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The Ecological Status and Distribution of Mangrove in Gujarat: A Systematic Review

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ABSTRACT

Mangroves are the only species that survive in harsh conditions where no other species can survive. They mainly found at intertidal zones of tropical and sub-tropical regions of all over the world. They form a bridge between terrestrial and aquatic ecosystem and enables flow of energy between them. These woody species consist various adaptation in anatomy, physiology and morphology to survive in harsh environment conditions. This forest provides important and unique ecosystem good and services to human society as well as to coastal and marine ecosystem. Biotic pressure and natural calamities are the enemies of these ecosystems. Urbanisation and industrialization are the main cause of deforestation of the mangal. Due to pollution and over extraction caused by aquaculture, agriculture and urban development, large scale deforestation of these ecosystem has been recorded in past few decades. Intensive conservation efforts are needed to conserve these sensitive ecosystems. The ecology, diversity and distribution of mangroves in Glob, in India and particular in Gujarat has been reviewed in this paper. The data obtained from various literature of the authors had been analysed. Also, the importance, threats and conservation strategies to protect these ecosystems were also reviewed in briefly.

Keywords: Mangrove, Mangrove cover, Mangrove diversity, Mangrove distribution, Gulf of Kachchh.

I. INTRODUCTION

Mangroves are woody shrub, palms, herbs, ferns or tree plants that grow at the interface between the land and sea widely distributed at tropical and sub-tropical latitudes (Primavera *et al.* 2004). UNESCO (1973) defined mangroves as the evergreen sclerophyllous, broad leaved trees with areal roots, like pneumatophores or stilt roots and viviparous germinated seedlings. The intertidal flora or floral association and the faunal assemblage are commonly termed as 'mangrove ecosystem' (MacNae, 1968).

They form dense intertidal forests that dominate intertidal muddy shores, frequently consisting of virtually nonspecific patches or bands (Hogarth, 1999). The term mangrove is used to mean both plants and the habitat in which these plants are found (Kathiresan and Bingham, 2001).

Davis (1940b) described 'mangrove' as a general term applied to plants which live in muddy, loose, wet soils in tropical tide waters. According to Macnae (1968), 'mangroves are trees or shrubs that grow between the high-water mark of spring tides and a level close to but above mean sea level. Chapman (1939, 1940, 1944a) described silt, sand, peat and coral reefs as mangrove habitats. Macnae (1968), used the term 'mangrove' which refers to individual plant species, and the term 'mangal' which refers the swamp forest community. The word mangrove is thought to be a combination of the Portuguese word '*mangue' and the* English word 'grove'. In French the word is '*manglier'* (Macnae, 1968), in Spanish '*manglar'* and, '*mangro'* in Surinam which is a common name for *Rhizophora* (Chapman, 1976). According to Kathiresan and Bingham (2001), all these words are thought to be derived from the Malaysian word 'manggi-manggi' meaning 'above the soil. Mangrove forests are also known as 'oceanic rain forest', 'tidal forest', 'root of the sea', 'blue carbon forest' and coastal woodlands' (Kathiresan and Qasim 2005).

Mangroves are found in the transition zone, where salinity varies with tide, lack of oxygen in soil, and where tide rises and falls daily. Generally, the temperature below 20ºC and the minimum temperature variation below 5ºC as well as more than 200cm annual rainfall is a suitable environment for the mangrove growth (Saenger *et al.* 1983). In order to survive in such harsh conditions, they developed very distinct morphological as well as physiological adaptations. Such as presence of fleshy leaves (to cope with high salinity), sunken stomata, areal roots i.e. 'pneumatophores' (to cope with low oxygen content), stilt roots (to cope with daily change in tides and salinity), viviparous type of reproduction etc.

Tomlinson (1986) defined mangroves in three groups i.e.

1. Major or true mangrove or exclusive mangrove or strict mangrove or obligate mangrove,
2. Minor mangrove species and
3. Mangrove associates or semi-mangrove or back mangrove or nonexclusive species.

According to Tomlinson (1986), there are total 34 species in 9 genera and 5 families in major mangroves and 20 species of minor mangroves belongs to 11 genera and 11 families for total of 54 mangrove species in 20 genera and 16 families. Some of the plant species other than mangroves which grow in the terrestrial environment and pure halophytes that grow only in saline area can also be found within or in the peripheral area of mangrove wetlands. These species are known as mangrove associates. They found in elevated lands present within the mangrove ecosystem.

II. THE ECOLOGICAL STATUS OF MANGROVE COVER

2.1. Global status

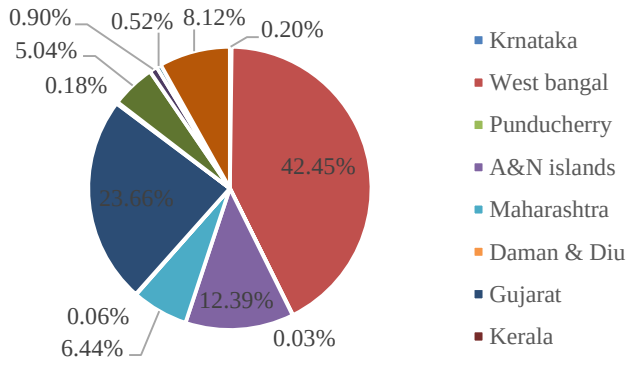
Globally mangroves are found in latitudes between 30º North and 30º South (Forest survey of India 2007). Worldwide, mangroves distributed mainly into two zones 1). West zone (which include African cost of Atlantic, north and South American portions also including Galapagos Island) 2). East zone (includes eastern part of African coast, south and southeast Asian countries). The global mangroves are distributed between the tropic of Capricorn and tropic of cancer in 124 countries (Jia 2014; Spalding *et al.,* 2010) and in 112coutries (Kathiresan and Bingham, 2001; SK Basha, 2018). According to SK Basha (2018), it spread in 112 countries coastlines of tropical and subtropical regions for an area between 167000 and 181000 km sq²; and are distributed along approximately one quarter of the world's tropical coastlines (Spalding et al., 1997).

The largest extent of mangroves is found in Asia (42%), followed by Africa (20%), North and Central

America (15%), Oceania (12%) and South America (11%). World-wide, species diversity, height and biomass are the lowest in the northern and southern extremes and increase towards the tropics. The well develop mangroves are found in the Sundarbans, Mekong Delta, Amazon, Madagascar, Papau New Guinea and Southeast Asia (Giri *et al.,* 2011). According to Duke *et al.,* (1998) the Indo-Malaysian region has highest species diversity anywhere in the world, containing 48 mangrove species.

2.2. Indian status

In terms of total mangrove cover worldwide, India ranks at fourth position with a 4662 km² (Forest survey of India, 2011), 4921 km² occupying 3.2% of global mangrove cover (Forest survey of India, 2015). They are found at coastlines of nine states (west Bengal, Gujarat, Andaman and Nicobar, Andhra Pradesh, Orissa, Maharashtra, Tamil Nadu, Goa and Karnataka) and three union territories.



FSI report 2019

Sundarbans (West Bengal) and Gujarat occupy 44% and 23% of mangrove cover in India, respectively and thus 67% of mangroves are found in these two stats only. Remaining 58% are found in East coast (Bay of Bengal), 29% on the west coast (Arabian Sea), and 13% on the Andaman and Nicobar Islands.

Selvam (2003) classified environmental situation of mangroves of India into four types:

a) Tide dominant (occupies 49.3%) - Sundarbans in west Bengal and Mahanadi mangroves in Odisha.
b) River dominant (23.4%) - Krishna and Gosavari mangroves in Andhra Pradesh, Muthupet and Pichvaram in Tamil Nadu.
c) Drowned bedrock valley (0.3%) – gulf of Kachchh and gulf of Khambhat mangroves in Gujarat.
d) Carbonate platform on low-energy coast (13%) – Andaman and Nicobar Islands.

2.3. Gujarat status

After West Bengal Gujarat stands second in the areal extent of mangrove vegetation, forming about 1107 km² mangrove cover. The major mangroves in the state are located in the Kori Creek and Sir creek, Gulf of Kachchh, Porbandar in Saurashtra, Gulf of Khambhat, and in South Gujarat (Singh 2000; Forest Survey of India, 2013).

Approx. 74.1% (775 km²) of the total mangrove cover found in the single Kachchh district, covering the forest of kori creek; 15% (157 km²) of the mangrove cover are found in Jamnagar, covering the mangroves of gulf of Kachchh; and the remaining 10.9% (114 km²) are spread across nine districts of the gulf of khambhat and south Gujarat (Pandey and Pandey).

III.DIVERSITY AND DISTRIBUTION OF MANGROVES

3.1. Global scenario

Chapman (1976) reported 90 species worldwide. According to Tomlinson (1986), around 34 major and 20 minor mangrove species belonging to about 20 genera in over 11 families have been exists globally, he recorded total 114 species from 66 genera, worldwide. Duke (1992) recorded 69 mangrove species belongs to 26 genera in 20 families. Approx.52 species from 28 genera in 20 different families recognized globally (Duke *et al.,* 1998).

author	No. of mangrove species	Region	Remarks
Tomlinson (1986)	126	World	Mangroves and mangrove associates
Duke (2006)	42	Australia	Mangroves only
Naskar (2004)	112	India	Mangroves and mangrove associates
Kathiresan (2001)	39	India	Mangroves only

(Pandey & Pandey, 2010)

Mangroves of South and Southeast Asia form 41.4 % of global mangroves, forming world's most diverse and extensive ecosystem (Singh *et al.* 2012).

3.2. Indian scenario

Mangroves form one of the world's most unique ecosystem because they thrive where no other trees can survive – in the transition zone between the ocean and land. They are also among the world's most productive ecosystem. Naskar (1983) reported total 35 true mangrove species and 35 mangrove associates from Indian mangal. There are 39 core mangrove species along with 3972 other mangrove associates including 920 floral and 3091 faunal species are present in Indian mangrove ecosystem. The IUCN lists 11 endangered mangrove species worldwide.

Mangrove region	Species distribution
East coast	36
West coast	25
Andaman & Nicobar Islands	36

Among them 2 species i.e. *Sonneratia griffithii* and *Heritiera fomes* exist in India. Because of their slow growing and low-seed viability (Kathiresan, 2017). Untawale *et al.* (1987) reported 33 mangroves from west coast and 47 mangroves from east coast, while Banerjee *et al.* (1989) listed 59 species under 41 genera and 20 families as major mangrove, Naskar (1989) has reported 30 true species from Indian-sub-continent, Jagtap *et al.* (1993) reported 50 mangrove species from India.

Authors	Number of mangrove species in India
Blasco (1975)	**60**
Untawale (1985)	**59**
Botanical survey of India (1989)	**59**
Kathiresan and Bingham (2001)	**39**

(Pandey & Pandey, 2010)

3.2.1. Sundarbans

The most dominant and single largest mangrove cover of world is present in sundarban, situated at the southern part of the four districts of Bangladesh (66%) and two districts of India (34%) (West Bengal) which covers about 4266.6 km^2, at Ganga-Brahmaputra-Meghna deltaic regions. 56 mangroves species have been reported from different regions of Sundarban. *Heritiera fomes* and *Heritiera littoralis* these two species are the dominant and characteristic one in Sundarban.

3.3. Gujarat scenario

Total fifteen true mangrove species are found in Gujarat among which eleven species are rare and 90% of the mangrove forest covered by only single species i.e. *A. marina* (Pandey and Pandey, 2013). In Gujarat, various agencies such as the state forest department, space applications centre (SAC), Indian Space Research Organization (ISRO), Ahmedabad and Gujarat Ecological Education and Research Foundation (GEER), Gandhinagar have done significant work on the state's mangrove (Bhatt *et al.,* 2009).

Study of vegetation includes various parameters such as density of mature tree, girth at breast height (GBH), canopy cover in term of index, stand dynamics by measuring age classes i.e. regeneration and recruitment class. The status of the mangroves can analyse based on given data (Sawale and Thivakaran, 2013).

3.3.1. Gulf of Kachchh

Gulf of Kachchh consists around 986 km^2 of mangrove cover, total eight true mangrove species had been reported with dominant species *Avicennia marina*, and form second largest forest in Indian coastal region (ICMAM 2004; GEC and BISAG 2008).

Singh (1994) reported total seven mangrove species i.e. *Avicennia marina* (Forsk.) Vierh*, A. officinalis* L.*, A.alba* Bl.*, Bruguiera cylindrica* (L.) Bl.*, Rhizophora mucronata* Lamk.*, Aegiceras corniculatum* (L.) Blanco, *Ceriops tagal* (Perr.) Robinson from gulf of Kachchh despite of which at present only four species are generally found in this region as three species namely *A. marina, A. alba and Bruguiera* have not been documented for the last ten years (Pandey and Pandey). Mangroves are distributed in arid and semi-arid coastal belts among them semi- arid coastal belt of Kachchh shows harsh environmental conditions (Blasco and Aizpuru, 1997).

Thivakaran *et al.* (2020) carried out study on structural features of semi-arid mangroves at 10 different locations on the northern and southern coast of the gulf of Kachchh with the help of line intercept method and determine the various status of the mangrove species. In this area mature tree ranged from 350 to 1567 individual ha^{-1}, and average height and GBH ranges from 1 to 6.8m and 3 to 137cm, respectively. Canopy index of most trees was recorded in class <2 cm. the structural characteristic of *Avicennia marina* was poor than the mold dominated mangroves because of the aridity brought on by infrequent, heavy rainfall and excessive soil and water salinity.

The water salinity increases from south to north coastal stretch of Kachchh (Mundra to Kori creek) due to reduced rain fall and decreased aridity index. The regeneration potential of mangroves of Kori creek had high potential due to high recruitment class of mature trees (Thivakaran *et al.,* 2003). The west coastal region of Kachchh mangroves shows monospecific vegetation with only *A. marina* due to hyper-saline condition enabling survive of it only (Singh, 1999). Similarly, in southern coast only one species (*A.marina*) have been reported due to non-availability of the propagules of other mangrove species in that particular area (Thivakaran *et al.,* 2003).

Saravanajumar *et al.* (2009) did the survey on vegetation structure of mangrove in gulf of Kachchh between 1999 and 2000 in arid zone. The ambient temperature and salinities are high in the macrotidal estuary and its decreasing during monsoon. The tides of the sites show mixed semi diurnal type with varying amplitude. Seasonally, the dissolved oxygen shows negative tendency against temperature and salinity i.e. during monsoon season the value of dissolved oxygen increases. The value of nitrite, nitrate and phosphate were high during the monsoon may due to heavy rainfall, land runoff or due to weathering of rocks. The content of silicate was relatively higher than other nutrients due heavy influx of freshwater or from bottom sediments exchange with overlying water due to the turbulent nature of water in mangrove environment. The pH of sediment, the value of total organic carbon was high in summer and vice versa.

Das *et al.* (2019) carried out the study of the natural regeneration on four mangrove species including *Avicennia marina, Ceriops tagal, Aegiceras corniculatum* and *Rhizophora mucronata* at southern gulf of Kachchh. They reported the natural occurrence of *A. marina* was higher in all the studied sites compare to other three. The physic-chemical analysis of water and sediments were also studied. The salinity, organic carbon and organic matter were relatively less compared to other mangrove soils of world and thus favourable for the remaining three species to grow and establishment. The density of

natural occurrence of four species shows in the order of *A. marina* > *C. tagal* > *A. corniculatum* > *R. mucronata*.

At Mundra stands the density of mature tree ranges between 1820 and 4325 ha^{-1}, the height 1 to 6.7 m, the GBH ranges between 3 and 112 cm. wherein Kharo stand shows the density range 1084 to 3559 ha^{-1}, the height 1 to 7.8 m and GBH ranges from 5 to 112 cm. The mean stand density of mangrove was recorded 3076/ha and 2679/ha at Mundra and Kharo respectively (Sawale and Thivakaran, 2013).

Thivakaran and Sawale (2016) studied for 2 years on the macrofuanal community present at Mundra and Kharo stands. They observed 51 species in 44 genera composed of 5 major groups from which gastropods and crustaceans seemed dominant with 14 and 15 species in 24 genera. Mangrove associates flora also play important role in mangal ecosystem. The distribution of bacteria depends on physico-chemical parameters. Zaharan *et al.* (1992) believed that in the high salinity environment halophilic bacteria are dominant. Kumar and Ramanathan (2013) reported four types of bacterial colonies including free living nitrogen fixing, nitrate forming, cellulose degrading and phosphate solubilizing bacteria at gulf of Kachchh. At old Bedi port, Naarara and Mundra the population of nitrogen fixing bacteria was high (4×10^3 cfu/g soil) indicating the higher concentration of NO_3^- in the water. The concentration of phosphate solubilizing bacteria and cellulose degrading bacteria varied from 3-17 × 10^3 cfu/g soil and 5-13× 10^3 cfu/g soil respectively. The water sample collected from different locations contain some common nutrients such as NO_3^-, SO_4^{2-}, PO_4^{2-} along with dissolved H_2SIO_4. Phytoplankton also present as mangrove associates which play a vital role in the food chain of marine community. Saravanakumar *et al.* (2008) carried out study on the phytoplankton present in the creek water of western (semi-arid zone) mangrove of Kachchh. Total 104 species including 82 of diatoms, 16 of dinoflagellates, 3 of blue green algae and 2 species of green algae had been reported. *Hemidiscus hardmanianus, Cosinodiscus radiatus, Cerataulina bergonii and Spirulina* were found most abundantly.

3.3.2. Gulf of Khambhat

Gulf of Khambhat includes manly four districts which contain mangrove cover. These coastlines include Bharuch, Navsari, Surat and Bhavnagar. However, it has been reported that gulf of Khambhat contain unique mangrove species despite having less mangroves overall. Bhatt *et al.,* (2011) reported fourteen mangrove species from gulf of Khambhat namely *Avicennia marina* (Forsk.) Vierh*, A. officinalis* L.*, A.alba* BI.*, Bruguiera cylindrica* (L.) BI.*, B. gymnorhiza* (L.) Savigny*, Ceriops tagal* (Perr.) Robinson*, C. decandra* (Griff.) Ding Hou*, Rhizophora mucronata* Lamk.*, Aegiceras corniculatum* (L.) Blanco*, Excoecaria agallocha* L.*, sonneratia apetala* Buch.-Ham.*, Kandelia candel* (L.) Druce*, Acanthus ilicifolius* L.*, Lumnitzera racemosa* Wild.

Devi and Pathak (2016) carried out study on coastal regions including Ghogha from Bhavnagar, Dahej from Bharuch, Dumas from Surat and Dandi from Navsari and reported total eight mangrove species containing both true mangroves and mangroves associates i.e. *A. marina* (Forsk.) Vierh, *B. gymnorhiza* (L.) Lam., *S. apetala* Buch.-Ham., *Acanthus ilicifolius*, *Ipomoea pes-caprae* (L.) R.Br., *Sesuvium portulacastrum*, *Salvadora persica* and *Suaeda* sp. Among this *A. marina* founded most abundant and frequent species in all coasts. The average GBH of selected species ranged from 0.28 to 22 cm. Of all the species, *Sonneratia apetala* had the heighest mean height at 230.86 cm, followed by *Avicennia marina* at the Navsari site with (127.28) and at Bharuch site with 114.6 cm and *Bruguiera gymnorhiza* at Navsari site with 109.82 cm. The mean height of A. marina reported maximum at Navsari with 127.28 cm and minimum at Bhavnagar with 71.68 cm. according to this study the plant mean height decreases with increasing plant density. The temperature was ranges from 29.9 C to 33.5 C, The value of pH was 8.37 (Navsari), 8.39 (Bhavnagar), 8.68 (Surat), the moisture content was high at Navsari (60.1%) than remaining

other followed by Bhavnagar (44.4%) and Surat (23.7%). The total nitrogen and phosphorus content were reported between 1.21% to 4.7% and 3.32 ppm to 5.89ppm respectively. The organic carbon content in Navsari, Surat, Bhavnagar reported 0.17%, 1.09% and 1.52% respectively. The value of total organic matter was recorded from 0.29% to 2.62%.

Singh (2020) reported total 16 species including 6 mangrove species and 10 associated plant species at four intertidal area of gulf of khambhat. Out of these 15, 10, 7 and 6 species were recorded at Navsari, Surat, Bhavnagar, Bharuch and respectively. *A. marina* as mangrove species and *Suaeda maritima and Sesuvium portulacastrum* where most dominant mangrove associates are found in all the locations. Five true mangrove species at Navsari i.e. *A. marina, A. ilicifolius, B. cylindrica, C. tagal and Sonneratia apetala*; three species at Surat i.e. *A. marina, A. officinalis and S. apetala*; two species from Bharuch (Dahej coast) i.e. *A. marina and A. officinalis*; and only one species i.e. *A. marina* from Bhavnagar (Ghogha coast) were recorded.

Mangroves ecosystem also contain diverse macro-micro algae. Mehta and Mehta (2022) studied on the habitat characteristics of macroalgae present at Gopnath coast, Bhavnagar. They reported one group of ulva genus including four species of green algae mainly *U. ovate, U. intestinalis, U. prolifera* and *U. compress*. According to them the presence and absence of macroalgae depends on the morphological structure of pneumatophores and the seasonal changes that would affect the growth of macroalgae.

Bhavsar and Pandya (2018) reported 19 different species of phytoplankton of seven different genera i.e. Cosinodiscus, Cylindrotheca, Nitzschia, Navicula, Plurosigma, Prorocentrum and Surirellia from five different districts (Ahmedabad, Bhavnagar, Surat, Valsad, Anand) of gulf of khambhat. Trivedi et al. (2017) studied allometric equation of mangroves at Kntiyajal village present at gulf of Khambhat from 2010 to 2013 to estimate the height-biomass relationship to establish allomatric equation for the young *Avicenna marina* mangroves.

IV. WHY MANGROVES ARE IMPORTANT

Mangrove forest is among the most productive and biologically important ecosystems of the world because they provide important and unique ecosystem goods and services to human society and costal and marine ecosystem (Giri et al., 2011; Duke et al., 2014). Mangroves have immense ecological and economic importance. They provide socio-economic benefits to local tribes, protect the coastal areas against natural disasters and facilitates the formation of land by trapping sediments (Kathiresan 2003a).

Ecologically, it shields the coast from solar UV-B radiation, greenhouse gasses, storms, floods, natural disasters such as tsunamis and hurricanes, rising sea level, wave action and erosion of the coastal soil. In other coastal environments, they serve as nutrient sources, sinks, and traps for sediment, provide feeding, breeding, and nursery grounds for many food fishes and wildlife animals. They are known to support a large variety of crabs and also influence the availability of fish in mangrove and adjoining areas. They also protect various aquatic ecosystems such as seaweed beds, coral reefs, island, and seagrass meadows.

Economically, mangroves produce goods for fishing and forestry, as well as they provide sites for the developing eco-tourism industry. They hold enormous potential for bioprospecting as a valuable source of chemical, salt-tolerant genes, and valuable products with applications in the food (seeds can used as vegetables), industrial, medical (for chicken pox, injury) and agricultural sectors. Mangrove also provide firewood, timber, honey, medicine and cattle feed. (Kathiresan 2021).

It consumed by households in coastal areas as fuel wood, to manufacture charcoal, to obtain timber which can use to construct boat and houses. The fodder of it is believed to be nutritive as cottonseeds

and it help to improve the fat content in milk. It provides raw material for the manufacturing of various products such as alcohol, gum, honey, vinegar and other medicines (Hirway and Goswami, 2007). Mangroves and its associated soil could sequester approximately 22.8 million metric tons of carbon each year (Giri et al., 2011). Today it is established that mangroves sequester 50 times more carbon than tropical forests which play major role in regulating the global carbon cycle (Cummings and Shah, 2017). In India, mangrove forest can remove 9 tonnes of carbon every day (Kathiresan and Qasim, 2005).

V. THREATS ON MANGROVES

Despite its value, the mangrove ecosystem is one of the most threatened on the planet. According to Hamilton and Casey (2016) mangroves experience 0.16% to 0.39% annual loss globally. And in South Asia only, these forests have been destroyed at 0.18% average rate every year (Richards and Friess, 2016). Mangroves are being destroyed at rates 3-5 times greater than average rates of forest loss and over a quarter of original mangrove cover has already disappeared (Duke *et al.*, 2014). Proximate divers such as aquaculture, agriculture, and urban development have caused large-scale mangrove deforestation and also degraded by resource over extraction and pollution (Friess *et al.* 2019). According to G. Acharya (2002), the loss of these ecosystem would mean local, national and global welfare losses.

As per the IUCN Red List, total 57 mangrove species are under threat in India. These species are categorised as follow:

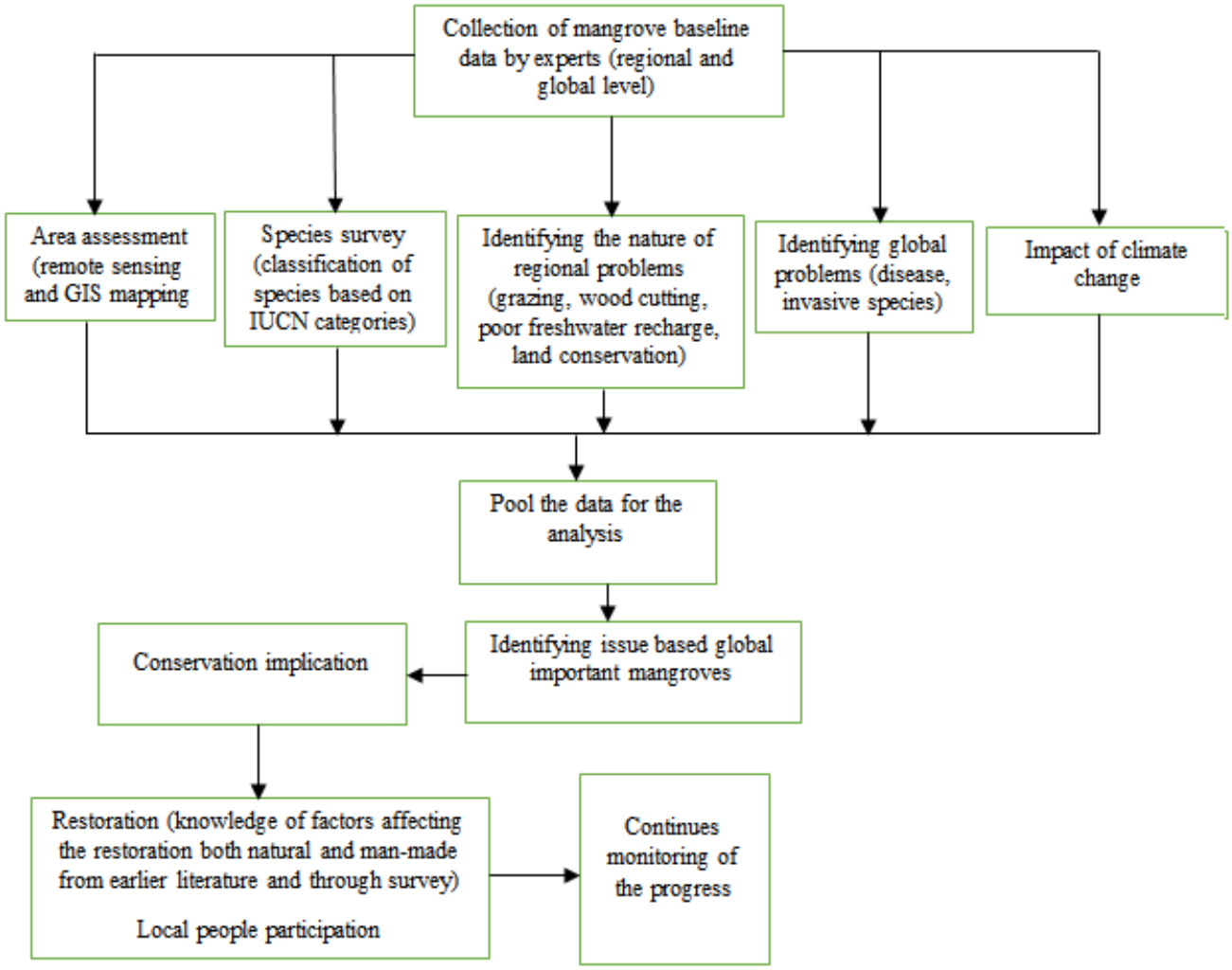
Sr. No.	Category	Species
i.	Endangered (EN)	39 (68%)
ii.	Critically Rare (CR)	11 (19%)
iii.	Vulnerable (VU)	5 (9%)
iv.	Low Risk (LR)	1 (2%)
v.	Low Risk near threatened	1 (2%)

(Pandey & Pandey, 2010)

There is total 60 plants species are associated with Indian mangal. Among them 12 species are critically endangered, 42 species are endangered, and 3 species are vulnerable. There are 23 algal associated species are present among them 2 are critically endangered and 12 are endangered (Hirway and Goswami, 2007). The main cause of decreasing of Mangrove Forest is the several human activities such as industrialization and urbanization causing the deposition of heavy metal pollution in the mangrove forest sediments. Beside these other causes are agriculture and aquaculture expansion, exploitation of mangroves for provisioning services such as industrial purposes, natural calamities, pollution, threats from unsustainable tourism, and climate change are the threats to mangal ecosystem. In particular Gujarat, developmental activities and degradation of coral reef are the main causes of the decreasing of mangrove cover (Ashokkumar and Irfan, 2018).

VI. MANAGEMENT AND CONSERVATION STRATEGIES

According to Duke et al. (2007) the conservation of momentous ecosystem is required vitally for global well-being or else the good services and the other beneficial offers provided by mangroves will be reduced or lost forever. A practical paradigm for managing mangrove ecosystems for fisheries resource development, biodiversity enrichment and coastal protection should be developed through participatory integrated coastal zone management (Sandilyan and Kathiresan 2012).



Implementation of conservation strategies for global mangrove conservation

Numerous legislative and regulatory bodies have been established in India for the protection purpose of mangroves (Ashokkumar and Irfan, 2018). Three management strategies are effectively employed in India to manage mangrove forests i.e. 1) promontory; 2) regulatory and 3) participatory. In the promontory approach, the Management Action Plan (MAP) has been imply by government of India in 38 mangrove areas of coastal region. In regulatory management, India has significant legal support for the preservation of mangroves in National Parks, Reserved Forests, Wildlife sanctuary, Protected Forests and Community Reserves. While participatory approach involve various conservation and management practices has been demonstrated by India government such as Maharashtra Mangrove Conservation Model, Kannur Mangrove Mission, Canal bank planting with 'Fish Bone' design for mangrove restoration and Participatory mangrove management model (Kathiresan 2018).

VII. CONCLUSION

In India, Sundarban and Gujarat consists highest mangrove cover occupying 67% of total mangrove cover. These two states consist highest biodiversity in mangal. In Gujarat total 15 true mangrove species have been reported among which eight species are found in gulf of Kachchh only. It has been reported that *Avicennia marina* is the only species that is dominant in all over Gujarat and *Rhizophora mucronata* is also dominant in some area around Gujarat. Mangroves are found manly in arid and semi-arid coastline regions of Gujarat. Not only true

mangrove species but its associates are also present in Gujarat mangal. Mangrove ecosystem provides livelihood for millions of people and sustains unique biodiversity, yet it is under significant threat from a variety of human activities. Among the 15 species, 11 species are rare. The polluted water released from industries consists various heavy metals such as Cr, Pb, Zn, Ni, Hg, Cu, Cd etc. that may cause some serious impact on mangrove health that could affect the qualities and quantities of mangroves. Because of the ongoing efforts at conservation and restoration by efficient governance and the application of policies, the mangrove cover has been steadily increasing over the past ten years.

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