on Indian beaches. It is responsible for the majority of transitional vegetation[21]. *I. pescaprae's* elongated root system, long trailing stem and thick rootstock makes it an excellent sand binder[18]. The cultivation of *I. pescaprae* can serve as an income generation for the local community because the plant possesses an immense treasure house of bioactive phytoconsituents[2]**.** The cultivation does not require much care because it grows luxuriantly in the Indian seashore.

(2) *Boerhavia diffusa*: *B. diffusa* is an excellent sand binder because it is a diffused herb with prostrate branches and a well-developed root system. It plays an important role in the coastal ecosystem. The plant is also extremely beneficial to one's health[33]. The plant is used in local cuisine as a leafy vegetable. It is a rich source of minerals, especially iron and calcium. This species is also a component of many traditional ayurvedic drugs and is underutilized while considering its potential[20].

(3) *Canavalea rosea*: *C. rosea* is an erosion-resistant legume with distinctive root biomechanical properties against soil erosion[14]. Apart from having a multitude of medicinal importance, the plant also serves as green manure as well as forage purposes and livestock feed[32].

(C) Shrubs

(1) *Scaveola taccada*: An excellent shrub that grows well on beaches, is commonly known as beach cabbage. It can survive salt spray and salinity[9]. The plant is useful for sand erosion mitigation, beach stabilisation and landscaping through plantation activity. As a result, it is a promising plant for restoring coastal vegetation and maintaining the carbon balance at the coastal region[26]. This species is less exploited at all. Scientific studies reveal that this species possesses unique UV-absorbing properties and a product can be developed for sun screen[31].

(2) *Pandanus species*: Screw pines are classified as small trees or large shrubs. Pandanus is an excellent choice for bioshielding in the coastal belt. This is due to Pandanus' ability to reduce storm surge wave height[13]. As a result, it is highly recommended to be deployed as a fence near coastal areas and homesteads. Even after possessing good fiber and volatile compounds and being used as a raw material for many small-scale industries by tribals, the species is highly ignored especially in India[19].

(3) *Vitex trifolia*: This robust shrub prefers sandy beaches. Subsoil adventitious roots network throughout the soil and act as a barrier to prevent soil erosion. Furthermore, a high number of litter leaves contributes to nutrient recycling. Because of these characteristics, *V. trifolia* is an excellent candidate for bioshield sand fixation projects[15]. It is used in several medicinal and ethnobotanical formulations[34].

(D) Trees

(1) *Casuarina sp.*: Because of its fine network of subsurface roots, this tree is ideal for seashore bio-belts. It has the added benefit of preventing wind and soil erosion[27]. Furthermore, its roots can fix nitrogen, making the soil nitrogen rich[27]. It has a high economic value because it is having a long history of use in industries related to dye, paper and agroforestry[3] .

(2) *Calophyllum inophyllum*: This tree is well adapted to coastal areas. *C. inophyllum* protects the seashore ecosystem from erosion and saline intrusion[1]. The oil obtained from the seeds has been reported to have medicinal properties and also is a potential candidate for biodiesel production[24].

(3) *Morinda citrifolia*: The plant is famous for its noni fruits. Because the plant can thrive in coastal environments[10], *M. citrifolia* is highly recommended for bio-fencing along beaches. From the economic point of view, this plant is having the highest potential because of its use for medicinal purposes, health supplements and green insecticide[4].

Conclusion

There exist many species which are naturally growing at the seashore of Indian coastlines. They can tolerate well the salt spray, wind and salinity faced at their habitat. Such species also nourish the local fauna. Many of such species are used in traditional and ayurvedic medicinal preparations and economic products. Most of them are underutilized. The study recommends constructing a bioshield to mitigate natural calamities in coastal areas using such underutilized species. Such a model can serve as a multi-purpose coastal vegetation in the long run conservation, enriching the local flora and fauna, generating income for the local community as well as acting as a bio-barrier.

Developing an integrated approach is critical and is the need of the hour for reducing the damage to the coastal areas and human population. The study proposes the development and immediate implementation of a bioshield policy for a long-term management.

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