INTRODUCTION
1. INTRODUCTION

The teeming life which Nature abounds
Is treasured secret in solemn ground
From Man to bring to his knowledge door
The wonder gift of the ocean floor

-------- Srinivasan.

Biodiversity is the term given to the variety of life on Earth and the natural patterns it forms. The biodiversity we see today is the fruit of billions of years of evolution, shaped by natural processes and, increasingly, by the influence of humans. It forms the web of life of which we are an integral part and upon which we so fully depend. This diversity is often understood in terms of the wide variety of plants, animals and microorganisms. The rich tapestry of life on our planet is the outcome of over 3.5 billion years of evolutionary history. It has been shaped by forces such as changes in the planet's crust, ice ages, fire, and interaction among species. As per the extant databases available there are actually about 13 million species, though estimates range from 3 to 100 million. Biodiversity also includes genetic differences within each species.

Yet another aspect of biodiversity is the variety of ecosystems such as those that occur in deserts, forests, wetlands, mountains, lakes, rivers, and agricultural landscapes. In each ecosystem, living creatures, including humans, form a community, interacting with one another and with the air, water, and soil around them. It is the combination of life forms and their interactions with each other and with the rest of the environment that has made Earth a uniquely habitable place for humans. Biodiversity provides a large number of goods and services that sustain our lives.

At the 1992 Earth Summit in Rio de Janeiro, world leaders agreed on a comprehensive strategy for "sustainable development" meeting our needs while ensuring that we leave a healthy and viable world for future generations. One of the key agreements adopted at Rio was the Convention on Biological Diversity (CBD). This pact among the vast majority of the world's governments sets out commitments for maintaining the world's ecological underpinnings as we go about the business of
economic development. The Convention establishes three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources. The Convention on Biological Diversity, as an international treaty, identifies a common problem, sets overall goals and policies and general obligations, and organizes technical and financial cooperation. However, the responsibility for achieving its goals rests largely with the countries themselves.

India as a signatory to the CBD need to provide the critical role of leadership, particularly by setting rules that guide the use of natural resources, and by protecting biodiversity where they have direct control over the land and water. Under the Convention, governments undertake to conserve and use biodiversity sustainably. They are required to develop national biodiversity strategies and action plans, and to integrate these into broader national plans for environment and development. This is particularly important for such sectors as forestry, agriculture, fisheries, energy, transportation and urban planning. Other treaty commitments include:

1. Identifying and monitoring the important components of biological diversity that need to be conserved and used sustainably 2. Establishing protected areas to conserve biological diversity while promoting environmentally sound development around these areas 3. Rehabilitating and restoring degraded ecosystems and promoting the recovery of threatened species in collaboration with local residents 4. Respecting, preserving and maintaining traditional knowledge of the sustainable use of biological diversity with the involvement of indigenous peoples and local communities 5. Preventing the introduction of, controlling, and eradicating alien species that could threaten ecosystems, habitats or species 6. Controlling the risks posed by organisms modified by biotechnology 7. Promoting public participation, particularly when it comes to assessing the environmental impacts of development projects that threaten biological diversity 8. Educating people and raising awareness about the importance of biological diversity and the need to conserve it 9. Reporting on how each country is meeting its biodiversity goals.
1.1 Conservation and Sustainable Use:

The conservation of each country's biological diversity can be achieved in various ways. "In-situ" conservation - the primary means of conservation - focuses on conserving genes, species, and ecosystems in their natural surroundings, for example by establishing protected areas, rehabilitating degraded ecosystems, and adopting legislation to protect threatened species. "Ex-situ" conservation uses zoos, botanical gardens and gene banks to conserve species.

Promoting the sustainable use of biodiversity will be of growing importance for maintaining biodiversity in the years and decades to come. Under the Convention, the "ecosystem approach to the conservation and sustainable use of biodiversity" is being used as a framework for action, in which all the goods and services provided by the biodiversity in ecosystems are considered. The Convention is promoting activities to ensure that everyone benefits from such goods and services in an equitable way.

Sustainable utilization of the coastal habitats and the resources they accrue has immense bearing on the livelihood of coast dwellers. Under the CBD, as a member nation, India has a key role to play, ensuring equitable and sustainable use of its biodiversity both aquatic and terrestrial. The present endeavor by the author is directed towards this goal in exploring and documenting the marine algal wealth of under-explored coastal zones along the Maharashtra coast of India. Attempts have been made here to study the nature of habitat as well as the marine algal diversity in detail so as to add to the existing knowledge.

India is considered to be one of the 17 - mega diverse countries in the world hosting about 45,000 plant species of which around 17,500 are flowering plant species and the remaining are non-flowering plant species. The total forest area in India is 7,74,740 sq. km which is 23.57 % of the total geographical area. Presently, there are 95 National Parks, 500 Wildlife Sanctuaries, 14 Biosphere Reserves and 29 Tiger Reserves in India for conserving the flora and fauna of the country.

India being a maritime state has bountiful of marine resources as compared to many land-locked countries viz. Nepal, Bhutan etc. Mainland India and several islands around together have a long coastal belt of about 7500 km and vast Exclusive Economic
Zone (EEZ) of 2.5 million sq km besides a large shelf area i.e. 0.13 million sq km. We have a rich heritage especially of marine biological wealth constituting a number of seaweeds and sea grasses besides aquatic fauna having huge economical and ecological potential. The utility of the coast nowadays is measured in how the coast is economically used in the form of EEZ.

The mainland coast and a number of islands harbour a large number of species of marine algae. On the West coast, the Arabian Sea is associated with the shores of Gujarat, Maharashtra, Goa, Karnataka and Kerala whereas, on the East side, the Bay of Bengal shows association with the coasts of West Bengal, Orissa, Andhra Pradesh, Tamilnadu and Pondicherry. The southern part of Indian Peninsula is bathed by the Gulf of Mannar and Indian Ocean. There are two important gulfs viz. Gulf of Kutch and Gulf of Cambay on the Arabian Sea side whereas Chilika lake in Orissa and the creeks and inlets of Sunderbans are the important marine ecosystems on the Bay of Bengal Coast.

The most known important places for algal collection along the Indian coast are Okha Port, Dwarka and many other places along the Gujarat Coast; Mumbai; Karwar; Travancore; Kanyakumari and the Islands in Gulf of Mannar; Tuticorin; Mahabalipuram; Waltair; Chilika Lake and Sunderbans. The Andaman & Nicobar Islands, Lakshadweep and Minicoy are of great importance as far as marine algae are concerned.

Marine algae most commonly called ‘seaweeds’ yield natural products viz. phycocolloids which have innumerable applications in the industry in India and globally. Their importance as food, feed and pharmaceuticals is well known. Ecologically, the marine algae which are abundant both in terms of diversity and luxuriance in many pockets along our coastline stabilize the coastal substratum and protect from soil erosion.

Owing to the importance attached to the marine algae, it is but obvious that we understand them fully well from taxonomic point of view as authenticity of identity of each and every species is a prerequisite before any conservation and utilization strategies are drawn up for safeguarding them from depletion whether it is man-made or natural.
The coastal areas of planet - Earth are amazing areas. The interface between land and sea, the coast is a unique geological, ecological and biological domain of vital importance to an astounding array of terrestrial and aquatic life forms, including humankind. The importance and value of the coastal zone cannot be overstated. It is one of the most productive areas accessible to people. Fish and other seafood meet a significant portion of the dietary needs for millions of people around the world and the fishery and aquaculture industries are commercial mainstays for thousands of coastal communities.

The coast also is an important safety feature for people living near the ocean. Many types of coasts provide a barrier from natural hazards emanating from the turbulent seas. Beaches, dunes, cliffs and barrier islands act as buffers against the high winds and waves associated with coastal storms. The recreational aspect of the coastal zone is the another reason.

Most of us go to the coast for the sheer beauty of it. There is something restorative and regenerative about the waves crashing and wind whistling. The aesthetic and scenic elements of the coastal zone make it valuable as a source of inspiration and peace.

The coastal zone also provides a unique habitat for thousands of plant and animal species. The coastal system is made up of myriad interconnected subsystems whose functions cannot be duplicated elsewhere. For instance, estuaries, with their unique mixture of fresh water and salt water, provide a nursery area for numerous species of fishes. Likewise, coastal wetlands are home to a variety of birds, plants, and other biota and also serve the important role of filtering impurities in the water coursing through them. These and other segments of the coastal ecosystem are precisely balanced fragile areas susceptible to a variety of including those posed by human interference in the natural system.

Despite its fragility, the coastal zone is amazingly resilient. The coastal ecosystem as a whole is a dynamic and regenerative force; if left alone; natural mechanisms maintain equilibrium between living things and the natural environment. However, there are limits to the extent to which the coastal ecosystem can withstand
external assaults to its integrity. Pressures emanating from human activities are particularly threatening.

Coastal systems extend from the littoral region which is lying between the mainland and the inner most margins of the seashore and marine regions from the upper tidal limits out across the continental shelf, slope and rise. It includes rocky and sandy shores, beaches, estuaries, deltas, backwaters, lagoons and Exclusive Economic Zones (EEZ), which is approximately 200 nautical miles wide along the 4,40,000 km long outline of the continents. The system is usually covered with dry coastal beach vegetation, beach forest of sandy or rocky habitat types, wet coastal mangroves, salt marshes, seaweeds, sea grasses, corals reefs and associated sub-tidal benthos. It also includes important endemic areas like continental and oceanic islands. Biological diversity in the coastal ecosystem differs from terrestrial ecosystem at higher taxonomic level. They also show greater diversity of types of organisms and types of adaptive specialities than the terrestrial system.

Coastal ecosystem is the world’s highest importance by virtue of its biological productivity, specialized adaptive capacity of the biodiversity, complexity in the ecological processes and finally importance of the resources have a wide range of natural functions and that variously used for sustainable life support to the mankind and other biological components directly or indirectly. Indirectly, various amenities provided by coastal ecosystems for conservation and protection of environment are so valued that the coast couldn’t be evaluated even with the help of monetary measures. Due to dominance of large physical forces of wind, salt spray, temperature, saline tide water and unstable substrata, some regions may harbour comparatively lower degree of biodiversity, but this biodiversity shows high range of taxonomic diversity and survive in the constrained ecological conditions by morphological, physiological and biochemical adaptations for adjusting gradations of small variation of ecological and environmental factors. This high level of diversity in the coastal systems reveals that species within the functional group are physiologically and genetically more distinct from one another than the terrestrial assemblage. More they respond among the members of a functional group, more they respond differently to different environmental changes and more will be the physiological and genetic base for adaptation to change. Importance of coastal system for sustainable life support and other amenities for environmental security is high. Most of the world’s people live within 80
km of the coast. Most of the sustainable living activities related to land and sea based activities are concentrated at the coastal margin which are world’s richest fish catch, mariculture, tourism, domestic and industrial waste disposal, transportation, Kelp forest and mining industries, even more many sustainable life support resources of the world like food, fuel, house and boat building materials, fishing and thatching materials, textiles, tannins, furniture materials, oils, gums, resins, incense, paper pulp, softwood, honey wax, reptile skin, fishes, shellfishes, crustaceans, prawns, crabs, birds and mammals are found along the coastal lands. The coastal systems are very rich habitats for many biological components and without these many important biological germplasm would have been extinct. It serves as a nursery ground for many estuaries, fishes, shellfishes, crustaceans and edible crabs. It acts as a nesting ground for many resident and migratory birds, reptiles and olive Ridley turtles. It also serves as a unique habitat for Royal Bengal Tigers restricted along the Sunderbans and Bangladesh coast. Mangroves, Sea grasses and seaweeds which form a potential habitat of coastal system have become most vulnerable throughout the world due to heavy exploitation and environmental degradation.

Another important objective of coastal ecosystem is the global balance of atmospheric and climatic conditions by active and trace gases produced by wide variety of phytoplankton, bacteria and macrophytes in marine system. Some of marine biogases, like Carbon, Sulphur, Nitrogen, Halogens and most important Carbonyl-sulphur (COS) and Dimethyl-sulphur (DMS) which are the main biogenic sources of coastal marine areas produced by phytoplankton, bacteria and macrophytes play a vital role on atmosphere and consequently on global climate. Loss of biodiversity, increased pollutants, eutrophication, sedimentation, depletion of ozone with consequent increase of UV radiations will cause a serious alteration of global climate. The most surprising fact is the coastal systems which contribute vital and pivotal support for human life are seriously affected mostly by human activities. The major threats include overexploitation, coastal aquaculture alteration of habitat, coastal pollution, biological invasions, and land based activities and many others are responsible for the changes or partial loss of coastal diversity. Documentation of coastal plant diversity and impact of threats haven’t been properly investigated in India. However, in the present study some sincere efforts were done for studying the marine algal diversity including the threats
and conservation strategies at Maharashtra Coast which have been focused for future conservation and management practices of Indian seaweed communities.

The coastline or the littoral region, lying between the main land and the innermost edges of the seashores is the meeting line of the sub-aerial and marine processes of erosion and deposition. These continental and marine systems are very different in their rate and intensity of the coastal processes. These varies widely in their structure and function in different parts of the country due to various geomorphological features. It is narrow along the Konkan and Malabar Coast of the west due to formation of cliffs, barriers, spits and wider in the Coramondal - Circaur regions due to formation of deltas, sand beaches and off-shore beds.

1.2 Physiography of the West Coast:

Coastal landscape of the Indian sub - continent comprises ecosystems according to the nature of physiography. Indian coastline can be subdivided into three major regions as:

1) Gujarat Coast Region       2) West Coast Region       3) East Coast Region

**West Coast Region:** West coastal plains of India fall between the Sahyadris and Arabian Sea extending from 8° 15’N to 20° 22’N and 73° 40’E to 77° 30’E covering about 1,400 km long and 10 - 80 km broad coastline. This coast land includes Konkan and Malabar coastal provinces within the states of Maharashtra, Karnataka, Kerala and the Kanyakumari district of Tamilnadu. The South of the river Narmada to Mangalore is known as Konkan coast and south of Mangalore to Cannanore in the Malabar Coast. Western Ghats, the richest ecozone in India stretches from Ratnagiri to Cannanore in this coastal region. A distinct strip of low land along with hills of elevation of 150 m to 360 m is the characteristic feature of this coastal line. It is composed of sandy beach, coastal sand dunes, and alluvial tracts of muddy flats along the rivers, lagoons or rivers, lateritic platforms and erosional surfaces in the hard basement rock. The Sayadris rising in the elevation from 700 to 1000 m run almost parallel to the coastline and present their steep face to the coastal low levels but its continuity is interrupted by the presence of a few Ghats or gaps. The steep, west facing scrap of the Sahyadris is the product of faulting which preceded the subsidence of Arabian Sea, blocked between India and Africa during Eocene period. Raised beaches and planes of marine erosion of earlier times are found at altitudes varying from 30 - 91 m along the western coast of India.
The raised beaches are nothing but littoral concrete composed of an agglutinated mass of gravel, sand, shells and corals. Occurrence of bevelled surface in Deccan lava surmounted by isolated hills (that look like offshore islands) seen in Konkan coast, besides the presence of laterite capped residual plateaus along the southern part of Ratnagiri district in South Konkan. The undulating lands of the Konkan are 530 km long and 30 - 50 km broad. These are widest near Mumbai, which has probably forced the Sahyadris in this part to recede inwards away from the coast. The north of the Vaitarini River or the northern Konkan is composed of two landscape forms:

1) Sandy spits intruding into muddy shallows, close to the sea.

2) Low coastal ranges altering with longitudinal valleys farther inlands.

Whereas the southern Konkan is a rocky rugged country, lofty hills and elevated platues intersected by numerous creeks and streams are found close to the coast.

1.3 Geomorphology:

Geomorphologically coastal zone of India can be divided into three main features such as Offshore, Onshore and Coast land features.

i) Offshore Geomorphology: The offshore land includes the continental shelf under water. Its origin, morphological nature, slope, deposit, geology and island formation in India will be very much helpful in determining evolution of different shorelines in India. A submarine contour map shows that it is of about 100 fathoms i.e. 183 - 200 m where the most prominent break of slope occurs in the submarine floor in India. Evolution of different shore lines in India depends on different formations of continental shelf. This shelf is widest near the Gulf of Khambat, about 400 km across and narrowest of the delta mouths (Sunderbans or Krishna mouth) of about 30 - 35 km. The continental shelf near the eastern coast is approximately one - third of the width from the shelf of the western coast of India. The deposit on the continental shelf around the mainland may be sub-divided into 2 regions:

1) Littoral region - shore zone between the high tide and low tides.

2) Neritic region - shore zone between low water and 200 m depth of the sea.
Among the littoral deposits, pebbles are most common on the west coast from Mumbai to Karwar. Sandy beaches are common near Chennai, Puri and other areas of eastern coast. Mud flats are seen in Gulf of Khambat. Deposits of sediments with large share of organic matters are seen among the lagoons of Kerala. Indian continental shelf must have extended with the same geological formation of the lands adjoining to the coast. Major parts of the shelf between Ratnagiri and Kathiawar consist of Deccan Lava and the shoreline of the entire region from Ratnagiri to Daman and Kathiawar Peninsula is also found covered with Deccan lava. Geologically the lands adjoining the coasts and behind the shoreline may be grouped into 4 major types;

1) Alluvium in the deltas, part of East coast and Gujarat.

2) Archean crystalline gneisses and granites occur in parts of N. Circars, Tamilnadu, Kerala and South Mysore.

3) Deccan trap in Maharashtra, part of Kathiawar and Kutch.

4) Marine terriaries in disconnected patches from Midnapur to Cape Comorin and in Kerala and near Ratnagiri.

Andaman and Nicobar regions are covered by Arakanyoma, consisting of marine fossiliferous sandstones & lime stones and some volcanic materials. Coralline lime stones are common in Lakshadweep and Minicoy Islands. Indian coastline is well-known as regular coastline but few islands occur within the coastal zone. These Islands are found in the offshore regions or they are found distantly. They are further divided into alluvial types in the deltas or rocky or sandy types in the lagoons and coastal regions. The offshore islands are similar islands situated within 1 - 5 km of the shore and the distant islands are larger ones, occur 1000 to 2000 km of the shore, such as 265 islands of Andaman and Nicobar. There are another important group of islands and atolls made up of coral deposits in the Lakshadweep, Adivivdi and are situated outside the continental shelf adjacent to main land.

ii) Onshore Geomorphology: The definition of the shore land is the junction of sea and land. In low tide, it becomes longer and more seaward and during high tide, it becomes short & more landwards. There is an upper limit during the highest eddtide-flow and lower limit at lowest eddtide-flow and the land mass which lies in between the highest and lowest eddtide-flow is known as shoreline of the coast. This shoreline may be
divided into two types according to the nature of tidal flow as backshore and foreshore. The part of the landmass that lies between the ordinary low & high tide is known as foreshore and the part of land mass that lies above it is known as backshore.

Numerous depositional features built mainly by the sea and lands within the shoreline are responsible for formation of beach, coastal dunes, offshore bars, barriers, spits, lagoon, lakes, cliffs, deltas, estuaries, Coastal terraces and Rias.

1.4 Beach Formation:

Beaches are nothing but the deposit of soil particles and debris in shore zone from land through streams and from the seafloor. The beach materials may range in grade from boulder through shingle, pebbles and sand to silt depending on the wave action. It is very commonly and temporary deposit alternately deposited and removed which is known as beach cycle. There are annual cycles marked by storms and high waves on most of the Indian coast during south - west monsoon. The fortnight cycle marked by spring and neap tide and other type of beach cycle formed by storm. It is very much obvious that beaches are formed in calm and constructive wave action where wash is more powerful than backwash. During storm, destructive wave actions are more powerful because of which backwash is seen rather than wash, here the sediments are thrown far inside the sea instead of depositing it on the shorelines and causes shore erosion. Therefore, it is seen that the beaches better developed along the low or shallow shoreline and under developed or ill developed near highly elevated eroded shore and cliffed shore. Beaches grow constantly on the shoreline and in a pro-grading shore it becomes permanent but in retro - grading shore it becomes temporary. In permanent beaches, sometimes the materials are blown inland to form coastal dunes and sometimes parts of the sediments are carried by land wind to the sea.

Beach formation is very common, extensive and often seen on shallow coastline like the eastern shore of India and relatively uncommon on steep and cliffed shore along the western side from Mangalore to Daman. Therefore, eastern coast of India possesses long stretches of shore where beach is a common feature. (Banerjee et al., 2002)

The area between $13^{\circ} \text{N}$ to $16^{\circ} \text{N}$ that is from Mangalore to Malvan, is most indented due to formation of Ria - type river mouths, bays, bay heads, different spits and offshore mouths. Beach formation from north of Malvan areas with latitude $16^{\circ} \text{N}$
to Kutch is composed of littoral concretan or beach rock. This rocky formation often strikingly continues for 14 km long and 100 - 1200 m broad either directly with formation of sandy beaches, muddy flats or marshy areas. Sometimes, the rock formation is also located as isolated patches. This littoral concrete or rocky beaches sometimes act as protection against the force of wave where it helps in the formation of sandy beach or marshy land or muddy swamps between the rocky beach and the mainland.

1.5 Classification of Coastal Zones in India:

Due to the changes of the sea floor the sea coast formation appears to be different. There are mainly two types of movements on the sea floor viz:

a) Localised change of coast due to “Earth Movement”.

b) Extensive change of coast during cold age due to melting of ice and expansion of seawater level “Eustatic movement”.

Due to movement of earth, sea floor emerges out from the sea and forms emerged coast such as North Circar coast which is in between Ganga & the Krishna delta and the coast lines between Krishna & Cape Comorian. In such a kind of coasts, the coastline becomes straight and long. But, where the coastal land subsides into the sea, the coasts become submerged. Such submerged coasts are found along Maharashtra, Deccan lava coasts from Karwar to Bulsar and Khambat to Bhavnagar. These coasts are uneven and rough and near coastline, islands and Bay lands are common. When in the same coast emerged and submerged processes are seen, then that coast is known as compound coast such as the coast of Karnataka and Kerala. Behind these coasts many “Kylas” or backwater and lagoon formations are common. In many parts there are no traces of emerged and submerged processes but the sediment deposits are found dominant. These types are known as neutral coasts. Such types are seen along the Deltas of Ganga, Mahanadi, Godavari, Krishna and Cauvery.

Indian coasts can be divided into following categories according to Ahmad (1972) based on dominant physical characteristics:

1. Founded type
2. Deltaic type
3. Compound type
4. Interdistributary type
5. Maharashtra type / submerged type
6. Gujarat type
3. Depositional plain type

4. Malabar type/ Compound Coast

**Maharashtra Type / Submerged Type:** The coast lines from Goa to Mumbai and rest of Gujarat are dominated by lava and there is no confirmed structure of the coast and if at all structured they are transversed to the coast. Lower slopes of the Western Ghats are supposed to be dominant faulting processes of the coastal zone due to terrestrial erosion from the high relief. They occupy larger parts of the coastal zone above the cliffs or Rias and Bay heads. The dominant action is terrestrial erosion resulting from high relief.

**1.6 Coastal Sand Dune Formation:**

The nature of the sand dune formation depends on the movement of the wind. The dunes are more common on low coastal plains of the east coast. In the high coastal plains of the cliffed coast along the western region, dune formation is very frequent. The dimensions and extensions are more where the wind is oblique to the shoreline and less where the wind is transverse to the shoreline. There are three types of dune formations along the shore and coastal zones in India. (Ahmad, 1972; Banerjee et al., 2002).

A. Ephemeral sand dunes which occur on the shore during high wind in low tide and are destroyed during high tide.

B. Semi - stable dunes formed by the sea waves during storm and abnormally high tide along the back shore zone and not in the coastal zones.

C. Permanent coastal dunes beyond the reach of sea waves are found along the coast line with vegetation cover for stabilisation of the dunes.

A very good example of this kind was observed by the author during her seaweed collection tour at Kelshe near Dapoli in district Ratnagiri. The sand dune is formed measuring about 35 - 40 feet high and about 1 to 2 km wide.

Besides the deposits of sands, the river alluvium and laterite are other two important features along the coastal zone in India. The east coast has many large river mouths and deltas that extend to a greater distance with alluvium deposits than the west coast where rivers and catchments are less and in a steep slope where as the alluvium
deposits are restricted only towards the vicinity of rivers. The extent of the alluvial plain determines the depth of shore zone and coastal dune formation. Laterites in many parts of Indian coasts are found as interrupted fringes. From Bombay to Ratnagiri it occurs as a plateau sometimes it is found to extend 25 - 28 km inland terminating in cliffs. Near Malvan it starts on gneiss base and in Kerala it overlies fossiliferous tertiaries.

1.7 Climate of the West Coast:

The climate of the earth is intimately connected with the ocean through the atmosphere which serves as the common link for both, transferring enormous quality of water vapour, thermal energy and momentum from the sea to the land. Deep and extensive survey on the air - sea interaction will enable us to predict climatic changes over longer periods and this will help us to diminish climatic changes over longer periods and will be helpful to diminish environmental disasters like drought and flood. The ocean is like a flywheel which stores thermal energy when the supply is large during the day or summer and releases the energy when the supply is reduced during night or winter. The ocean micro layer that is 1 cm in thickness of the ocean surface plays a major role in air - sea interaction. It not only transfers energy but also rich in nutrients like Nitrogen, Phosphorus and Potassium into atmosphere. The temperature over the whole ocean ranges from 2° C (the freezing point of salt water) to 30° C and any other place it hardly varies more than 1° C during the course of a day and 10° C during the course of a year. The ocean moves both horizontally and vertically, under the influence of wind force.

Carbon dioxide is very important in the ocean and atmosphere interaction. The total CO₂ in the earth’s atmosphere is 2300 billion tons which is 0.03 % of its total mass. This amount is dependent on the quality of CO₂ withdrawn or supplied from the oceans, rocks and living organisms. The total CO₂ in the ocean is 50 times as much as in the air. When atmospheric CO₂ increases, ocean tends to absorb the excess and when it falls the ocean replenishes it. In this way ocean plays a role of rescuer whenever there is an imbalance in CO₂ (Banerjee et al., 2002). If there is a lush green growth of vegetation on land taking up large quality of CO₂, after sometime equilibrium with the ocean reduces the atmospheric concentration to nearly half of its original value and average temperature of earth falls by 3.9° C. This drop will cause glaciers to spread and oceans to shrink resulting in a slow release of excess CO₂ from ocean. This will again
rise the temperature and restore the CO₂ in the atmosphere. The consumption of fossil fuels in the world every year show that in the past 100 years man has added 360 billion tones of CO₂ to the atmosphere and which causes the rise of world’s temperature by 0.5 % in this way, it will rise by 1.8° C. If it continues like this, then after 1000 years CO₂ would increase 18 times. And when ocean - atmosphere attains equilibrium, there will be 10 times CO₂ more than today. Because of this the acidity will increase the pH of sea water and it would not be possible for man to live on this planet. The increase in temperature will cause increased volume of sea water level which will result in submergence of all the land areas adjacent to the seashore. There are few examples of Submergence: Sunderbans in West Bengal and Indira Point in Andaman (Southern part of Arakanyoma Mountain and Northern part of Sumatra Mountain).

The west coast represents more or less same climate with high temperatures almost throughout the year associated with evening cool breezes on the shore. The Konkan coastal region shows distinct climatic diversities ranging from sub - humid type in Mumbai to humid type in Ratnagiri.

At national level, the Ministry of Environment & Forests, Government of India has enacted a number of environmental laws from time to time in the form of Indian Forest Act, 1927; Wildlife Protection Act, 1972; Forest Conservation Act, 1989; Environment Protection Act, 1986; Environmental Protection Act, 1990; Tribal Forest Protection Act, 2004 etc. to safeguard the forest resources for conservation & sustainable use by all the stakeholders while, CRZ Act, 1991, Environment (Protection) Act, 1996 and Coral Reef Conservation Act, 2000 & Coral Reef Protection Act, 2009 were promulgated for protection and management of coastal zone, mangroves and Coral Reefs respectively.

1.8 Coastal Regulation Zone (CRZ) and Conservation of Seaweeds:

Coastal area between the low tide line and high tide line is Coastal Regulation Zone which is always on the forefront of civilization and has been by far the most exploited geomorphical unit of earth. Its easy access and resourcefulness have always attracted human activities, but its complexity in understanding has led to misuse and abuse. In recent time, the coastal zone of India in particular and the world in general is under increasing pressure due to high rate of human population growth, development of
various industries, fishing, mining, discharge of municipal sewage and industrial waste effluents. This industrial development on coast has resulted in degradation of coastal ecosystems and diminishing the living resources. Coastal area is vital to the prosperity of the country and is biologically most productive area, supporting wealth of living marine resources. Thus there is urgent need to conserve the coastal ecosystems and habitats by implementing the Coastal Regulation Zone Notification 1991 and integrated Coastal Zone Management. Coastal zone faces a problem of environment degradation due to population pressure, wastewater disposal, destruction of Mangroves, increasing urbanization, solid waste disposal, coastal constructions, natural disasters, impacts of ports, coastal erosion, atmospheric population, impact of aquaculture, impact of tourism, ingress of seawater, coastal mining, impact of power plants, sea level rise and coastal highways.

In order to address these problems the Ministry of Environment and Forests, Government of India issued a Notification in the year 1991, under Environment protection act of 1986, declaring coastal stretches as Coastal Regulation Zone (CRZ) and regulating activities in CRZ. As per this Notification, the CRZ has been classified into four categories: CRZ-I, CRZ-II and CRZ-III and CRZ – IV for the purpose of regulation of the permitted activities.

The CRZ Notification has put too many restrictions on the development along the coast. In Maharashtra, with its coast line 720 km and 54 river creeks, significant stretches in land are badly hit by the CRZ Notification. It is said that there are several problems before the planners and decision makers on one side and investors and developers in other. The CRZ Notification as mentioned earlier has put too many restrictions on the development along the coast. Various important issues of CRZ Notification and implication are involved in the process of planning and development.

In view of the restrictions in implementing the CRZ Notification 1991, the Ministry of Environment and Forests, Government of India has revisited the 1991 Notification and a new draft proposal is said to be issued in the year 2010.

For environmentally effective coastal zone management, up to date and comprehensive scientific data on coastal resources, both biological and non biological, are required for any policy decision to be taken. Present study on the seaweed resources
along the Maharashtra coast (mostly intertidal region) has been undertaken in qualitative terms while efforts are being made by other agencies / organizations to study the resource base of mangroves, sea grasses besides marine fauna.

1.9 Maharashtra State - Area Under Present Study:

Located in the north centre of Peninsular India, with a command of the Arabian Sea through its port of Mumbai, Maharashtra has a remarkable physical homogeneity, enforced by its underlying geology. The dominant physical trait of the state is its plateau geology. Mahatashtra is a plateau of plateau, its western upturned rims rising to form the Sahyadri Range and its slopes gently descending towards the east and southeast. The major rivers and their master tributaries have carved the plateaux into alternating broad-river valleys and intervening higher lever interfluves, such as the Ahmednagar, Buldana and Yavatmal plateaux.

The Sahyadri Range is the physical backbone of Maharashtra. Rising on an average to an elevation of 1000 m it falls in steep cliffs, to the Konkan on the west. Eastwards, the hill country falls in steps through a transitional area known as Malwa to the plateau level. The series of crowning plateaux on the crest forms a distinctive feature of the Sahyadri Range.

The Konkan, lying between the Arabian Sea and the Sahyadri Range is narrow coastal lowland, barely 50 km wide. Though mostly below 200 m, it is far from being a plain country. Highly dissected and broken, the Konkan alternates between, steep-sided valleys and low laterite plateau.

The Satpuras, hills along the northern border, and the Bhamragad-Chiroli-Gaikhuri Ranges on the eastern border form physical barriers preventing easy movement, but also serve as natural limits to the state.

Except around Mumbai, and along the eastern limits, the state of Maharashtra presents a monotonously uniform, flat-topped skyline. The state enjoys a tropical monsoon climate; the hot scorching summer from March onwards yields to the rainy monsoon in early June. The rich green cover of the monsoon seaop persists during the mild winter that follows through an unpleasant October transition, but turns into a dusty,
barren brown as the summer sets in again. The seasonal rains from the western sea-
clouds are very heavy and the rainfall is over 400 cm on the Sayadrian crests. The
Konkan on the windward side is also endowed with heavy rainfall, declining
northwards. East of the Sahyadri, the rainfall diminishes to a meager 70 cm in the
western plateau districts, with Solapur-Ahmednagar lying in the heart of the dry zone.
The rains increase slightly, later in the season, eastwards in the Marathwada and
Vidarbha regions. The highly pulsatory character of the monsoon, with its short spells
of rainy weather and long dry breaks, floods as well as droughts add much to the
discomfort of the rural economy.

The soils of Maharashtra are residual, derived from the underlying basalts.
Forests comprising only 17% of the state area cover the eastern region and the Sahyadri
Range, while open scrub jungle dots the plateaux.

1.10 Studies on Seaweed Resources in India:

The marine algae are popularly known as ‘Seaweeds’, which form one of the
major living resources of the ocean. The luxuriance of algal vegetation mostly depends
on the tidal effects and the nature of the substratum in the littoral belts. The rocky nature
of any coast is due to naturally occurring rocks, huge boulders, stones or extensive
formations of coralline beds and reefs. These are ideal for supporting various algal
vegetations where as a purely sandy beach doesn’t harbour any alga or very little or few
forms. However, the important factors influencing the growth of seaweeds are the
nature of substratum, effect of tides, surf or wave action, clearness of seawater and
seasonal and biotic changes.

This biological and geographically diverse and important area harbours variety
of natural resources including flora and fauna which are widely used as a source of
food, fodder, fuel, fertilizer, medicines and many natural products such as agar-agar,
carrageenan and alginates. They are also a source of fine chemicals like prostaglandins,
natural pigments, mannitol, iodine and cosmetics. Seaweed based fertilizers which
contain a range of growth promoting hormones are also gaining importance as bio-
fertilizers because they have proved their efficacy for a variety of crops. Oriental
countries like Japan, China, Thailand etc are extremely popular for seaweed-based food
products. In the coming years, due to less availability of land and habitats, utilisation of seaweed based food products will increase.

Late Prof. M.O.P. Iyengar realised as early as thirties, the importance of marine algae and the wealth of knowledge that still remained to be unravelled in the field of algology and particularly in the marine algae of Indian coasts. His deep knowledge and insight into the mysteries of these fascinating groups of plants and his passion for algae had influence on his pupils, benefiting considerably by his discourses, practical demonstrations on life activities of various groups of seaweeds, their methods of propagation, reproduction, structure, ecological and morphological peculiarities etc have left an indelible impression. Although, Iyengar was the first algologist to work on the marine algae of South Indian coast whose works are being posthumously published even now, our current knowledge of Indian marine algae stems from the publications of Børnjesen who carried out the pioneering work on marine algae of south India, Mumbai and Gujarat coasts. The first record of any algae from the Indian Ocean is perhaps that of Amphiroa which was collected by Herman in 1672 from the Cape of Good Hope. Subsequently, in 1703 several pioneers have recorded marine algae which would be the 17th and 18th century records of marine algae of Indian Ocean region. In the 19th century, a number of expeditions were carried out for collections of marine algae. Although these expeditions didn’t touch the mainland coasts of India, they have collected marine algae from the Bay of Bengal and Arabian Sea islands.

Collections of marine algae from the Indian Ocean were made by a number of workers like James Murray and W. J. S. Pullen. These marine algae are found in herbaria of W.J.Hooker, Bertol, Rudolph, Coleman, Areschoug and Hauck, while some specimens collected from India are found in the Agardh herbarium, Lund and Rijks herbarium and Leiden herbarium. In early twentieth century, writers on Indian marine algae included Barton, Svedelius, Reinbold, Grunow and Iyengar.

Studies on marine algae have been reviewed from time to time by various workers like M.O.P. Iyengar, 1927, Biswas, 1932, 1934 and Srinivasan, 1965. Seventy years ago based on collections of M.O.P. Iyengar and on his own collections, Børjesen has published a series of papers on green, brown and red algae of Northern parts of the West Coast (Børjesen, 1930; 1931, 1932a,b; 1933a,b; 1934a,b and 1935) and brown and red algae of Southern India (Børjesen, 1937a,b & 1938b). Subsequently, work has
been done on the taxonomy of Indian algae during the last five decades. A general review of the marine algae of the West Coast was published by Biswas (1945), he published a list of Indian marine algae from the West Coast and later Biswas and Sharma (1950) worked on the Indian Sargassum. Anand (1943) gave an account of the algae from Karachi Coast.

Srinivasan (1947) studied the marine algal flora of Mahabalipuram. Biswas (1932) and Parija & Parija (1947) studied the algal flora of Chilika Lake. Chacko et al., (1955) have listed the algal flora of the Kursadii Island and Gulf of Mannar. Varma (1961) studied the Flora of the Pearl beds of Tuticorin. Srinivasan (1969 & 1973) has given a detailed account of marine algae in the form of Icons in Phycologia Indica. According to Srinivasan, 162 genera and 413 species of marine algae were known from the Indian waters. The list of species of Indian marine algae have been published by Dixit (1966, 1968, 1970 and 1980), the list consist of 411 species which also include records from Pakistan and Sri-Lanka. Misra (1966) has reported the brown algae which occur along the Indian Coasts in the form of Monograph. Srinivasan (1966) has published an account of the Indian Species of Sargassum. The marine algae of Gopnath has been studied by Sreenivasa Rao and Kale (1969) and that of Gulf of Kutch by Gopalkrishnan (1970). The species of Ulva from Indian waters was published by Krishnamurthy and Joshi (1969). An annotated list of 80 algae growing along the Visakhapatnam Coast has been given by Umameshwara Rao and Sreeramulu (1970a). A checklist of 520 species of Indian marine algae has been published by Krishnamurthy and Joshi (1970). Joshi and Krishnamurthy (1972) have listed 13 species of Enteromorpha from India. Umameshwara Rao (1973) has published the Coral reef flora of the Gulf of Mannar and Palk Bay. The description of 17 species and 2 varieties of Gracilaria and 2 species of Gracilariopsis and also their habitats, distribution in Palk Bay, India was given by Umameshwara Rao (1973). Agadi and Untawale (1978) have reported 50 algal species from the intertidal areas along the Goa Coast. Untawale et al., (1983) enumerated 624 species of marine algae and their distribution along the maritime states of India. Krishnamurthy and Joshi (1970) and Untawale et al., (1983) has published list on Indian marine algae. Checklist by Sahoo et al., (2001) listed 770 species which include 184 species of green, 166 species of brown and 420 species of red algae. According to the recent checklist by Oza and Zaidi (2001) marine algal flora of Indian coast comprises of 844 species including forma and varieties, out of these 434
species belong to Rhodophyta, 216 species belong to Chlorophyta, 191 species belong to Phaeophyta and 3 species of Xanthophyta. In addition to checklist of Untawale et al., (1983), 237 new species have been reported since then and included in the revised checklist.

1.11 Studies on Marine Algal Flora of the Maharashtra Coast:

In recent times, considerable importance is given to preserve or rather conserve our flora and fauna. The present floristic study of Marine Algal Flora of the Maharashtra Coast, India was undertaken to explore the rich and unexplored area of the Maharashtra Coast extensively and intensively. The ultimate aim was to bring out a comprehensive floristic account and also to study the various other aspects regarding marine algal wealth of the Maharashtra coast.

The area has been less explored so far. There are very few collections from the Maharashtra coast deposited in various herbaria. Though the area has tremendous potential as far as the floristic point of view, it was ignored due to many reasons like inaccessibility to many places, remoteness from the main coasts and only few species or a particular genus has been studied less as far as taxonomic point of view.

Floristic study of Marine algae from the Maharashtra Coast was undertaken as a part of Botanical Survey of India project on the lower plants. The important objectives of the project are: Survey, identification and inventorisation of the marine algal diversity along the Maharashtra coast and to prepare computerized database on the above for easy storage and retrieval of the information.

One of the first steps towards a successful national biodiversity strategy is to conduct surveys and document to find out what biodiversity exists in a variety of habitats, its value and importance, and what is endangered. On the basis of these survey results, governments can set measurable targets for conservation and sustainable use. National strategies and programmes need to be developed or adapted to meet these targets.